Peroneus Longus Tendon Graft as Competent Option for ACL Reconstruction with Two years Follow-up and its Anthropometric Correlation

Choudhary N, MS Orth, **Raghav L,** MS Orth, **Ahmed S,** MS Orth, **Kalra M,** MS Orth, **Ahlawat A,** MBBS

Department of Orthopaedics, Lady Hardinge Medical College, New Delhi, India

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ABSTRACT

Introduction: ACL Reconstruction (ACLR) with various autografts is associated with several complications. Autograft diameter is an important factor contributing to ACLR failure. In this study, we evaluated the long-term functional outcome of the peroneus longus tendon (PLT) graft in primary ACLR and donor site morbidity, and evaluated the correlation of PLT dimensions (length and diameter) with various anthropometric parameters.

Materials and methods: The patient's pre-operative anthropometric data were recorded. Ipsilateral PLT graft was harvested, and the distal part tenodesis done with the peroneus brevis. Graft diameter and length were noted intra-operatively. The Lachmann test, Pivot Shift test, Lysholm II knee score, and AOFAS were recorded at pre-operative, six months, one year, and two years post-operatively. Results with p-values <0.05 were considered significant.

Results: During this study 51 patients were enrolled. Mean graft diameter and length were 7.93mm and 25.71cm, respectively. Mean Lysholm Score was 97.07, and AOFAS was 98.07 at 2 years follow-up. Six patients showed Lachman Grade 1+, and 3 had Pivot shift test positive 1+ at 2 years. A strong positive correlation of graft diameter and length with both patient height (cm) and weight (kg) was observed. But neither graft diameter nor length was significantly correlated with either age or BMI.

Conclusion: PLT autograft demonstrate favourable long-term functional outcome at the knee, minimal donor site morbidity at the ankle. Among anthropometric parameters, height and weight are associated with PLT diameter and length prediction. No association of patient's age and BMI was found with graft diameter and length.

Keywords:
ACL reconstruction, anthropometric relation, AOFAS, peroneus longus tendon graft, Lysholm score

INTRODUCTION

ACLR constitute major proportion of surgery in Sports Injuries. The ideal graft for reconstruction of ACL is biomechanically similar to the native ligament, easily harvested, has the least donor site morbidity, can be secured predictably, and gets well incorporated with bone. Literatures suggest that each graft has associated pros and cons, and the search is still on for an optimal graft[1].

ACLR can be done by Autograft, Allograft, or Synthetic graft. Three autograft options commonly used are bone-patellar tendon-bone (BPTB), Hamstring (HS), and bone quadriceps tendon (BQT)[1]. Allograft has an advantage considering elimination of donor site morbidity, decreased pain, shorter operating and rehabilitation times, and better cosmesis with drawback of higher cost, delayed incorporation, disease transmission and immune reactions[2].

BPTB is still considered the "gold standard" for ACL reconstruction and is frequently chosen because of its excellent clinical results and high level of patient satisfaction in long-term follow-up. But complications like patellar tendon rupture, patellar/tibial fracture, quadriceps weakness, loss of full extension, anterior knee pain, and difficulty in kneeling are seen with the BPTB graft. Hamstring tendon graft is associated with reduced knee flexion strength, sciatic/saphenous nerve palsy, and inferior fixation strength[1].

Some studies advocate the use of the peroneus longus graft (PLT) in ACL reconstruction. The PLT has an important role to strengthen first ray plantarflexion and to evert the foot[3]. PLT has synergistic action with the peroneus brevis, which can offer some advantage if both undergo tenodesis. The diameter of the autograft in ACL reconstruction surgery is an important factor contributing to failure. The exact graft diameter needed to avoid such failure rates is not clear[4]. Every 0.5mm rise in graft diameter found with a reduction in

Corresponding Author: Lokesh Raghav, Department of Orthopaedics, Lady Hardinge Medical College, Shaheed Bhagat Singh Marg, Connaught Place, New Delhi, Delhi 110001, India
Email: lokeshraghav10@gmail.com

chances of re-surgery to 0.8 times with a graft thickness of 7mm to 9mm[5]. Magnussen *et al* stated that the ideal minimum graft diameter of 7mm is best to avoid revision surgery[6]. Hence, predicting the graft diameter in ACLR is important by helping surgeons make comprehensive pre-operative plans and opt for alternative graft choices.

In this study, we have evaluated the functional outcome at two-year follow-up and donor site morbidity efficacy of PLT as a graft for primary ACL reconstruction and its association with anthropometric parameters.

MATERIALS AND METHODS

This study is a prospective cohort type conducted from November 2019 to October 2021 in a tertiary care centre. Diagnosis of ACL tear was established based on clinical examination and MRI. A total of 51 patients with ACL tear between the age group 20 – 50 years with grade V peroneus longus function were enrolled with their written informed consent and followed up for a minimum of two years. Patients with ACL injury due to bony avulsion, any neurological deficit to the lower limb, with meniscal and chondral lesions, and a history of fracture to the ipsilateral knee, foot, and ankle were excluded.

Pre-operative anthropometric data, including gender, height, weight, and BMI, were collected. Lysholm-II knee scoring system for functional assessment of the knee and the AOFAS score to assess donor site morbidity were recorded pre-operatively, at six months, one year, and two years post-operatively.

Under spinal anaesthesia, in supine position with tourniquet in the thigh, diagnostic knee arthroscopy was done for ACL rupture, followed by ipsilateral PLT graft harvest. A vertical incision was made 2 – 3cm above and 1cm posterior to the lateral malleoli and was extended distally. Soft tissue dissection was done, and PLT was exposed on its posterolateral surface through the incision after carefully incising the fascia. Beneath that peroneus brevis tendon was found.

After everting the foot, the peroneus longus tendon was secured with polyester suture no 5. The distal part of the peroneus longus tendon was sutured with the peroneus brevis tendon using polyglactin suture no 2. The peroneus longus tendon graft was harvested using a tendon stripper till 4cm below the fibular head to avoid peroneal nerve injury. Length of the graft was noted. Pre-tensioning of the harvested graft was done on a tendon board. The graft was then looped to constitute a double or triple graft as per diameter and length of the graft.

Incision was closed using absorbable subcutaneous sutures and staples. Pre-tensioning of the harvested graft was done on a tendon board. Femoral fixation device was attached to one end of the graft. Graft was passed through cylindrical sizers to determine the exact diameter of the graft to be matched with the needed femoral and tibial tunnels. Standard AM and AL portals were made. Arthroscopic shaving of the remnants of the torn ACL and a notchplasty, if required, was done. The femoral and tibial tunnels were drilled independently, and ACL reconstruction was done by tripled PLT graft. An effort was made to seat at least 25mm of graft into the femoral tunnel. The femoral end of the graft was fixed with Endobutton. The tibial graft site was then fixed under tension at 30° flexion of the knee joint using an interference screw (bioabsorbable).

For rehabilitation, the patients were allowed to bear weight as soon as they came out of spinal anaesthesia, but this was protected with crutches for the first two weeks. A tolerable range of motion was encouraged, while avoiding hyperextension. Knee flexion was started from 0 – 90° (gradually increased) in three weeks, and further flexion was subsequently achieved. Closed-chain activities were started at an early stage, and open-chain exercises were introduced at three months. Sport-specific training was allowed starting at six months, with the gradual introduction of cutting movements. Return to contact sports was delayed for a minimum of 9 to 12 months.

Post-operatively Functional outcome was measured by using the LYSHOLM II knee scoring, and donor site morbidity was assessed by using the AOFAS scoring at six months, one year, and two years follow-up.

Statistical analysis was performed using the SPSS statistical package [version 17.0; SPSS Inc., Chicago, IL, USA]. Continuous variables, including Lysholm II score and AOFAS score values over time within the groups, were analysed using repeated measures analysis of variance (ANOVA) followed by Bonferroni's post hoc testing. Values were given as mean (SD), frequency, and percentages. For the anthropometric correlation of graft, CI (Confidence Interval), with Spearman Correlation Coefficient (rho)is given. A p-value of <0.05 was considered statistically significant

RESULTS

A prospective evaluation of early results following arthroscopic anterior cruciate ligament (ACL) reconstruction using the peroneus longus tendon autograft was conducted in 51 patients (39 males, 12 females) between November 2019 and October 2021. The mean patient age was 35 years, with an average height of 166.31 cm. The mean graft diameter and length were 7.93 mm and 25.71 cm, respectively (Table I). The mean Lysholm Score improved from a pre-operative value of 51.43 to 97.07 at two years post-operatively (Table II). The mean AOFAS score decreased from a pre-operative

Table I: Subject characteristics.

	Mean ± SD	Range	N
Age (yr)	35.37 ± 7.54	23 – 48	
Sex			
Male			39
Female			12
Height (cm)	166.31 ± 8.02	155 – 186	
Graft Thickness (mm)	7.93 ± 0.55	6.5 – 9	
Graft length (cm)	25.71 ± 1.90	22 – 30	

Table II: Knee functional outcome scoring.

Timepoint	Lysholm Score		p-value
	Mean (SD)	Range	
Pre-operative	51.43 (7.37)	36.00 – 67.00	<0.001
Six months	84.76 (5.27)	74.00 – 94.00	
One year	90.90 (3.63)	83.00 – 97.00	
Two years	97.07 (4.53)	92.00 – 98.00	

Note - *Paired t-test

Table III: Donar site morbidity scoring.

Timepoint	AOFAS score		p-value
	Mean (SD)	Range	
Pre-operative	100.00 (0.00)	100.00 - 100.00	<0.001
Six months	91.59 (4.45)	80.00 - 100.00	
One year	96.08 (2.66)	90.00 - 100.00	
Two years	98.07(2.92)	91.00 - 100.00	

Table IV: Lachman test.

Indicator	Pre-operative	Six months	One year	Two years
Grade 0 (1 – 2mm)	0	45 (88.2%)	44 (86.2%)	45 (88.2%)
Grade 1 (3 – 5mm)	0	6 (11.7%)	7 (13.7%)	6 (11.7%)
Grade 2 (6 – 10mm)	27 (53.0%)	0	0	0
Grade 3 (>10mm)	24 (47.0%)	0	0	0

Table V: Pivot shift test.

Indicator	Pre-operative	Six months	One year	Two years
Negative (EQUAL)	24 (47.0%)	48 (94.1%)	48 (96.0%)	48 (94.0%)
1+ (GLIDE)	9 (17.6%)	3 (3.9%)	3(3.9%)	3 (3.9%)
2+ (CLUNK)	12 (23.5%)	0	0	0
3+ (GROSS)	6 (11.7%)	0	0	0

Table VI: Anthropometric correlation with graft diameter and graft length.

Variable	Graft Diameter			Graft Length		
	Spearman Coefficient Correlation (rho)	95 % CI	p-value	Spearman Coefficient Correlation (rho)	95% CI	p-value
Height	0.66	0.45 to 0.80	<0.001	0.55	0.3 to 0.73	<0.001
Weight	0.59	0.35 to 0.75	<0.001	0.44	0.17 to 0.65	<0.001
Age	0.04	-0.24 to 0.31	0.807	0.06	-0.22 to 0.33	0.668
BMI	-0.15	-0.41 to 0.13	0.287	-0.31	-0.54 to -0.03	0.027

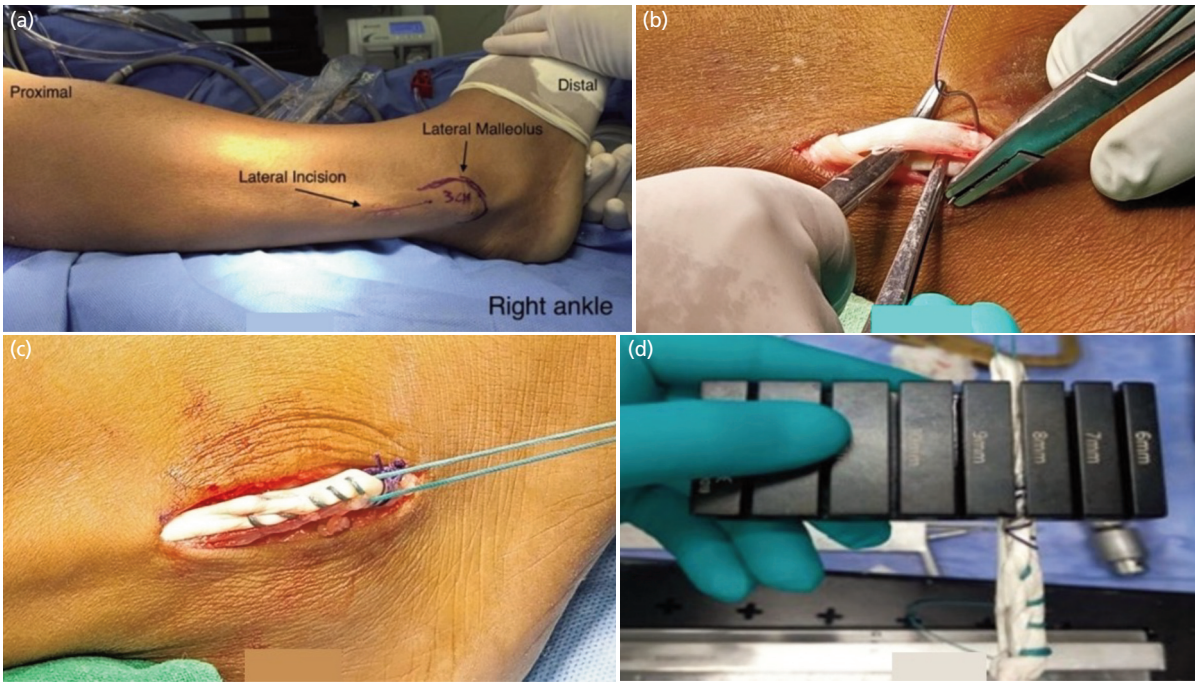

Fig. 1: (a) Position of harvesting of PLT graft, (b) PLT identified and tagged, (c) distal part of PLT secured with Peroneus brevis, (d) measuring PLT graft diameter.

maximum of 100.00 to a minimum of 91.59 at six months, then increased to 98.07 at two years (Table III). Six patients exhibited a Grade 1 positive Lachman test at two years, and among them, three also demonstrated a 1+ positive Pivot Shift test (Tables IV and V). A strong positive correlation was observed between graft diameter and both height ($\rho = 0.66$, $p < 0.001$) and weight ($\rho = 0.59$, $p < 0.001$). Similarly, graft length showed a strong positive correlation with height ($\rho = 0.55$, $p < 0.001$) and weight ($\rho = 0.44$, $p < 0.001$). No significant correlation was found between graft diameter or length and either age or BMI (Table VI).

DISCUSSION

ACL injuries are one of the most common knee injuries with a need for satisfactory reconstruction. ACL reconstruction with BPTB autograft produced good clinical results[2]. Another graft of consideration, HT is seen with lower donor site morbidity compared to BPTB in terms of anterior knee pain, extension loss with similar functional outcome, and post-operative knee stability[7,8]. But HT graft possesses a longer healing and graft integration time within the bone tunnel because of the absence of bone plugs at the ends of the graft and tunnel widening[9], but Rahardja *et al* found statistically insignificant knee pain or symptoms in BPTB autograft W.R.T HT, except for kneeling difficulty[10]. Marques *et al* also reported knee pain as multifactorial, not solely due to graft donor site morbidity[11].

To avoid these complications, we chose the PLT graft for ACL reconstruction and studied knee function for graft effectiveness and ankle function for donor site morbidity. Native ACL has an ultimate tensile load of 2020 ± 264 N. However, peroneus longus tendon has an ultimate tension load of 4268 N, making it one of the effective alternatives to ACL[12].

Rhatomy *et al* and Mostafa *et al* compared the graft thickness of hamstring and peroneus and concluded that there was a mean difference of 0.6mm and 1.28mm in favour of peroneus longus graft[13,14]. Ho *et al* showed a strong and significant relationship for the determination of pre-operative factors in the form of anthropometric data for HT graft diameter prediction[15]. By Song *et al*, height, weight, and duration of injury were found to be important pre-operative predictors for the diameter of PLT graft[16]. In this study, we found that anthropometric parameters of gender, height, and weight were significantly associated with the PLT graft diameter.

In our study, the mean graft diameter on tripling was 7.93mm (ranging from 6.5mm to 9.0mm); this is considered an optimum size and is associated with less re-rupture and revision rate[11]. In males, the mean graft diameter was 8.12 ± 0.42mm, and in females, it was 7.33 ± 0.49mm, showing a significant difference between gender and graft diameter ($W = 418.500$, $p = <0.001$). However, all other anthropometric parameters, like age, weight, and height, were also lower in females. So direct gender-based association can't be identified. In one female patient, very short stature had the minimum graft diameter of 6.5mm, which is less than the recommended diameter. To avoid re-rupture and revision rate

in the above-mentioned patient, we had done an HT graft augmentation along with the PLT graft.

There was a strong positive correlation between Graft Diameter (mm) and both Height (cm) and Weight, and this correlation was statistically significant (Table VI). For every 1 unit increase in Height (cm) and Weight (Kg), the Graft Diameter (mm) increases by 0.05 units. No statistically significant correlation for Graft Diameter was found with Age (rho = 0.04, p = 0.807). and BMI (rho = -0.15, p = 0.287).

Joshi *et al* found 21cm as the minimum graft length that is required when cortical button is used as a femoral fixation[17]. In our study, the mean length of autograft was 25.71 ± 1.90cm; 26.13 ± 1.70 in males and 24.33 ± 1.91 in females, showing a significant difference between gender and graft diameter (W = 358.500, p = 0.006). This gives us an extra edge while reconstructing ACL using a bilateral bioabsorbable screw.

There was a strong positive correlation between Graft length (cm) with both Height (cm) and Weight (Kg), and this correlation was statistically significant (Table VI). For every 1 unit increase in Height (cm) and Weight (Kg), the Graft length (cm) increases by 0.16 units and 0.12 units, respectively. Sakti *et al* and Soney *et al* also found body height and weight to be significantly directly correlated with PLT diameter and length[18,19]. Khan *et al* found height as best predictor for PLT diameter[20]. No statistically significant correlation for Graft length was found with Age (rho = 0.06, p = 0.668). and BMI (rho = -0.31, p = 0.027), similar to Soney *et al*[19].

While harvesting the autograft for ACL reconstruction, donor site morbidity is always an important consideration. Anterior kneeling pain was also found in about 31% of patients after BTPB grafts, get lower down to 6% in hamstring tendon harvesting[1,7]. This symptom is still a concern. In our study, we used an ipsilateral PLT autograft, and it was not associated with complications such as kneeling pain, weak flexion and extension at the knee joint, thigh hypotrophy. Kerimoğlu *et al* reported a deficit in plantar flexion of the first ray of the foot after harvesting PLT[21]. They reported functional deteriorations of push off during the stance phase. However, this push-off strength of the first ray is significant for athletes, and as our study consisted of nonathletes, there was no such complication in any of the patients.

In our study, we used AOFAS score to deduce the ankle functional outcome, and it had a mean score of 91.59 ± 4.45 at 6 months and improved up to a mean score of 98.07 ± 2.92 at 2 years, which was similar to Rhatomy *et al*. In their study, the mean FADI score of 99.71 ± 0.57 and the mean AOFAS score of 98.71 ± 3.03 at the donor site were considered as excellent results[3]. In a study by Angthong *et al*, FADI and AOFAS scores were similar[22]. Zhao and Huangfu also reported that there were no ankle or foot injuries experienced by patients after peroneus longus tendon harvest[23].

This shows that the function of the donor ankle was excellent after harvesting the peroneus longus tendon. This is probably because the peroneus brevis is still intact in the donor ankle. Peroneus brevis is a more effective evertor of the ankle, which will maintain the eversion function of the ankle after harvesting the peroneus longus tendon[24,25].

ACL reconstruction with peroneus longus autograft showed good results, in terms of functional outcome and knee stability[8]. A systematic review by Quinn *et al* and a narrative review by Viswanathan *et al* also support this by comparison with the hamstring tendon[26,27]. Rhatomy *et al* compared hamstring with PLT autograft and did not find any significant difference between the two in one year follow-up. Although considered only a functional outcome, the mean Lysholm II was 94.9 ± 5.6[13].

In our study, the mean pre-operative Lysholm II score was 51.43 + 7.3, which improved to a mean value of 84.76 + 5.2, 90.90 + 3.6, and 97.07 + 4.5 post-operatively at 6 months, 1 year, and 2 years. The difference in pre-operative and post-operative Lysholm II score was statistically significant with a p-value <0.001.

In a study by Laxdal *et al*, the mean Lysholm II Knee Score pre-operatively was 70 (14 – 95), and post-operatively, it was 95, which is similar to our study[28].

Autograft choice is one of the most important considerations during ACL reconstruction surgery. In our study, we found comparable results with the peroneus longus autograft at two years of follow-up. It also has the advantage of a larger graft diameter, simplicity of technique, and minimal donor site morbidity. Complications associated with hamstring graft, like thigh hypotrophy, anterior knee pain, hypoesthesia due to injury to the infrapatellar branch of the saphenous nerve, can be prevented[29].

However, a small cohort, use of subjective score for knee and ankle assessment, lack of control group, and no differentiation of functional outcome between athletes and the normal population are the limitations of the study. A regression equation for the influence of anthropometric features on PLT graft diameter prediction could not be established because of the small sample size. Further need for objective scoring, longer follow-up with a larger sample size is there.

CONCLUSION

Arthroscopic ACL reconstruction using Peroneus longus tendon autograft results in favourable functional outcome in knee, minimal donor site morbidity at ankle. Among the anthropometric parameters, Gender, height, and weight are the anthropometric parameters associated with PLT diameter and length prediction. No association of patient's age and BMI was found with graft diameter and graft length. These can be used to identify those patients with a high risk of inadequate graft size and to provide important pre-operative information for the surgeon.

CONFLICT OF INTEREST

Authors have no conflicts of interest.

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