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Functional Assessment of Anterior Cruciate Ligament Reconstruction Using Peroneus Longus vs. Hamstring Tendon at 6, 12, And 24 Months Follow Up: A Meta-Analysis

Ricky Renardi Pratama[1], I Gusti Ngurah Wien Aryana[2]

[1] Resident, Dept. Orthopaedic & Traumatology, Prof IGNG Ngoerah General Hospital, Udayana University, Bali, Indonesia
[2] Consultant, Dept. Orthopaedic & Traumatology, Prof IGNG Ngoerah General Hospital, Udayana University, Bali, Indonesia

Correspondence: Ricky Renardi Pratama

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ABSTRACT

Background: Anterior cruciate ligament (ACL) tear occurs between 29 to 38 cases per 100.000 people annually with more than half of cases requiring an ACL reconstruction. Peroneus longus tendon (PLT) has growing popularity as an autograft for ACL reconstruction providing comparable outcomes with proper graft diameter size, lack of donor site morbidity and uncomplicated harvesting technique. Unfortunately, certain studies did not agree with the superiority of PLT to the standard hamstring tendon (HT).
Objective: The aim of study is to compare the knee functional outcome of an ACL reconstruction using peroneus longus and hamstring tendon according to recent publications.
Methods: This study conducted a thorough systematic search for relevant scientific reports on multiple medical databases, including PubMed, Embase, and Google Scholar, using a combination of keywords such as "peroneus longus," "hamstring tendon," "ACL reconstruction," "IKDC," and "Lysholm". The search was performed in April 2013-2023, resulting in 1567 studies. Two reviewers (RR, WA) independently screened the abstracts and reference lists, with any discrepancies resolved through consensus, concluding 5 included studies.
Results: Five studies are included with a total of 538 patients consisting of 267 patients who underwent ACL reconstruction with PLT and 271 patients who underwent ACL reconstruction with HT. Up to 24 months follow-up, there are equally balanced satisfactory functional outcomes between ACL reconstruction using peroneus longus and hamstring tendon, in terms of IKDC (I^2 = 74%; SMD = 0.08 95%CI, -0.21 to 0.38; p = 0.57) and Lysholm score (I^2 = 75%; SMD = 0.06 95%CI, -0.27 to 0.39; p = 0.73).
Conclusion: ACL reconstruction using the peroneus longus tendon is a safe and effective procedure with excellent short to long term functional outcome of the knee.

Keywords: Anterior Cruciate Ligament Reconstruction, Functional Outcome, Hamstring tendon, Human, Peroneus Longus Tendon.

INTRODUCTION

Anterior cruciate ligament (ACL) injuries are a significant public health concern, with an incidence rate ranging from 29 to 38 cases per 100,000 people annually.[1,2] ACL tears often occur during activities that involve sudden stops, pivots, or changes in direction, making athletes and physically active individuals particularly susceptible. The instability and functional impairment caused by an ACL tear frequently necessitate surgical intervention, with more than half of these cases requiring ACL reconstruction (ACLR) to restore knee stability and function. ACL reconstruction is a critical surgical intervention designed to restore knee stability and function following an ACL rupture.[3,4] This procedure frequently employs various graft types, with autografts and allografts being the primary categories.

The hamstring tendon autografts have gained popularity, especially in the Asian population, due to their ease of harvest and minimal donor site morbidity. The hamstring tendons, specifically the semitendinosus and gracilis, provide a graft with a tensile strength comparable to the native ACL.[4,5] However, the hamstring tendon graft can be unpredictable in size, which may necessitate intraoperative adjustments. Additionally, harvesting the hamstring tendon can lead to a reduction in hamstring muscle strength, which is crucial for athletes who rely heavily on hamstring power for performance.[6,7] Given these limitations, there has been growing interest in the peroneus longus tendon as an alternative autograft for ACL reconstruction.[8] The peroneus longus tendon is already utilized in various orthopedic procedures, such as spring ligament reconstruction, deltoid ligament reconstruction, and medial patellofemoral ligament reconstruction. Its synergistic function with the peroneus brevis allows for its use without significantly compromising ankle stability and function. Previous studies have suggested that the peroneus longus tendon offers sufficient tensile strength for ACL reconstruction, comparable to that of the hamstring tendon. However, there is still some debate regarding the morbidity associated with harvesting the peroneus longus tendon.[9–11]

Some case series have reported favorable clinical outcomes and minimal donor site morbidity when using the peroneus longus tendon for ACL reconstruction, while others have noted potential complications. For instance, a study by Rudy et al. in 2017 found no significant difference in tensile strength between the peroneus longus and hamstring tendons.[4] Additionally, studies by Rhatomy et al. reported better functional scores with the peroneus longus tendon compared to the hamstring tendon, without any significant dysfunction at the donor site.[12] Despite these findings, there remains a paucity of comparative studies examining the clinical outcomes of the peroneus longus tendon relative to other grafts used in ACL reconstruction.

Given the ongoing debate and the increasing utilization of PLT in clinical practice, it is crucial to systematically evaluate and compare the functional outcomes of ACL reconstruction using PLT versus HT. The current systematic review and meta-analysis aim to address this gap by comparing the functional outcomes and donor site morbidity associated with peroneus longus and hamstring tendon autografts over a follow-up period of 6, 12, and 24 months.

METHODS

Search Strategy

The study followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. A comprehensive search was conducted to identify relevant studies from April 2013 to 2023, using PubMed, Embase, and Google Scholar databases. Two reviewers (RR and WA) independently screened abstracts and reference lists, resolving any disagreements through consensus or consultation with a third reviewer if necessary. This research included randomized controlled trials that compared PLT and HT autografts, were published in English, and had available full-texts. The meta-analysis focused on comparing the clinical and functional outcomes of PLT and HT autografts in ACL reconstruction.

Inclusion Criteria

Studies were included if they met specific criteria, such as studies had to involve primary ACL reconstruction using either the PLT or the HT. Functional outcomes had to be reported using validated scoring systems, specifically the International Knee Documentation Committee (IKDC) score and the Lysholm score. Additionally, studies needed to provide follow-up data at 6, 12, and/or 24 months post-surgery. Only studies published in English between April 2013 and April 2023 were considered to maintain a focus on recent and relevant research. Randomized controlled trials (RCT) and quasi-RCT/Controlled clinical trials (CCT), cohort/longitudinal comparative studies, and case-control studies were included. Publication dates were not restricted in this study. We examined all published English-language articles that were accessible in full text for analysis. However, studies were excluded if they involved revision ACL reconstruction or included patients with multi-ligament knee injuries, as these factors could confound the results and introduce variability unrelated to the graft type. Studies that did not provide sufficient data for extraction or analysis were also excluded to ensure the integrity and completeness of the meta-analysis. We also excluded case series, case reports, reviews, systematic reviews, meta-analyses, editorials, letters, book chapters, study protocols, non-clinical/pre-clinical studies (in vitro, cadavers, animals) and conference abstracts that did not include full reports. The criteria of the studies are shown in table 1.

Table 1. PICO Criteria for Inclusion Study

	Inclusion	Exclusion
Population	Patient with ACL tear	Patient with associated osteoarthritis, multiple ligamentous injury, revision surgery and previous history of surgery
Intervention	Patients treated with ACL reconstruction using Peroneus longus tendon	Patients treated with conservative measures and surgery of other technique other than all-arthroscopic or mini-open rotator cuff repair
Control	Patients treated with ACL reconstruction using Hamstring tendon	Patients treated with conservative measures and surgery of other technique other than all-arthroscopic or mini-open rotator cuff repair
Outcome	IKDC and Lysholm score at 6-, 12- and 24-months follow-up	Outcomes not clearly mentioned Outcome with other parameter than our inclusion criteria.
Design	Randomized controlled trials (RCT)	Case report, case series, cross-sectional study, cohort study, systematic review or meta-analyses

Study selection process

Two reviewers (RR and WA) independently screened the titles and abstracts of all identified studies to assess their eligibility based on the inclusion and exclusion criteria. Full-text articles of potentially eligible studies were retrieved and reviewed in detail. Articles that meet our inclusion criteria were marked as "included", while articles that do not meet our criteria were marked as "excluded". Uncertain studies were marked "maybe" and discussed. To determine whether the potentially eligible studies met the inclusion criteria, the reviewers conducted a thorough review. Discrepancies between the reviewers regarding study eligibility were resolved through discussion and consensus. If necessary, a third reviewer was consulted to reach a final decision. The study selection process was documented using a PRISMA flow diagram to ensure transparency and reproducibility.[13]

Data extraction

Standardized data extraction was performed using Microsoft Excel (Microsoft Corporation, USA). The form was pilot-tested on a subset of studies to ensure its comprehensiveness and clarity. Extracted data included:

Study characteristics: author, year of publication, study design, sample size, and follow-up duration.

Patient demographics: age, sex, and activity level.

Surgical details: type of graft used (PLT or HT), surgical technique, and postoperative rehabilitation protocols.

Functional outcomes: IKDC and Lysholm scores at 6, 12, and 24 months follow-up.

Adverse events: complications, re-operations, and graft failures.

The extracted data were independently reviewed by both reviewers to ensure accuracy. Any discrepancies were resolved through discussion.

Data Synthesis

Data extraction was conducted by recording basic characteristics and outcomes in designated tables using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) for all the studies identified and included. When quantitative data were available, analysis was performed with Review Manager (RevMan, version 5.3, the Cochrane Collaboration, 2014; The Nordic Cochrane Center, Copenhagen, Denmark). Results were displayed as forest plots. For each study, mean differences for continuous outcomes and odds ratios for dichotomous outcomes were calculated, both with 95% confidence intervals (CI). A fixed-effects model was used if heterogeneity (I^2) was below 50%, while a random-effects model was applied if heterogeneity was above 50%.

RESULTS

Study Selection & Study Characteristics

Out of the initial 1567 studies, we removed 1379 duplicates articles, 38 records marked as ineligible by automation tools, 35 records due to to other reasons. We screened 115 articles and found 30 articles for eligibility assessment. Having done that, we excluded 15 non-English articles, 7 unavailable full-text articles, and 3 articles that is not-eligible (Figure 1). The five articles are consisted of randomized controlled trial with level of evidence II. The characteristics of patients included in this review are elaborated in Table 2.

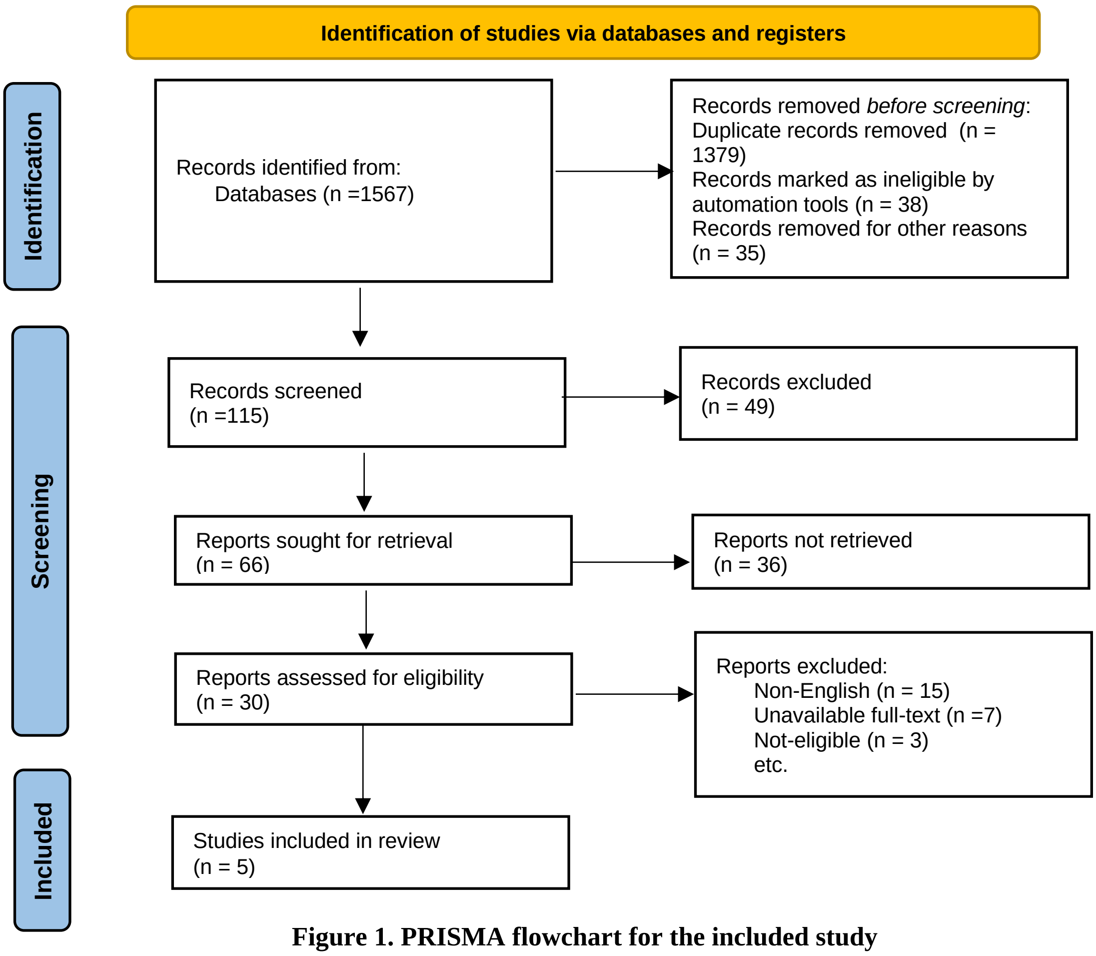

Figure 1. PRISMA flowchart for the included study

Table 2. Characteristics of the studies

No.	Studies	Journal	Study Design	Level of Evidence
1	Bi et al. (2018)[14]	The Journal of Knee Surgery	Randomized Controlled Trial	II
2	Rhatomy et al. (2019)[12]	Knee Surgery, Sports Traumatology, Arthroscopy	Randomized Controlled Trial	II
3	Shi et al. (2018)[15]	The Journal of Knee Surgery	Randomized Controlled Trial	II
4	Agarwal et al. (2023)[16]	Cureus	Randomized Controlled Trial	II
5	Keyhani et al. (2022)[8]	The Archives of Bone and Joint surgery	Randomized Controlled Trial	II

Qualitative synthesis

Five articles met the inclusion criteria, comprising a total of 538 patients. Among these, 267 patients underwent ACL reconstruction with PLT, and 271 with HT. Our review assessed the outcomes of IKDC and Lysholm score in 6, 12, 24 months follow-up. The mean age of PLT group was 28.74±6.42 and the HT group was 27.45±6.6. The summaries findings are provided in Table 3 and 4.

Table 3. Characteristic of the study populations

No.	Studies	Number of Subjects	Age (years)	Male	Female	Follow Up (Months)
1	Bi et al. (2018)[14]	PLT: 62 HT: 62	PLT: 29.1±6.5 HT: 27.9±6.7	PLT: 34 HT: 31	PLT: 28 HT: 31	30
2	Rhatomy et al. (2019)[12]	PLT: 24 HT: 28	PLT: 26.4±8.6 HT: 23.4±8.1	PLT: 20 HT: 24	PLT: 4 HT: 4	12
3	Shi et al. (2018)[15]	PLT: 18 HT: 20	PLT: 28.7 HT: 31.1	-	-	6, 12, 24
4	Agarwal et al. (2023)[16]	PLT: 98 HT: 96	PLT:28±4.9 HT: 27.5±4.1	PLT: 68 HT: 57	PLT: 30 HT: 39	6, 12
5	Keyhani et al. (2022)[8]	PLT: 65 HT: 65	PLT:29.8±7.5 HT: 27.6±8.1	PLT: 58 HT: 61	PLT: 7 HT: 4	24

Table 4. Characteristic of Outcome of studies

No	Reference	Outcome Measure					
		IKDC score			Lysholm score		
		6 months	12 months	24 months	6 months	12 months	24 months
1	Bi et al. (2018)[14]	PLT: 89.3±8.4 HT: 90.4±7.1	-	-	-	-	-
2	Rhatomy et al. (2019)[12]	-	PLT: 92.5±6.2 HT: 88.8±9.7	-	-	PLT: 94.9±5.6 HT: 93.1±7.3	-
3	Shi et al. (2018)[15]	PLT: 89.5±2.9 HT: 90.1±4.5	PLT: 90.5±2.3 HT: 90.2±4.3	PLT: 90.1±3.1 HT: 89.2±3.8	PLT: 94±6 HT: 95±2.3	PLT: 94±6.7 HT: 95±3.5	PLT: 94±6.8 HT: 93±5.2
4	Agarwal et al. (2023)[16]	PLT: 83.3 ±3.7 HT: 79.7±6.8	PLT: 94.1±4.6 HT: 95.1±0.7	-	PLT: 97±0 HT: 96.3±1.6	PLT: 99.1±2.8 HT: 99.8±0.37	-
5	Keyhani et al. (2022)[8]	-	-	PLT: 92.5±9.8 HT: 93.4±6.2	-	-	PLT: 95.1±6.2 HT: 94.9±10.5

Quantitative synthesis

IKDC scores

The meta-analysis showed no significant difference in IKDC scores between the PLT and HT groups at 6months follow-up (SMD

0.15; 95%CI, -0.46 to 0.75; I^2 = 85%; p = 0.63). The IKDC scores between the PLT and HT groups at 12 months follow-up showed no significant difference. (SMD 0.03; 95%CI, -0.45 to 0.50; I^2 = 66%; p = 0.92). The IKDC scores between the PLT and HT groups at 24 months follow-up showed no significant difference (SMD -0.03; 95%CI, -0.33 to 0.28; I^2 = 0%; p = 0.86). The meta-analysis of overall sub-group analysis showed no significant difference in IKDC scores between the PLT and HT groups (I^2=0%, p=0.87). The results is elaborated in Figure 3.

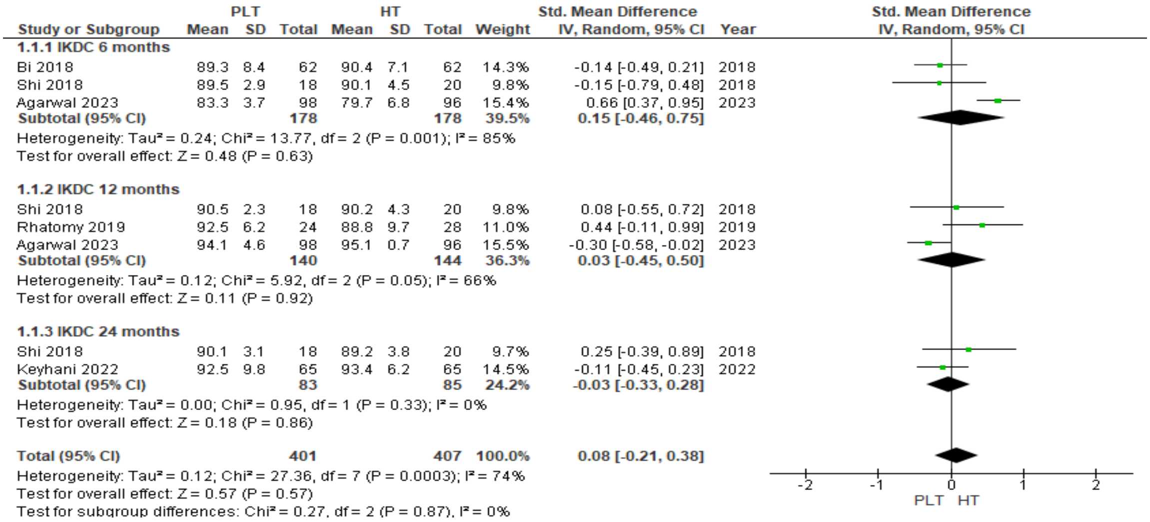

Figure 2. Forest Plot Analysis for IKDC Score between Peroneus Longus Tendon and Hamstring Tendon for ACL Reconstruction at 6, 12, and 24 months

Lysholm score

The meta-analysis showed no significant difference in Lysholm scores between the PLT and HT groups at 6months follow-up (SMD 0.25; 95%CI, -0.57 to 1.07; I^2 = 82%; p = 0.55). The Lysholm scores between the PLT and HT groups at 12 months follow-up showed no significant difference. (SMD -0.14; 95%CI, -0.52 to 0.24; I^2 = 48%; p = 0.47). The Lysholm scores between the PLT and HT groups at 24 months follow-up showed no significant difference (SMD 0.05; 95%CI, -0.25 to 0.36; I^2 = 0%; p = 0.72). The meta-analysis of overall sub-group analysis showed no significant difference in Lysholm scores between the PLT and HT groups (I^2=0%, p=0.61). The results is elaborated in Figure 4.

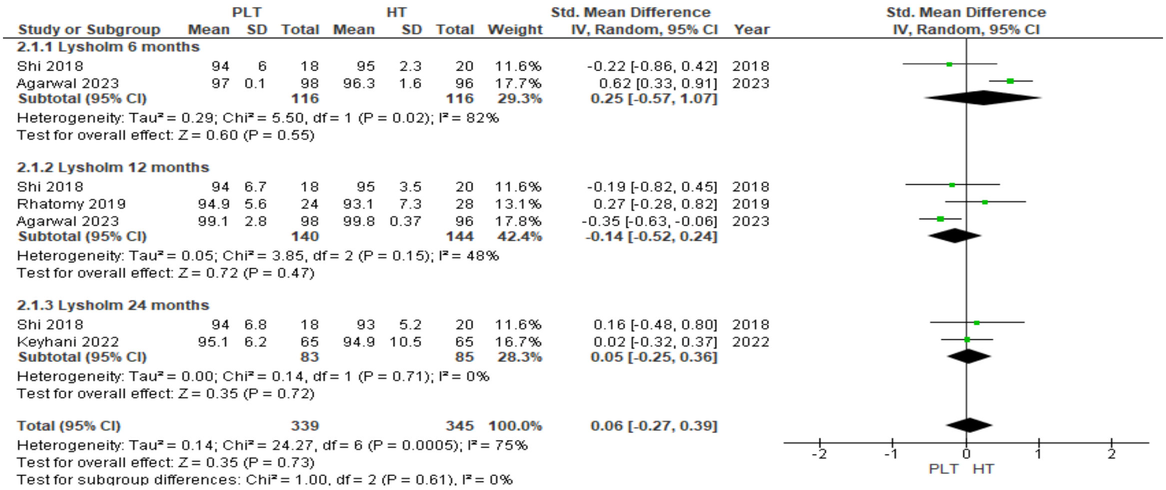

Figure 3. Forest Plot Analysis for Lysholm Score between Peroneus Longus Tendon and Hamstring Tendon for ACL Reconstruction at 6, 12, and 24 months

DISCUSSION

This systematic review and meta-analysis compared the functional outcomes of anterior cruciate ligament (ACL) reconstruction using peroneus longus tendon (PLT) versus hamstring tendon (HT) autografts over follow-up periods of 6, 12, and 24 months. Our analysis revealed no significant differences between the two graft types regarding IKDC and Lysholm scores at any follow-up interval, indicating comparable efficacy in knee function restoration. The most important findings in the present study were as follows: the peroneus longus autograft showed a comparable functional score at the 1-year follow-up compared with the hamstring tendon; the peroneus longus autograft had a larger diameter compared with the hamstring autograft; less thigh hypotrophy was found in the peroneus longus graft group; some of the patients in the hamstring group experienced anterior kneeling pain. The selection process of studies balance enhances the reliability of comparisons made between the two groups.

IKDC score is a comprehensive tool used to evaluate knee function, taking into account symptoms, sports activities, and knee joint function. It is a standardized measure widely utilized in clinical and research settings for assessing outcomes post-ACL reconstruction. Our meta-analysis found no significant differences in IKDC scores between the PLT and HT groups at any follow-up point. At 6 months, the standardized mean difference (SMD) was 0.15 (95% CI, -0.46 to 0.75), indicating no significant difference ($p = 0.63$). This suggests that both graft types are similarly effective in restoring knee function in the short term following surgery. At 12 months, the SMD was 0.03 (95% CI, -0.45 to 0.50), again showing no significant difference ($p = 0.92$). By this time, patients are typically transitioning from rehabilitation to more demanding physical activities, and the comparable scores suggest that both graft types support similar levels of knee function and stability during this critical recovery phase. At 24 months, the SMD was -0.03 (95% CI, -0.33 to 0.28), with no significant difference ($p = 0.86$). This long-term data indicates sustained knee function and stability, with no significant difference between the graft types. The consistent lack of significant variation in IKDC scores across all time points underscores that both PLT and HT grafts are effective in providing stable and functional knee joints. The consistent lack of significant variation in IKDC scores suggests that both graft types are equally effective in restoring knee stability and function. The previous study reported the results that similar with our findings.[12,14–16]

The Lysholm score is another validated instrument used to measure knee function, particularly focusing on symptoms such as pain, instability, locking, swelling, limp, stair-climbing ability, and the need for support. The results showed no significant differences between the PLT and HT groups. At 6 months, the SMD was 0.25 (95% CI, -0.57 to 1.07), indicating no significant difference ($p = 0.55$). This indicates no significant difference between the PLT and HT groups. Both grafts appear to offer comparable relief from symptoms and similar improvements in knee function during the early stages of recovery. At 12 months, the SMD was -0.14 (95% CI, -0.52 to 0.24), showing no significant difference ($p = 0.47$). Patients at this stage typically resume higher levels of physical activity, and the similar Lysholm scores suggest that both grafts effectively support knee function and symptom relief, allowing patients to engage in more demanding activities without significant issues. At 24 months, the SMD was 0.05 (95% CI, -0.25 to 0.36), with no significant difference ($p = 0.72$). This indicates that both graft types maintain comparable knee function and symptom management in the long term. The absence of significant differences in Lysholm scores over two years post-surgery highlights that both PLT and HT grafts provide durable functional outcomes. The comparable Lysholm scores indicate that patients in both groups experience similar levels of symptom relief and functional recovery. The previous studies showed the results aligned with our findings in this study.[3,12,14–16]

These findings have important clinical implications. The comparable outcomes of PLT and HT grafts provide surgeons with the flexibility to select grafts based on individual patient needs and specific clinical scenarios.[17,18] For example, PLT may be preferred in cases where preserving hamstring strength is crucial, such as in athletes who heavily rely on hamstring power.[19] Additionally, PLT can be a valuable option in revision surgeries where the hamstring tendons may already have been used. This flexibility can enhance personalized patient care and optimize surgical outcomes.[20] Autograft choice is one of the most important considerations during ACL reconstruction surgery of the knee. We found that there was a significant difference in graft diameter between the hamstring and peroneus longus tendons, with a mean difference of 0.6 mm in favor of the peroneus graft. Previous studies have concluded that a graft diameter of 8.5 mm had a 1.7% revision rate.[21] Furthermore, the risk of a patient needing a revision ACL reconstruction was 0.82 times lower with every 0.5 mm increase in graft diameter between graft thicknesses of 7 mm and 9 mm.[22,23] A previous biomechanical study, with the same cross-sectional surface area, reported no significant difference in tensile strength between the peroneus longus (446.1 ± 233.2) and a four-strand hamstring (405.8 ± 202.9). Other biomechanical studies reported that the ultimate tensile strength of the peroneus longus tendon was 2500 N, while the ultimate tensile strength of the native ACL was 1725 N.[24,25]

There was some donor site morbidity when using hamstring grafts, including thigh hypotrophy and subjective symptoms experienced by the patient, such as hypoesthesia or anaesthesia caused by injury to the infrapatellar branch of the saphenous nerve.[26] Thigh hypotrophy due to hamstring (semi T and gracilis) tendon harvesting results in reduced hamstring strength, especially at deep flexion angles. The hypotrophy of the hamstring also results in a quadriceps–hamstring imbalance, which results in an imbalance in dynamic knee stability.[27]

The findings have important clinical implications. The comparable outcomes of PLT and HT grafts provide surgeons with the flexibility to select grafts based on individual patient needs and specific clinical scenarios. For example, PLT may be preferred in cases where preserving hamstring strength is crucial, such as in athletes who heavily rely on hamstring power. Additionally, PLT can be a valuable option in revision surgeries where the hamstring tendons may already have been used. This flexibility can enhance personalized patient care and optimize surgical outcomes.

The strengths of this study include a comprehensive search strategy and rigorous selection process. The systematic approach ensured the inclusion of studies with validated functional outcome measures, enhancing the reliability and applicability of the findings. The thorough evaluation of multiple databases, including PubMed, Embase, and Google Scholar, minimized the risk of publication bias and ensured a comprehensive review of the available literature. Despite its strengths, this meta-analysis has several limitations that warrant consideration. Firstly, the high heterogeneity observed among the included studies may limit the generalizability of the findings. Variations in study methodologies, patient populations, and surgical techniques contribute to heterogeneity and challenge the synthesis of data. Secondly, the limited number of included studies and the variability in follow-up durations across studies may influence the robustness of the conclusions drawn. Furthermore, we did not conduct the risk of bias assessment in this study. Additional well-designed studies with standardized protocols are needed to further validate these findings and provide more definitive conclusions. Future research should focus on addressing the identified limitations to strengthen the evidence base for ACL reconstruction using PLT. Longitudinal studies with larger sample sizes and standardized outcome measures could provide deeper insights into the comparative effectiveness and long-term outcomes of PLT versus HT. Moreover, studies exploring patient-reported outcomes, return to sports timelines, and cost-effectiveness analyses could further inform clinical practice and optimize patient care strategies.

CONCLUSION

This systematic review and meta-analysis found no significant differences in functional outcomes between ACL reconstruction using peroneus longus tendon and hamstring tendon autografts at 6, 12, and 24 months follow-up. Both grafts offer comparable knee stability and patient satisfaction, allowing surgeons to select the most appropriate graft based on individual patient factors without compromising functional recovery. These findings contribute valuable insights for optimizing surgical decisions and improving patient outcomes in ACL reconstruction. The peroneus longus tendon autograft showed comparable functional outcomes at the 1-year follow-up compared with the hamstring tendon autograft in ACL reconstruction. The peroneus longus tendon autograft had a larger diameter, less thigh hypotrophy, and fewer complications related to donor site morbidity. These findings suggest that the peroneus longus tendon autograft can be considered a viable alternative to the hamstring tendon autograft for ACL reconstruction, especially in patients with specific concerns related to donor site morbidity and autograft diameter.

Declaration by Authors

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