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Peroneus Longus Tendon Autograft for Primary Arthroscopic Reconstruction of the Anterior Cruciate Ligament

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SUMMARY

Purpose. Peroneus longus tendon graft is not a popular first choice for ACL reconstruction. However, newer literature has shown good outcomes with its use. This study compares functional outcome and donor site morbidity of peroneus longus with hamstring tendon autograft to assess if it can be considered as one of the first choices for ACLR.

Methods. This prospective cohort study involves 54 patients who underwent arthroscopic single-bundle ACLR. 27 patients each were operated on with hamstring and peroneus longus autografts. At 2 years follow-up, functional outcome was compared between groups using International Knee Documentation Committee (IKDC), Modified Cincinnati, and Tegner-Lysholm scores. Donor site morbidity in the peroneus longus group was assessed using Foot and Ankle Disability Index (FADI) and The American Orthopaedic Foot and Ankle Society (AOFAS) scores.

Results. At 2 years follow-up, there was no statistically significant difference in the mean IKDC (77.26 *vs* 80.78), Modified Cincinnati (84.41 *vs* 89.07), and Tegner-Lysholm scores (85.19 *vs* 88.78) between the hamstring and peroneus groups respectively. Mean FADI and AOFAS scores at 2 years follow up were 96.11 and 91.67 respectively in the peroneus group suggesting no significant donor site morbidity as compared to preoperative scores.

Conclusions. Peroneus longus performs similar to hamstring grafts and can be considered as one of the first choices for arthroscopic ACL reconstruction.

KEY WORDS

ACL injury; autograft; donor site morbidity; hamstrings; peroneus longus tendon.

INTRODUCTION

Arthroscopic anterior cruciate ligament (ACL) reconstruction is the most accepted treatment for complete ACL injury worldwide. The most popular autograft choices are bone-patellar tendon-bone (BPTB) and quadrupled hamstring tendon graft. Peroneus longus graft is not a popular first choice for primary ACL reconstruction at most centers, however, in the last decade or so, there has been an increasing trend for its use. Multiple studies have compared the efficacy of peroneus longus tendon graft with hamstring

graft in primary ACL reconstruction (1-6). Although many studies show comparable and good clinical outcomes, there have been persisting concerns over donor site morbidity following peroneus longus grafting such as weakness of eversion-inversion and ankle instability (7).

The indications for peroneus longus graft which were earlier restricted to revision cases or multiligamentous reconstructions are now gradually expanding to primary ACL reconstructions. Due to limitations in both quality and quantity of studies, non-inferiority of peroneus longus to hamstring grafts is yet to be established substantially. In our study, we have prospectively compared two cohorts of patients who underwent arthroscopic ACL reconstruction with peroneus longus and hamstring graft, respectively. We aim to assess if the peroneus longus autograft is comparable to hamstring autograft in terms of functional outcome and donor site morbidity for primary arthroscopic ACL reconstruction, making it a safe alternative first choice.

METHODS

This was a prospective cohort study conducted in a tertiary referral center at Mangalore, India, following the approval by Institutional Ethics Committee (Protocol No.- KMCMLR 09-19/428 – Date of approval: September 25, 2019). Patients between the age of 18 to 50 years who were diagnosed to be having isolated complete ACL tear based on clinical and MRI evaluation and who underwent arthroscopic ACL reconstruction were included in the study by purposive (non-random) sampling. Patients who had a multi-ligamentous knee injury, intra-articular fractures, chondral injuries, meniscal injuries, arthritic changes or previous ankle lesions were excluded. All those patients who completed a minimum follow up of 2 years from September 2019 to December 2022 were included in the study. The sample size of 54 patients was selected with reference to a study by Rhatomy *et al.* in which they studied a total of 52 patients, (80% power at 5% level of significance) (2). The study population was divided into two groups of 27 each. Patients in group A received hamstring autograft and those in group B received peroneus longus autograft. To avoid selection bias, every consecutive patient was allotted alternatively between the two groups. Informed consent was taken from all the subjects in this study and the rights of participants were protected. Demographic data (age and gender) was collected from all patients. Preoperative anterior drawer and Lachman test results were documented for each patient. Preoperative American Orthopaedic Foot and Ankle Society (AOFAS) Ankle hindfoot score (8) and Foot and Ankle Disability Index (FADI) (9) were assessed in the peroneus longus group to be able to compare them postoperatively.

Surgical technique of single-bundle ACL reconstruction

All patients in both groups were operated on by the same surgical team. Surgery was done under spinal anesthesia and a high groin tourniquet was used in all patients. Initially, a thorough diagnostic arthroscopy was performed through standard anteromedial and anterolateral portals (10). After confirmation of ACL tear, autografts were harvested.

Harvesting peroneus longus graft

A longitudinal incision was made over the posterolateral aspect of the distal leg, just posterior to the lateral malleolus. After subcutaneous dissection, peroneus longus and brevis tendons were identified and tagged. Sural nerve was not encountered in the approach. Lesser saphenous vein and its tributaries were protected. Tenodesis was performed at their distal most aspect with polyester nonabsorbable braided suture. Following this, the peroneus longus tendon was whip stitched, cut distally, and harvested using an open tendon stripper. Stripper was carefully maintained just superficial fibula, while not extending into proximal 1/3rd of leg, in order to prevent injury to superficial and deep peroneal nerves. While harvesting the peroneus tendon graft, the ankle is maintained in plantar flexion to minimize the risk of sural nerve injury (11). The harvested graft was consistently

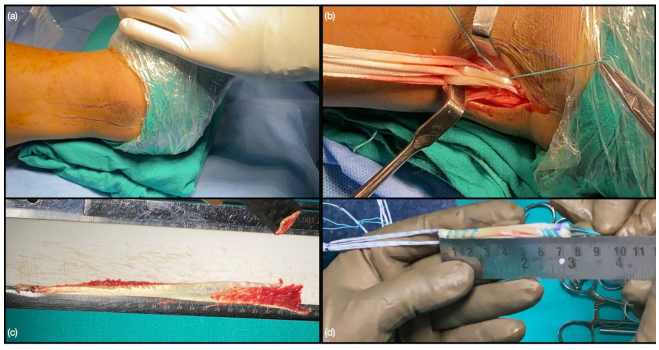

Figure 1. Steps of harvesting of peroneus longus autograft and preparation.

(a) Skin marking for incision; **(b)** Identification and isolation of peroneus longus and brevis along with their distal tenodesis; **(c)** Graft length measurement and preparation; **(d)** Tripled peroneus autograft.

between 24- 26 cm in length and after tripling had a diameter between 7.5 to 9 mm (**figure 1**).

Harvesting hamstring graft

An oblique 5 cm long incision was made over the anteromedial surface of the proximal third of the leg overlying the pes anser-

inus insertion. After subcutaneous dissection, sartorius fascia was identified and divided, following which semitendinosus was identified and tagged (**figure 2**). The tendon was whip stitched, cut distally, and harvested using an open tendon stripper. In 20 out of 27 cases, semitendinosus alone was insufficient for the desired graft thickness. Hence gracilis tendon was additionally harvested and the graft was quadrupled or tripled to attain optimal dimensions (8 cm ± 0.5 cm length and 8.5 mm ± 1 mm diameter). In both groups, the graft was wrapped with vancomycin-soaked gauze (12) and tensioned.

Figure 2. Harvesting hamstring autograft.

(a) Skin marking for standard knee arthroscopy portals and hamstring harvesting; **(b)** Isolation of semitendinosus graft after the division of sartorius fascia.

Tunnel preparation and graft fixation

Standard methods of femoral tunnel (trans-portal) and tibial tunnel preparation were adopted for both groups (13, 14). On the femoral side, the graft was fixed using Ultrabutton adjustable fixation device (UB; Smith and Nephew, Andover, Massachusetts, USA). The tibial side was fixed using a titanium RCI (reverse thread interference) screw (RCI; Smith and Nephew, Andover, Massachusetts, USA). Before putting the RCI screw on the tibial side, cycling of the knee was performed to tension the graft and assess graft impingement (**figure 3**).

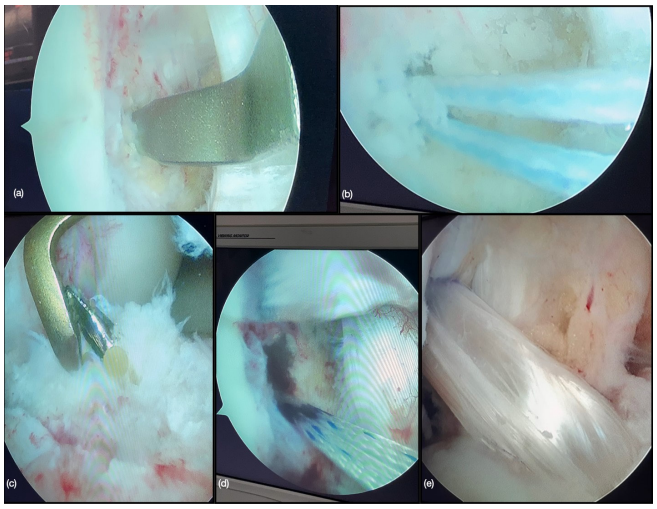

Figure 3. Steps of femoral and tibial tunnel preparation and graft passage.

(a) Marking femoral tunnel entry point; **(b)** Suture loop passed through femoral tunnel; **(c)** Placement of tibial tunnel through the footprint posterior to the anterior horn of lateral meniscus; **(d)** Passage of the adjustable loop with graft through the prepared tunnels; **(e)** Final graft position.

Rehabilitation

Postoperatively patients in both the groups underwent accelerated rehabilitation in 5 phases as described by Shelbourne *et al.* (15). Postoperative bracing was not used. Rehabilitation emphasized full knee extension on the first postoperative day and immediate weight-bearing as per the patient's tolerance. Patients were regularly followed up and periodic clinical and radiological assessments were done.

The functional outcome of both groups of patients was assessed at two-year follow-up along with donor site morbidity in the peroneal longus group. The functional outcome was quantified by questionnaire-based scoring systems like International Knee Documentation Committee (IKDC) (16), Modified Cincinnati (17), and Tegner-Lysholm (18) scores. Anterior drawer and Lachman tests were performed in both groups by the same team of surgeons. Donor site morbidity in the peroneus longus group was quantified using AOFAS Ankle hindfoot score and FADI.

Statistical analysis

The collected data were analyzed by descriptive and interferential statistical methods. Descriptive methods such as frequency and percentage were calculated to summarize categorical data. Mean and standard deviation (SD) were calculated to summarize the IKDC, Modified Cincinnati, Tegner-Lysholm, AOFAS, and FADI scores. Unpaired t-test was used to compare scores between the groups at two-year follow-up. The Chi-square test and Fischer's exact test were used to compare categorical parameters between the groups. Analysis was done using SPSS 25.0 software. The level of significance in this study was 5% (P-value less than 0.05).

RESULTS

In our study we included 54 patients who were divided subsequently into group A (hamstring) and group B (peroneus longus) of 27 each. In the hamstring group, the mean age of the patients was 32.11 ± 9.460 years of which 92.6% were males and 7.4% were females. In the peroneus longus group, the mean age of the patients was 31.74 ± 7.744 years of which 74.1% were males and 25.9% were females. Fischer's exact test revealed no significant statistical difference in age distribution between the two groups (p = 0.297). The Chi-square test revealed no statistical difference in gender distribution between the two groups (p = 0.067).

The anterior drawer test and Lachman test preoperatively in all the patients in both groups were positive (grade 3

Table I. Comparison of functional outcome at two-year follow-up in both groups of patients.

Scores (post-op)	Graft used	Sample size (n)	Mean	Standard deviation	t-test P-value
IKDC	Hamstring	27	77.26	7.209	0.085
	Peroneus longus	27	80.78	7.526	
Modified Cincinnati	Hamstring	27	84.41	15.445	0.169
	Peroneus longus	27	89.07	7.961	
Tegner-Lysholm	Hamstring	27	85.19	11.806	0.186
	Peroneus longus	27	88.78	7.418	

Table II. Comparison of donor site morbidity in the peroneus longus group.

Scores	Sample size (n)	Mean	Standard deviation	Mean difference	Standard deviation of the difference	Paired t-test P-value	
AOFAS Pre-op	27	100.00	0.000	4.333	6.367	0.198	NS
AOFAS Post-op	27	95.67	6.367				
FADI Pre-op	27	104.00	0.000	4.889	3.446	0.180	NS
FADI Post-op	27	99.11	3.446				

translation with a soft endpoint). At two-year postoperative follow-up, none of the patients showed clinical instability and all the patients showed Lachman grade 0 or 1 with a firm endpoint.

On comparison of two-year follow-up scores of both groups, there was no statistically significant difference noted in IKDC ($p = 0.085$), Modified Cincinnati ($p = 0.169$), and Tegner-Lysholm ($p = 0.186$) scores, implying that the peroneus longus group had an equally good functional outcome (**table I**).

To assess donor site morbidity in the peroneus longus group, the mean AOFAS ankle hindfoot score assessed at two-year follow-up was noted to be 95.67 ± 6.367 with a mean difference of 4.333 ± 6.367 from the preoperative scores. These differences were statistically not significant ($p = 0.198$). The mean FADI score at a two-year follow-up was 99.11 ± 3.446 with a mean difference of 4.889 ± 3.446 from preoperative scores which was also statistically not significant ($p = 0.180$) (**table II**). This implies there was no significant donor site morbidity in patients who underwent ACL reconstruction with peroneus longus autograft. No patients in the peroneus longus group showed adverse complications such as sural nerve injury.

DISCUSSION

Arthroscopic ACL reconstruction is a commonly performed surgery and has gained tremendous popularity in recent times, especially with the increasing exposure to contact sports. Currently, graft choices for primary ACL reconstruction (ACLR) are autologous hamstring semitendinosus gracilis (ST-G), quadriceps tendon, bone-patellar tendon bone (BPTB), peroneus longus autograft, allografts, and carbon filament-based synthetic grafts (19, 20).

Autografts are preferred for primary reconstruction of ACL due to ubiquitous availability, better biologic incorporation, no risk of disease transmission, and better biocompatibility. Allografts, on the contrary, have a higher risk of disease transmission, poor biocompatibility, poor graft incorporation, and face issues of unavailability in developing countries. However, they offer advantages over autografts such as reduced surgical time, no donor site morbidity, and abundance of graft material in multi-ligament reconstruction or revision cases (21, 22). Amongst autografts, BPTB graft has been considered the gold standard for the reconstruction of ACL. However, with the advent of hamstring (ST-G) autograft, the use of B-PT-B graft has declined due to the association of significant donor site morbidity (21, 22).

The quest to find better autografts is a never ending one. Although present medical practice has embraced the use of hamstring tendons as the graft of choice, there are certain concerns that prompt us to look for better alternatives. Hamstring graft harvest bear the concern of weakening knee flexion and causing an imbalance in quadriceps-hamstring dynamics (23). Hamstrings being dynamic stabilizers on the medial side, there is a concern while choosing hamstring graft in patients with multi ligamentous injury, especially those with medial collateral ligament injury (23). Moreover, semitendinosus tendon is often found to have

inadequate diameter as noticed in our study, thus requiring concomitant gracilis harvest with tripling or quadrupling of grafts. In females and chronic ACL deficient knees, one can anticipate further attenuation of hamstring tendons thus potentially compromising graft diameter. Lesser diameter of graft, especially below 7.5mm is known to increase risk of graft rupture and increases revision rate (24). Every 0.5 mm increase in graft diameter from 7 mm to 9 mm has been found to reduce revision rate by 0.82 times and also has a positive correlation with IKDC scores (25).

Since the pioneering study by a Turkish group in 2008, there have been numerous studies exploring the use of peroneus longus tendon as a graft for primary ACL reconstruction (26). Rhatomy *et al.* in their study used peroneus longus graft with tenodesis of the distal stump of peroneus longus to peroneus brevis. They noted the excellent functional outcome of the knee at 2 years follow-up without any significant ankle or foot disability (2). Cao *et al.* conducted a study on 35 patients using peroneus longus as a graft (1). At 15-months of follow-up, their Lysholm score was excellent in 25 patients, good in 6 patients, fair in 3 patients, and poor in 1 patient with an average score of 97.2 (range 60-100). KT-3000 evaluation was normal in 28, near normal in 4, abnormal in 2, and poor in 1. The average AOFAS score was 96.3 which was not statistically significant from preoperative scores. They concluded that peroneus longus is a good substitute for ACL reconstruction with no significant donor site morbidity. Mingguang *et al.* in 2018 compared the functional outcome of patients undergoing arthroscopic ACL reconstruction with the anterior part of peroneus longus and hamstring tendon (5). They concluded that the anterior part of the peroneus longus has a similar functional outcome as that of the hamstring tendon with satisfactory isokinetic muscle power and no donor site morbidity.

Using the peroneus longus tendon as the first choice for primary arthroscopic ACL reconstruction has also attracted skepticism regarding donor site morbidity and its *in vivo* biomechanical performance when compared to hamstring tendon graft. Angthon *et al.* in their study involving 24 patients, reported a significant decrease in isokinetic muscle strength (eversion and inversion) at 7-months follow-up as compared to the contralateral side. They reported the association of ankle instability in the early postoperative period and concluded that peroneus longus autograft is unfavorable for primary use (7). In contrast to these findings, Fu Dong Shi *et al.* found no statistical difference between peroneus longus and hamstring tendon groups while assessing inversion-eversion movements using a robotic dynamometer at 2 years postoperative period (4). Although Angthon *et al.* found inferior eversion muscle strength, interestingly they found no statistically significant donor site morbidity as assessed via American Orthopedic Foot-and-Ankle Society (AOFAS) for ankle-hindfoot score and Visual Analogue Score-Foot Ankle (VAS-FA) at an average 1-year follow-up (7). Similarly, a study on 16 patients conducted by Sasetyo *et al.* found no significant ankle or foot disability in patients undergoing ACL reconstruction with peroneus longus grafting at 6 months postoperative period (3).

Few studies have performed biomechanical tests to compare *in vitro* tensile strengths of hamstring *vs* peroneus longus tendons (4, 27). They have found no significant difference in strengths between the two graft options. Fu Dong Shi *et al.* in 2019 compared the biomechanical properties and functional outcome in patients undergoing arthroscopic ACL reconstruction with doubled peroneus longus tendon and quadrupled hamstring tendon (4). They found that by doubling the peroneus longus tendon, adequate length and thickness of graft could be attained. Whereas hamstring graft had to be quadrupled to achieve the same length and thickness. Also, biomechanically both tendons had similar *in vivo* stability, with no significant ankle donor site morbidity in the peroneus longus group. Concerns regarding the thickness of peroneus longus graft have been assessed in studies that have concluded satisfactory dimensions of graft on doubling or tripling (2, 4).

Some of the systematic reviews and meta-analysis have pointed out important conclusions to these various studies (23, 28). While most studies have found satisfactory clinical outcomes with peroneus longus autograft, there are only few studies which directly compare hamstring graft with peroneus longus graft using standardized tools and outcome measures (23). In such selected studies which compare the grafts, peroneus longus has found to give statistically higher scores of IKDC and Lysholm as compared to hamstring graft. Tegner activity scale has given statistically similar results. These meta-analyses have looked at donor morbidity to foot and ankle in terms of various parameters like AOFAS scores, FADI scores, strength assessment and hop tests. These have concluded that despite some biomechanical studies showing a reduced peak eversion torque, clinical parameters suggest no significant morbidity to foot and ankle (23). While these conclusions project non-inferiority of peroneus longus tendon, they also highlight the need for better studies to generate stronger evidence (28). Most studies have low sample size, lack of appropriate comparison, different grafting techniques (full thickness graft, anterior or posterior partial thickness graft), heterogenous surgical techniques (single bundle *vs* double bundle, anatomical *vs* non anatomical) and varied postop rehab. This heterogeneity potentially creates murkiness in the interpretation of results (23).

Hence, we designed our study as a prospective cohort type to add valuable evidence to this literature. We compared the

difference in the functional outcome of peroneus longus graft to the hamstring graft in 54 subjects over two years, along with the assessment of any donor site morbidity in the peroneus longus group. Our results show comparable functional outcomes in the three scoring systems (IKDC, Modified Cincinnati, and Tegner Lysholm scores) with no statistically significant difference between both groups. This implies that the *in vivo* biomechanical performance of the peroneus longus autograft was comparable to hamstring autograft. The donor site morbidity in the peroneus longus group as assessed using AOFAS and FADI scores, showed that at two-year follow-up patients had excellent ankle function with no residual weakness or functional limitations. None of the patients had any adverse outcomes such as ankle instability, loss of movement, weakness, nerve injury. All patients had resumed back to their pre-injury activities satisfactorily. In addition to this, we made few other important observations in favor of peroneus longus autograft. Firstly, the peroneus longus tendon was technically easier to identify and harvest. Peroneus brevis is deeper and muscular around the region, thus easily differentiating itself from superficial and tendinous peroneus longus. Secondly, the surgical time for harvest of peroneus longus graft was lesser than hamstring graft, which is beneficial economically and otherwise. Lack of fibrous attachments and vincula makes the harvest easier and reliably faster. Thirdly, we found peroneus longus to have a consistently thicker diameter and adequate length in all our cases (harvested graft was consistently between 24- 26 cm in length and after tripling had a diameter between 7.5 to 9 mm). On the contrary, our hamstring grafts commonly required quadrupling, and in most cases, we had to harvest both semitendinosus and gracilis. This prospective cohort study adds strong evidence to the literature in favor of peroneus longus tendon autograft for ACL reconstruction. It disproves notions of donor site morbidity associated with it. We conclude that peroneus longus tendon autograft is non-inferior to hamstring autograft in single bundle arthroscopic ACL reconstructions and it may be considered as one of the first line autografts in primary ACL reconstruction. Our study bears the limitation of being conducted in a single-center catering to the local population with a limited sample size. Multicentric studies with larger sample sizes and longer follow-ups would give stronger evidence and validity to the above conclusions. Our study lacks the inclusion of professional athletes. Studies focusing on clinical outcomes and donor site morbidity in selected athletic populations can throw better light in this regard.

CONCLUSIONS

The results of our study suggest that peroneus longus can be used as one of the first choices of autografts for primary arthroscopic ACL reconstruction.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

SA, AH, BSR, PM, CS: conceptualization, design. SA, AH, BSR, PM, CS, ST, VK: intervention. AH, BSR: supervision. SA, ST, PMD, AN: data collection. AH, PM, CS, ST, VK: results analysis and interpretation. SA, AH, CS, VK, ST, PMD, AN: drafting. All authors: revision results, manuscript approval.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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