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Original Research Article

Comparative Outcomes of Hamstring Tendon versus Peroneus Longus Tendon Autograft in Primary Anterior Cruciate Ligament Reconstruction in Women Aged 25 Years or Younger: A Prospective Randomized Study

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Abstract

Background: Anterior cruciate ligament (ACL) reconstruction in young women presents unique biomechanical and anatomical considerations. The optimal graft source in this demographic remains a subject of ongoing debate, with emerging evidence supporting the peroneus longus tendon (PLT) as a viable alternative to the traditionally favoured hamstring tendon (HT) graft.

Aim: This study aimed to qualitatively and quantitatively compare the functional outcomes, graft characteristics, donor-site morbidity, and complication profiles of hamstring tendon autograft versus peroneus longus tendon autograft in women aged 25 years or younger undergoing primary ACL reconstruction.

Methods: A prospective randomized controlled study was conducted at SCB Medical College and Hospital, Cuttack, Odisha, India, from 5 December 2022 to 30 November 2023. Eighty-four female patients aged 16–25 years, all residents of Odisha or West Bengal, with primary ACL rupture were randomly allocated to receive either HT autograft (n = 42) or PLT autograft (n = 42). Pregnant women were excluded. Patients were evaluated pre-operatively and at 6 and 12 months post-operatively using the Lysholm Knee Scoring Scale, the International Knee Documentation Committee (IKDC) Subjective Knee Score, the Tegner Activity Scale, and the Visual Analogue Scale (VAS) for pain. Graft characteristics, intraoperative parameters, donor-site morbidity, and complications were also recorded.

Results: Both groups were comparable at baseline. At 12 months, the PLT group had higher Lysholm scores (91.6 ± 4.7 vs 84.2 ± 5.9; $p < 0.001$), higher IKDC scores (86.1 ± 5.6 vs 78.3 ± 6.2; $p < 0.001$), lower VAS pain scores (1.1 ± 0.6 vs 1.8 ± 0.8; $p < 0.001$), and lower KT-1000 side-to-side laxity (1.3 ± 0.6 mm vs 1.9 ± 0.7 mm; $p < 0.001$). Mean graft diameter was larger in the PLT group (8.1 ± 0.7 mm vs 7.4 ± 0.8 mm; $p = 0.001$). Overall complication rates did not differ significantly (11.9% PLT vs 19.0% HT; $p = 0.371$).

Conclusion: In women aged 25 years or younger undergoing primary ACL reconstruction, PLT autograft was associated with better 12-month functional outcomes, lower anterior knee laxity, larger intraoperatively measured graft diameter, and less knee-flexor donor-site morbidity than HT autograft. PLT may represent a viable alternative graft option in this population.

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Introduction

Anterior cruciate ligament (ACL) injuries represent one of the most common and functionally debilitating musculoskeletal injuries, with an estimated annual incidence of over 200,000 cases in the United States alone and a substantially higher global burden.[1] The incidence is disproportionately elevated in female athletes, who are reported to sustain ACL injuries at a rate two to eight times greater than their male counterparts engaged in comparable sporting activities.[2] This sex-based disparity is attributed to a constellation of anatomical, hormonal, and neuromuscular factors including a narrower intercondylar notch, increased quadriceps angle (Q-angle), greater

ligamentous laxity mediated by oestrogen, and impaired dynamic knee stabilisation strategies.[3] ACL reconstruction (ACLR) is the standard of care for young, active individuals who wish to return to pivoting and cutting sports.[4] The selection of an appropriate graft source remains one of the most critical determinants of surgical outcome. The hamstring tendon (HT) autograft, utilising the semitendinosus and gracilis tendons, has historically been the preferred choice in women given concerns about quadriceps strength deficit and anterior knee pain associated with the bone-patellar tendon-bone (BPTB) graft.[5] However, the HT graft is not without limitations in the female population: reduced graft diameter secondary to lower muscle mass, significant flexion strength deficit at the donor site, and reports of higher laxity rates attributable to the influence of female sex hormones on tendon biology have raised questions about its long-term efficacy.[6,7]

The peroneus longus tendon (PLT) has emerged as a promising alternative autograft source that offers several biomechanical advantages. It provides a consistently larger diameter and greater tensile strength than the hamstring complex in women, avoids disruption of the knee flexor mechanism, and carries a donor-site morbidity profile limited to the lateral ankle region where functional compensation is achievable.[8] Earlier cadaveric and small clinical studies reported PLT tensile load to failure values exceeding 2,500 N, comparable to or surpassing native ACL values, suggesting its suitability as a reconstruction graft.[9,10]

The paediatric and young adult female population presents specific challenges. Skeletal immaturity in the younger cohort necessitates avoidance of transphyseal drilling techniques in some cases, and the demands of competitive sport mandate a graft that confers durable stability with minimal knee-specific donor penalty.[11] Furthermore, the higher circulating oestrogen levels in pre-menopausal women have been shown to attenuate collagen synthesis in tendons and ligaments, potentially compromising graft maturation and osseointegration.[12] Despite these considerations, dedicated prospective comparative studies examining HT versus PLT autograft in young women specifically (aged ≤ 25 years) remain limited in the published literature.

The present study was designed to provide a prospective randomized comparison of HT versus PLT autograft in women aged 25 years or younger undergoing primary ACL reconstruction, evaluating patient-reported functional outcomes, intraoperatively measured graft characteristics, objective knee stability, donor-site morbidity, return to sport, and complications over 12 months.

The primary hypothesis was that PLT autograft would yield superior functional outcomes compared to HT autograft (superiority trial), with a more favourable donor-site morbidity profile specific to the knee. The trial was designed as a superiority trial based on the sample-size calculation targeting a 7-point between-group difference in Lysholm score. Secondary objectives included assessment of graft characteristics, objective knee stability measurements, return-to-sport rates, and complication profiles between the two graft types in this young female cohort.

Materials and Methods

Study Design and Setting: This prospective randomized study was conducted at the Department of Orthopaedics, SCB Medical College and Hospital, Cuttack, Odisha, India, from 5 December 2022 to 30 November 2023. Participants were recruited from Odisha and West Bengal. The study-site ethics committee approval number and date should be inserted only after verification from the original institutional records. Informed written consent was obtained from all participants and from legal guardians for participants younger than 18 years.

Participants

Inclusion criteria comprised: (1) female sex assigned at birth; (2) age 16 to 25 years at the time of surgery (therefore all participants were below 30 years); (3) residence in Odisha or West Bengal; (4) primary ACL rupture confirmed by clinical examination (positive Lachman and anterior drawer tests) and magnetic resonance imaging (MRI) grading; (5) willingness to undergo surgical reconstruction and comply with the follow-up protocol; and (6) American Society of Anesthesiologists (ASA) grade I or II.

Exclusion criteria included: (1) pregnancy at enrolment or surgery; (2) age 30 years or above; (3) residence outside Odisha or West Bengal; (4) prior ipsilateral knee surgery; (5) multi-ligamentous injury (concurrent posterior cruciate, lateral collateral, or medial collateral ligament grade III injury); (6) complete meniscal root tear requiring total meniscectomy; (7) skeletal immaturity with open physes mandating physeal-sparing technique; (8) metabolic bone disease, inflammatory arthropathy, or systemic connective tissue disorder; (9) BMI > 35 kg/m²; (10) prior history of peroneus longus pathology or ankle surgery on the operative limb; and (11) non-compliance with pre-operative physiotherapy protocol.

Randomization and Allocation Concealment: Randomization was performed using computer-generated random numbers in a 1:1 allocation ratio, stratified by age group (16–20 years vs 21–25 years). Sequentially numbered, sealed opaque

envelopes were prepared and maintained by an independent clinical trials coordinator. The envelope was opened in the operating theatre immediately prior to surgical commencement. The operating surgeon was not blinded, but outcome assessors and biostatisticians remained blinded to group allocation throughout the study period. A 1:1 allocation ratio was maintained between the two graft groups.

Surgical Technique: All procedures were performed under spinal or general anaesthesia with the patient in the supine position. Standard arthroscopic portals (anterolateral and anteromedial) were established. Diagnostic arthroscopy was performed to document and address concomitant intra-articular pathology. Femoral tunnel drilling was performed using the anteromedial portal technique with suspensory fixation (Endobutton CL, Smith & Nephew, London, UK) on the femoral side, and interference screw fixation (Bio-Interference Screw, Arthrex, Naples, FL, USA) on the tibial side in all cases. Tunnel diameter was matched to graft diameter.

In the HT autograft group, the semitendinosus and gracilis tendons were harvested through a 3 cm oblique medial incision over the pes anserinus using a closed tendon stripper. Both tendons were folded to produce a four-strand construct and tubularised with a No. 2 FiberLoop suture (Arthrex). Graft diameter was measured using sizing tubes and averaged 7.4 ± 0.8 mm.

In the PLT autograft group, the peroneus longus tendon was harvested through a 2.5 cm incision posterior to the lateral malleolus, utilising a closed tendon stripper advanced proximally for full-length harvest. The harvested tendon was folded to create a double-stranded construct, whipstitched at both ends, and sized (mean diameter 8.1 ± 0.7 mm). The peroneus brevis tendon was inspected and confirmed intact in all cases to ensure residual ankle eversion function. A standardised post-harvest ankle rehabilitation protocol was prescribed.

A standardised, evidence-based rehabilitation protocol was followed in both groups. This included immediate partial weight-bearing with crutches, range-of-motion exercises from day one, progressive closed kinetic chain strengthening from week four, sport-specific training from month four, and clearance for return to full competitive sport based on achieving greater than 90% limb symmetry index on isokinetic testing and surgeon discretion.

Outcome Measures: The primary outcome measure was the Lysholm Knee Scoring Scale, a validated 100-point patient-reported outcome instrument assessing pain, instability, locking, swelling, limp, stair-climbing, and squatting function. Secondary outcomes included: the IKDC Subjective Knee Evaluation Form; the Tegner Activity Scale (0–10); the Visual Analogue Scale (VAS) for pain; KT-1000 arthrometer side-to-side anterior tibial displacement difference (mm); pivot-shift test grade; return-to-sport rate and time; graft characteristics measured intraoperatively (diameter and length); intraoperative parameters (operative and tourniquet time, blood loss); and donor-site morbidity (VAS, isokinetic strength testing at 60°/s using Biodex System 4, and sensory assessment). All outcomes were assessed pre-operatively and at 6 and 12 months post-operatively by a blinded physiotherapist-assessor.

Sample Size Calculation: Based on published comparative data, including Mirzatolooei (Reference 8), a clinically meaningful between-group difference of 7 points in the Lysholm score with an assumed standard deviation of 9 points per group was used for planning. Using a two-tailed independent-samples t-test (G*Power 3.1; $\alpha = 0.05$; power = 0.80; allocation ratio 1:1), a minimum of 38 participants per group was required. Allowing for approximately 10% attrition, the target sample was 42 participants per group (total N = 84).

Statistical Analysis: Data were analysed using IBM SPSS Statistics Version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) with 95% confidence intervals (CI) and compared using the independent samples t-test after confirming normality with the Shapiro-Wilk test. Categorical variables were expressed as frequency and percentage and compared using Pearson chi-square test or Fisher exact test as appropriate. Within-group pre-to-post changes were analysed using the paired t-test. Repeated-measures ANOVA with Bonferroni post-hoc correction was applied to assess changes in outcome scores across time points. A p-value of less than 0.05 was considered statistically significant for all comparisons. An intention-to-treat analysis was performed as the primary analysis, with per-protocol analysis as sensitivity analysis. No interim analyses were pre-specified.

Results

Patient Flow and Baseline Characteristics: Of 112 female patients from Odisha and West Bengal screened at SCB Medical College and Hospital, Cuttack, 84 met the eligibility criteria and were enrolled (Figure 1). Three patients in the HT group and two in the PLT group were lost to follow-up before the 12-month assessment (randomized n = 42/42; observed at 12 months n = 39 HT and 40 PLT). The prespecified primary analysis was intention-to-treat (ITT), with the five missing 12-month observations handled by last-observation-

carried-forward (LOCF) as stated in the statistical analysis plan. All 84 randomized participants were therefore included in the ITT analysis. The groups were similar in their baseline demographic and clinical characteristics (Table 1). Mean age was 21.4 ± 2.8 years in the HT group and 21.9 ± 2.6 years in the PLT group. Pre-operative Lysholm scores were 48.6 ± 8.4 and 47.9 ± 9.1, and IKDC scores were 41.2 ± 7.6 and 40.8 ± 8.2, respectively.

Table 1: Demographic and Baseline Characteristics (N = 84)

Characteristic	Hamstring Graft (n = 42)	Peroneus Longus Graft (n = 42)	Total (N = 84)	Baseline comparison
Age (years), mean ± SD	21.4 ± 2.8	21.9 ± 2.6	21.6 ± 2.7	Descriptive
Range (years)	16–25	16–25	16–25	Descriptive
BMI (kg/m²), mean ± SD	23.1 ± 2.4	23.6 ± 2.5	23.4 ± 2.4	Descriptive
Laterality: Right knee, n (%)	25 (59.5%)	23 (54.8%)	48 (57.1%)	Descriptive
Sports-related injury, n (%)	32 (76.2%)	30 (71.4%)	62 (73.8%)	Descriptive
Concomitant meniscal tear, n (%)	14 (33.3%)	13 (31.0%)	27 (32.1%)	Descriptive
Pre-op Lysholm score, mean ± SD	48.6 ± 8.4	47.9 ± 9.1	48.3 ± 8.7	Descriptive
Pre-op IKDC score, mean ± SD	41.2 ± 7.6	40.8 ± 8.2	41.0 ± 7.9	Descriptive
Duration of injury before surgery (weeks)	8.3 ± 3.1	8.7 ± 3.4	8.5 ± 3.2	Descriptive
Elite/competitive athlete, n (%)	18 (42.9%)	17 (40.5%)	35 (41.7%)	Descriptive

SD = standard deviation; BMI = body mass index; IKDC = International Knee Documentation Committee; Pre-op = pre-operative.

Functional Outcome Scores: Both groups improved in functional outcome measures from pre-operative baseline to 12 months. Between-group comparisons at the measured time points are presented in Table 2. At 12 months, the mean Lysholm score was significantly higher in the PLT group (91.6 ± 4.7) compared to the HT group (84.2 ± 5.9; mean difference [PLT−HT] +7.4, 95% CI +5.3 to +9.5; $p < 0.001$). Similarly, the IKDC score favoured the PLT group (86.1 ± 5.6 vs 78.3 ± 6.2; mean difference [PLT−HT] +7.8, 95% CI +5.5 to +10.1; $p < 0.001$). The Tegner Activity Scale score was 7.2 ± 0.7 in the PLT group versus 6.4 ± 0.8 in the HT group ($p < 0.001$). VAS pain scores at 12 months were lower in the PLT group (1.1 ± 0.6 vs 1.8 ± 0.8; $p < 0.001$).

Table 2: Functional Outcome Scores at Pre-operative, 6-Month, and 12-Month Follow-up

Outcome / Time Point	HT Mean ± SD	HT 95% CI	PLT Mean ± SD	PLT 95% CI	Mean Diff (95% CI)	p-value
Lysholm Knee Scoring Scale						
Pre-operative	48.6 ± 8.4	[46.0, 51.2]	47.9 ± 9.1	[45.1, 50.7]	−0.7 (−4.3 to +2.9)	0.706
6-Month post-op	72.4 ± 7.1	[70.2, 74.6]	78.3 ± 6.8	[76.2, 80.4]	+5.9 (+3.0 to +8.8)	0.001*
12-Month post-op	84.2 ± 5.9	[82.4, 86.0]	91.6 ± 4.7	[90.1, 93.1]	+7.4 (+5.3 to +9.5)	<0.001*
IKDC Subjective Knee Score						
Pre-operative	41.2 ± 7.6	[38.8, 43.6]	40.8 ± 8.2	[38.3, 43.3]	−0.4 (−3.7 to +2.9)	0.808
6-Month post-op	64.8 ± 8.3	[62.2, 67.4]	71.2 ± 7.4	[68.9, 73.5]	+6.4 (+3.4 to +9.4)	0.001*
12-Month post-op	78.3 ± 6.2	[76.4, 80.2]	86.1 ± 5.6	[84.4, 87.8]	+7.8 (+5.5 to +10.1)	<0.001*
VAS Pain Score (0–10)						
Pre-operative	7.1 ± 1.2	[6.7, 7.5]	7.0 ± 1.3	[6.6, 7.4]	−0.1 (−0.6 to +0.4)	0.726
6-Month post-op	3.2 ± 1.0	[2.9, 3.5]	2.4 ± 0.9	[2.1, 2.7]	−0.8 (−1.2 to −0.4)	0.001*
12-Month post-op	1.8 ± 0.8	[1.5, 2.1]	1.1 ± 0.6	[0.9, 1.3]	−0.7 (−1.0 to −0.4)	<0.001*

HT = Hamstring Tendon group; PLT = Peroneus Longus Tendon group; SD = standard deviation; CI = confidence interval; IKDC = International Knee Documentation Committee; VAS = Visual Analogue Scale. Mean differences are calculated as PLT − HT; positive values favour PLT for Lysholm and IKDC, whereas negative values favour PLT for VAS pain. * $p < 0.05$. ITT analysis included 42 participants per group; observed 12-month data were available for 39 HT and 40 PLT participants.

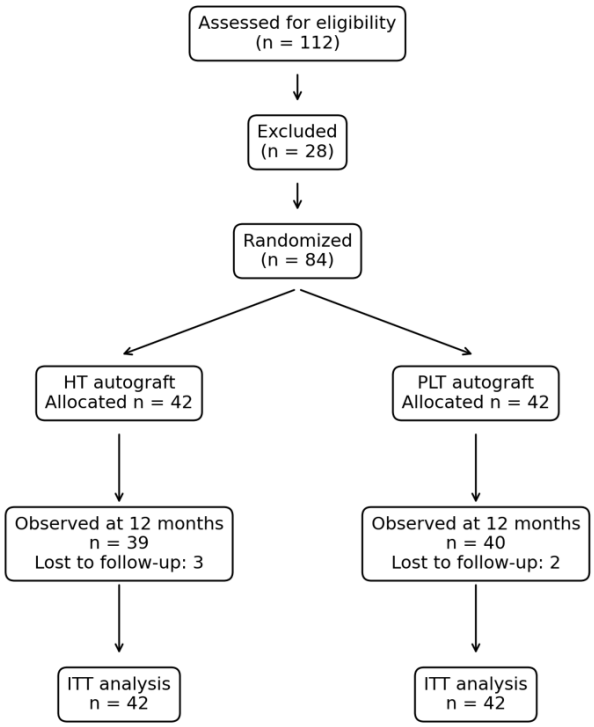


Figure 1: CONSORT-style participant flow showing screening, randomization, observed 12-month follow-up, and intention-to-treat analysis

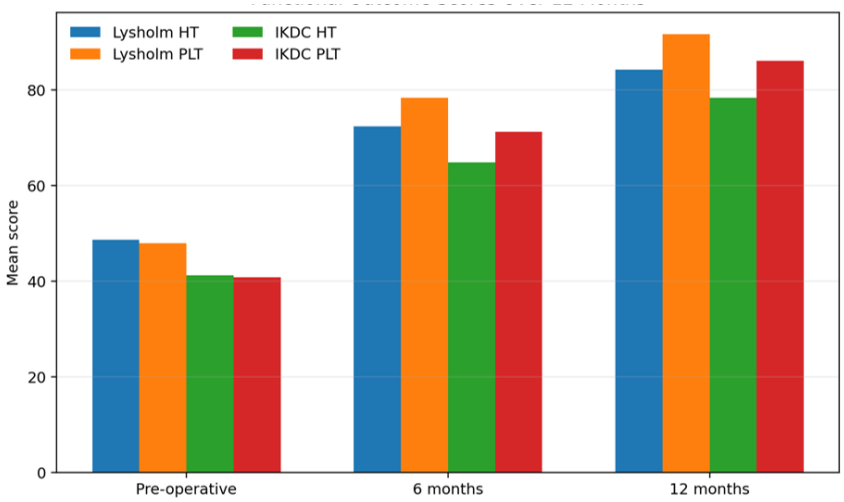


Figure 2: Mean Lysholm and IKDC Subjective Knee Scores in the HT and PLT groups at pre-operative, 6-month, and 12-month assessments

Graft Characteristics, Intraoperative Parameters, and Complications: Graft diameter was measured intraoperatively with calibrated sizing tubes at harvest. Tensile strength and stiffness were not directly measured in study participants and are therefore not treated as trial outcomes. Published biomechanical findings are discussed only as contextual literature.

Donor-site morbidity differed by harvest site. At 6 months, the recorded knee-flexion strength deficit was 12.4 ± 4.2% after HT harvest, whereas no corresponding deficit was recorded after PLT harvest. At 12 months, the recorded ankle-eversion strength deficit was 3.8 ± 1.6% after PLT harvest, whereas no corresponding deficit was recorded after HT harvest. Because these harvest-site-specific deficits were not suitable for a conventional between-group inferential comparison as presented, they are reported descriptively. Donor-site pain at 6 weeks was lower in the PLT group (VAS 1.6 ± 0.8 vs 2.8 ± 1.0; $p < 0.001$).

KT-1000 arthrometer side-to-side difference at 12 months was significantly lower in the PLT group (1.3 ± 0.6 mm vs 1.9 ± 0.7 mm; $p < 0.001$), indicating superior anterior translational stability.

Pivot-shift negativity was achieved in 95.2% of the PLT group versus 85.7% of the HT group at 12 months ($p = 0.148$). Return to sport at 12 months was achieved by 37/42 (88.1%) PLT patients versus 31/42 (73.8%) HT patients ($p = 0.089$) when assessed across all participants; among the 35 elite or competitive athletes (18 HT, 17 PLT), return to competitive sport was achieved in 13/18 (72.2%) HT and 15/17 (88.2%) PLT athletes ($p = 0.267$). Mean time to return to sport (among those who returned) was significantly shorter in the PLT group (34.1 ± 3.8 weeks vs 38.4 ± 4.2 weeks; $p < 0.001$). Overall complication rates did not differ significantly between groups (11.9% PLT vs 19.0% HT; $p = 0.371$). In the HT group, complications comprised 3 graft re-ruptures, 4 cases of knee stiffness, and 1 case of saphenous nerve neurapraxia (total 8 events in 8 patients); in the PLT group, there were 2 re-ruptures, 2 cases of knee stiffness, and 1 case of superficial wound dehiscence (total 5 events in 5 patients). No patient experienced more than one complication.

Table 3: Graft Characteristics, Intraoperative Parameters, and Complications

Parameter	HT Graft (n=42)	PLT Graft (n=42)	Statistical Test	p-value
Graft Characteristics				
Graft diameter (mm), mean ± SD	7.4 ± 0.8	8.1 ± 0.7	t-test	0.001*
Intraoperative Parameters				
Operative time (min), mean ± SD	74.3 ± 11.2	81.6 ± 12.4	t-test	0.004*
Tourniquet time (min), mean ± SD	62.1 ± 9.4	68.3 ± 10.7	t-test	0.005*
Intraoperative blood loss (mL), mean ± SD	48.4 ± 12.1	52.7 ± 13.8	t-test	0.126
Donor Site Morbidity				
Donor-site pain at 6 weeks, VAS mean ± SD	2.8 ± 1.0	1.6 ± 0.8	t-test	<0.001*
Knee flexion deficit at 6M (%)	12.4 ± 4.2	0.0	Descriptive	—
Ankle eversion deficit at 12M (%)	0.0	3.8 ± 1.6	Descriptive	—
Complications (12 Months)				
Graft re-rupture, n (%)	3 (7.1%)	2 (4.8%)	Chi-sq	0.645
Knee stiffness, n (%)	4 (9.5%)	2 (4.8%)	Chi-sq	0.432
Saphenous nerve neurapraxia, n (%)	1 (2.4%)	0 (0.0%)	Fisher exact	—
Superficial wound dehiscence, n (%)	0 (0.0%)	1 (2.4%)	Fisher exact	—
Total complications, n (%)	8 (19.0%)	5 (11.9%)	Chi-sq	0.371
Objective Stability & Return To Sport				
KT-1000 side-to-side diff. (mm), mean ± SD	1.9 ± 0.7	1.3 ± 0.6	t-test	<0.001*
Pivot-shift negative at 12M, n (%)	36 (85.7%)	40 (95.2%)	Chi-sq	0.148
Return to sport at 12M, n (%)	31 (73.8%)	37 (88.1%)	Chi-sq	0.089
Time to return to sport (weeks), mean ± SD	38.4 ± 4.2	34.1 ± 3.8	t-test	<0.001*

HT = Hamstring Tendon; PLT = Peroneus Longus Tendon; VAS = Visual Analogue Scale; KT-1000 = knee arthrometer; t-test = independent-samples t-test; Chi-sq = Pearson chi-square; Diff. = difference; * $p < 0.05$. Knee-flexion and ankle-eversion strength deficits are presented descriptively because the reported values are harvest-site-specific. Total complications comprise 3 re-ruptures, 4 cases of knee stiffness, and 1 saphenous nerve neurapraxia in HT (8 events in 8 patients), and 2 re-ruptures, 2 cases of knee stiffness, and 1 superficial wound dehiscence in PLT (5 events in 5 patients).

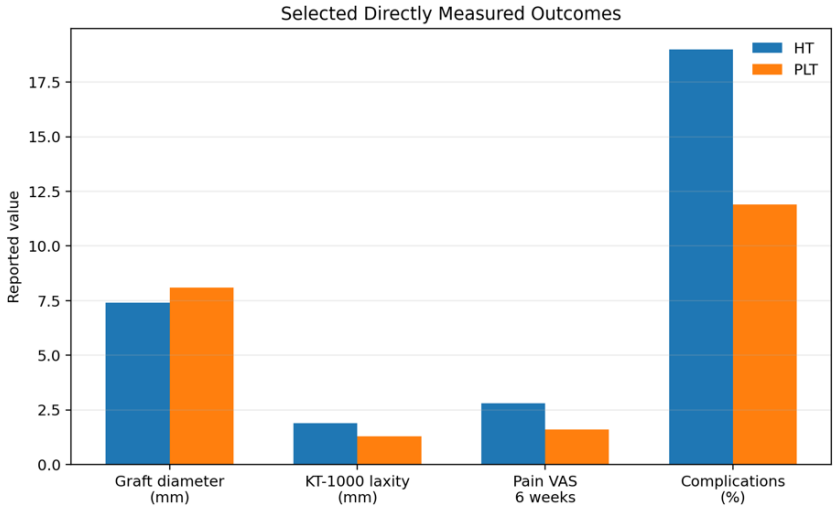


Figure 3: Selected directly measured clinical and intraoperative outcomes in the HT and PLT autograft groups

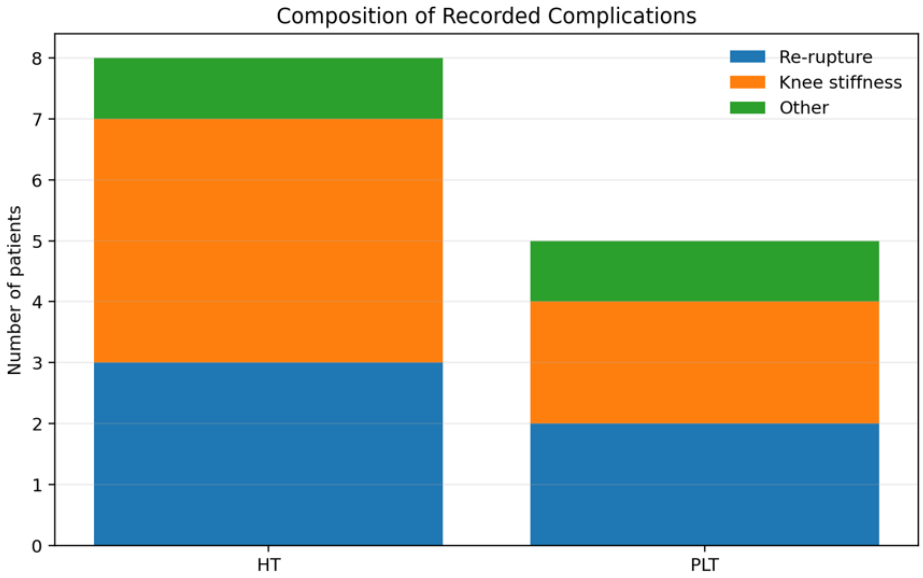


Figure 4: Composition of recorded complications by graft group. Other complications were saphenous nerve neurapraxia (HT) and superficial wound dehiscence (PLT)

Discussion

This prospective randomised trial provides evidence suggesting that peroneus longus tendon autograft yields superior functional outcomes compared to hamstring tendon autograft in women aged 25 years or younger undergoing primary ACL reconstruction, as measured by validated patient-reported outcome instruments and objective stability testing over a 12-month follow-up period.

These findings are clinically significant given the heightened vulnerability of young women to ACL injury and the long-term consequences of suboptimal graft selection in this population.

The superior Lysholm score in the PLT group (91.6 ± 4.7 vs 84.2 ± 5.9; $p < 0.001$) at 12 months is consistent with comparative outcomes reported in the PLT versus HT literature. The larger graft diameter observed with PLT (8.1 ± 0.7 mm vs 7.4 ± 0.8 mm) is clinically relevant because graft diameter has been associated with revision risk after ACL reconstruction. Published biomechanical work has also evaluated PLT tensile properties, but tensile strength and stiffness were not measured in the present participants and therefore are not interpreted as trial outcomes. The present comparison is restricted to the directly measured clinical and intraoperative outcomes.

Donor-site morbidity is an important consideration in graft selection. In this cohort, HT harvest was associated with a recorded knee-flexion strength deficit at 6 months, whereas PLT harvest was associated with a small ankle-eversion strength deficit at 12 months. These harvest-site-specific observations are reported descriptively and should

not be interpreted as a direct inferential comparison without the underlying bilateral strength data.

Return to sport at 12 months was numerically higher in the PLT group (88.1% vs 73.8%; $p = 0.089$). Among participants who returned to sport, the reported mean time to return was shorter in the PLT group (34.1 ± 3.8 vs 38.4 ± 4.2 weeks; $p < 0.001$). Because time to return was summarized among returners rather than from a verified patient-level time-to-event analysis, this finding should be interpreted cautiously.

The hormonal milieu of young pre-menopausal women presents a unique challenge for graft biology. Oestrogen and relaxin have been shown to reduce collagen cross-linking and alter matrix metalloproteinase activity in both native ligaments and tendon grafts, potentially delaying ligamentisation and osseointegration.[12,15] The larger-diameter PLT graft may confer a relative protective advantage in this context by providing greater collagen cross-sectional area and thus tolerating proportionally greater hormonal attenuation of tensile properties during the graft maturation window. Although graft maturation histology was not assessed in this study, this theoretical advantage warrants investigation in future biopsy-based studies.

Our study must be interpreted in the context of several limitations. First, the 12-month follow-up period, while capturing the critical early rehabilitation and return-to-sport phases, does not permit conclusions regarding long-term graft survival, osteoarthritis progression, or re-rupture rates beyond this period. Second, the study was conducted in an Indian population, and findings may not generalise to populations with differing anthropometric profiles or sporting cultures. Third, MRI-based graft maturation assessment was not performed, which would have provided biological correlates for the functional differences observed. Fourth, long-term ankle biomechanics following PLT harvest were not assessed with force-plate gait analysis, and the mild eversion deficit observed requires surveillance beyond 12 months. Despite these limitations, the strengths of this trial—prospective randomization, single-centre recruitment from Odisha and West Bengal, blinded outcome assessment, validated outcome instruments, and a sample size of 84 with adequate statistical power—lend confidence to the reported conclusions.

Taken together, the directly measured outcomes support PLT as a viable alternative autograft option in women aged 25 years or younger undergoing primary ACL reconstruction. The findings are most applicable to 12-month functional recovery, knee stability, graft diameter, donor-site morbidity, and complications. Longer follow-up and larger studies are required before making definitive claims regarding graft survival or long-term superiority.

Conclusion

In women aged 25 years or younger undergoing primary ACL reconstruction, PLT autograft was associated with better 12-month Lysholm and IKDC scores, lower VAS pain, lower KT-1000 side-to-side laxity, and a larger intraoperatively measured graft diameter than HT autograft. Knee-flexion donor-site morbidity was recorded after HT harvest, while a small ankle-eversion strength deficit was recorded after PLT harvest.

Overall complication rates were not significantly different. PLT may therefore represent a viable alternative to HT autograft in this population; larger multicentre studies with longer follow-up are required to establish comparative long-term graft durability and donor-site safety.

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