



Quadriceps Tendon versus Bone–Patellar Tendon–Bone Autograft for Primary ACL Reconstruction: A Systematic Review and Meta-analysis of Complications and Patient-Reported Outcomes

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ABSTRACT

Background: Bone–patellar tendon–bone has long been regarded as a benchmark graft for primary anterior cruciate ligament reconstruction, although donor-site morbidity remains a relevant limitation. Quadriceps tendon has emerged as an increasingly adopted alternative, but its comparative role remains to be clearly defined. **Objectives:** This systematic review and meta-analysis aimed to compare quadriceps tendon and bone–patellar tendon–bone autografts in primary anterior cruciate ligament reconstruction, particularly regarding patient-reported outcomes, graft failure, and postoperative complications. **Methods:** This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline. PubMed, Scopus, Web of Science, and Cochrane CENTRAL were searched for comparative studies evaluating quadriceps tendon versus bone–patellar tendon–bone autografts in primary anterior cruciate ligament reconstruction. **Discussion:** Six comparative studies met the eligibility criteria. Pooled analyses showed no significant differences between grafts in International Knee Documentation Committee subjective score, Tegner activity score, Lysholm score, or graft failure. In contrast, quadriceps tendon was associated with a lower rate of arthrofibrosis. A lower risk of contralateral anterior cruciate ligament tear was also observed, although this finding should be interpreted cautiously because of sparse event counts. **Conclusion:** Quadriceps tendon offers clinical effectiveness comparable to bone–patellar tendon–bone, with a potentially more favorable complication profile, supporting its use as a dependable alternative graft for primary anterior cruciate ligament reconstruction.

Keyword: anterior cruciate ligament reconstruction, autograft, bone–patellar tendon–bone, quadriceps tendon, systematic review

ABSTRAK

Latar belakang: Bone–patellar tendon–bone merupakan graft acuan pada rekonstruksi ligamentum krusiatum anterior primer, tetapi morbiditas donor-site tetap menjadi perhatian. Quadriceps tendon semakin banyak digunakan sebagai alternatif, namun efektivitas dan profil komplikasinya masih perlu dipertegas. **Tujuan:** Systematic review dan meta-analysis ini bertujuan membandingkan autograft quadriceps tendon dan bone–patellar tendon–bone pada rekonstruksi ligamentum krusiatum anterior primer, terutama terkait luaran pasien, kegagalan graft, dan komplikasi pascaoperasi. **Metode:** Studi ini dilakukan sesuai Preferred Reporting Items for Systematic Reviews and Meta-Analyses. PubMed, Scopus, Web of Science, dan Cochrane CENTRAL digunakan untuk mencari studi komparatif yang mengevaluasi quadriceps tendon versus bone–patellar tendon–bone pada rekonstruksi ligamentum krusiatum anterior primer. **Pembahasan:** Enam studi komparatif memenuhi kriteria inklusi. Analisis



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gabungan menunjukkan tidak ada perbedaan bermakna pada International Knee Documentation Committee subjective score, Tegner activity score, Lysholm score, maupun kegagalan graft. Sebaliknya, quadriceps tendon berhubungan dengan angka arthrofibrosis yang lebih rendah. Penurunan risiko robekan ligamentum krusiatum anterior kontralateral juga ditemukan, tetapi perlu ditafsirkan hati-hati karena jumlah kejadian yang terbatas. **Kesimpulan:** Quadriceps tendon memberikan efektivitas klinis yang sebanding dengan bone–patellar tendon–bone, dengan potensi profil komplikasi yang lebih menguntungkan, sehingga dapat digunakan sebagai alternatif graft yang andal pada rekonstruksi ligamentum krusiatum anterior primer.

Kata kunci: autograft; bone–patellar tendon–bone; quadriceps tendon; rekonstruksi ligamentum krusiatum anterior; systematic review

1. Introduction

Anterior cruciate ligament (ACL) rupture remains one of the most common serious knee injuries in young and physically active individuals, and ACL reconstruction continues to be performed at a high and rising rate in contemporary sports medicine practice ¹. Because many patients undergo reconstruction to restore knee stability, recover function, and return to sport, graft choice remains one of the most consequential and debated decisions in primary ACL reconstruction. ^{1,2} Among autograft options, bone–patellar tendon–bone (BPTB) has historically served as a benchmark because of its established fixation characteristics and durable clinical track record; however, its use is persistently tempered by donor-site morbidity, particularly anterior knee pain and kneeling difficulty. ³

Over the past decade, quadriceps tendon (QT) autograft has become an increasingly adopted alternative for primary ACL reconstruction. Comparative reviews and meta-analyses have consistently suggested that QT provides knee stability, functional recovery, and graft survival broadly comparable to those of established autografts, while offering a potential advantage in donor-site morbidity when compared specifically with BPTB. ⁴ This issue is clinically important because recent higher-level pooled evidence has shown that both hamstring tendon and QT autografts are associated with lower odds of donor-site morbidity than BPTB, whereas revision and overall complication rates do not appear clearly different across graft types. ^{5,6} At the same time, harvest-site concerns have not disappeared entirely: extensor mechanism complications after BPTB or QT harvest are uncommon overall, but they remain relevant when counseling patients and weighing the trade-offs of graft selection. ^{5,6}

Despite growing enthusiasm for QT, several clinically relevant uncertainties remain. Much of the earlier literature pooled QT against both BPTB and hamstring tendon comparators, combined different QT harvest techniques, and relied heavily on short- to mid-term follow-up. ⁷ Consequently, it has remained uncertain whether the apparent donor-site advantage of QT is achieved without compromising patient-reported outcomes, graft durability, or sports-specific recovery when compared directly with BPTB alone. This unresolved question is especially important because newer head-to-head studies have expanded the evidence base beyond earlier mixed-population comparisons. ⁷

Recent direct comparative studies have added several important layers of evidence. A 10-year randomized athlete cohort found comparable long-term function and stability between QT and BPTB, with less donor-site morbidity in the QT group. ⁸ A retrospective comparative study with prospectively collected outcomes likewise reported no significant differences in patient-reported outcomes or revision rates between grafts. ⁹ More recently, sport-specific data from cutting and pivoting athletes and from an all-female soccer cohort have suggested that QT can achieve patient-reported and return-to-sport outcomes similar to those of BPTB in populations where graft choice may be especially consequential. ¹⁰ These newer studies warrant focused reappraisal because they provide contemporary, directly comparative information that was underrepresented in earlier syntheses. ^{4,7}

Accordingly, an updated systematic review and meta-analysis focused specifically on QT versus BPTB in primary ACL reconstruction is warranted. The aim of the present study was to compare these two autografts with respect to patient-reported outcomes and complications, including graft failure and postoperative adverse events. We hypothesized that QT would demonstrate subjective and functional outcomes comparable to those of BPTB, without increased graft failure, while potentially offering a more favorable complication profile.

2. Method

2.1 Reporting Standard

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The review protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; registration number CRD420261336077) before completion of the formal review process.¹¹

2.2 Literature Search Strategy

A systematic literature search was performed in PubMed/MEDLINE, Scopus, Web of Science, and Cochrane CENTRAL from database inception to the final search date. The search strategy combined controlled vocabulary and free-text terms related to anterior cruciate ligament reconstruction, quadriceps tendon autograft, and bone–patellar tendon–bone autograft. Search terms were adapted for each database. Reference lists of included studies and relevant review articles were also screened manually to identify any additional eligible studies. Only studies published in English were considered for inclusion.

2.3 Study Selection

Studies were considered eligible if they directly compared quadriceps tendon (QT) autograft with bone–patellar tendon–bone (BPTB) autograft in patients undergoing primary anterior cruciate ligament reconstruction. Randomized controlled trials and comparative cohort studies were included. Studies were excluded if they involved revision anterior cruciate ligament reconstruction only, lacked a direct QT versus BPTB comparison, used other graft types without extractable QT versus BPTB data, or were case reports, case series without a comparator, review articles, technical notes, biomechanical studies, cadaveric studies, or conference abstracts without sufficient extractable data. Two reviewers independently screened titles and abstracts, followed by full-text eligibility assessment. Disagreements were resolved by discussion and consensus.

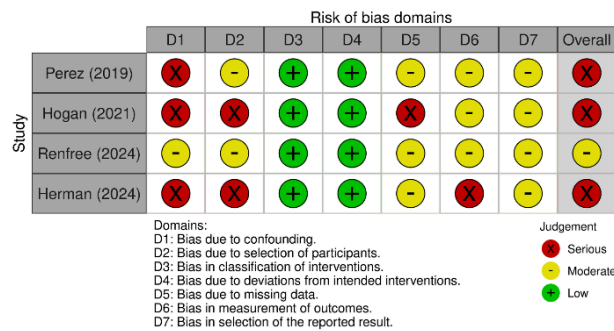
2.4 Data Extraction and Outcome Definitions

Two reviewers independently extracted study-level data using a standardized form. Extracted variables included study design, country, sample size, patient age, follow-up duration, graft type, and outcomes of interest. The primary outcomes were International Knee Documentation Committee (IKDC) subjective score and graft retear/failure. Graft failure was defined as graft retear, rupture, or revision anterior cruciate ligament reconstruction related to graft failure, according to the definitions used in the original studies. Secondary outcomes included Tegner activity score, Lysholm score, arthrofibrosis, and contralateral anterior cruciate ligament tear. Additional outcomes, including side-to-side anterior laxity, return-to-sport outcomes, and anterior knee pain or donor-site morbidity, were extracted and summarized narratively when pooling was not considered methodologically appropriate. For continuous variables, data at the latest available follow-up were extracted. When studies reported medians and interquartile ranges rather than means and standard deviations, summary statistics were converted using established methods when appropriate to allow quantitative synthesis¹².

2.5 Risk of Bias Assessment

Risk of bias was assessed separately according to study design. The two randomized controlled trials were evaluated using the RoB 2 tool, which examines bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result.¹³ The non-randomized comparative studies were evaluated using ROBINS-I, which assesses bias due to confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported result. Two reviewers performed the assessments independently, and disagreements were resolved by discussion.¹⁴

A) Risk of Bias Summary for Non-Randomized Study (ROBINS-I)



B) Risk of Bias Summary for Randomized Study (ROB-2)

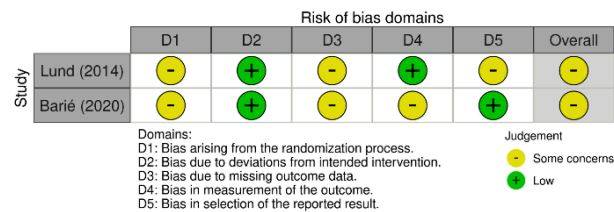


Figure 1. Risk of bias summary of included studies. (A) Non-randomized studies assessed with ROBINS-I. (B) Randomized studies assessed with RoB 2. Green indicates low risk, yellow indicates some concerns or moderate risk, and red indicates high or serious risk of bias.

2.6 Data Synthesis and Statistical Analysis

A quantitative synthesis was performed when at least two studies reported sufficiently comparable data for the same outcome. For continuous outcomes, pooled effect estimates were calculated using mean differences (MDs) with 95% confidence intervals when studies used the same measurement scale. If summary statistics required conversion or if standardization was considered more appropriate for comparability, standardized mean differences (SMDs) were used. For dichotomous outcomes, pooled risk ratios (RRs) with 95% confidence intervals were calculated. A random-effects model was used for all meta-analyses to account for expected clinical and methodological heterogeneity across studies. Statistical heterogeneity was assessed using the I^2 statistic and Cochran's Q test. Prediction intervals were examined where available to aid interpretation of between-study variability. When quantitative pooling was not feasible because of inconsistent outcome definitions or insufficient data, findings were synthesized narratively. Formal assessment of publication bias was not performed for pooled outcomes with fewer than 10 studies, because such methods are considered unreliable in small meta-analyses.

3. Result and Discussion

3.1 Literature Search Result

The PRISMA flow diagram illustrating the study selection process is presented in Figure 2. The database search identified 428 records, comprising 126 from PubMed, 142 from Scopus, 104 from Web of Science, and 56 from Cochrane CENTRAL. Following removal of 138 duplicate records, 290 unique records remained for title and abstract screening. Of these, 248 were excluded for not meeting the eligibility criteria. The remaining 42 reports were sought for full-text retrieval, of which 3 could not be obtained. Consequently, 39 full-text articles underwent detailed eligibility assessment. After full-text review, 33 articles were excluded for the following reasons: lack of a direct comparison between quadriceps tendon and bone–patellar tendon–bone autografts ($n = 12$), ineligible study design or absence of a comparative cohort or randomized controlled trial ($n = 7$), ineligible population or failure to focus on primary anterior cruciate ligament reconstruction ($n = 5$), non-extractable outcomes ($n = 4$), duplicate or overlapping cohorts ($n = 3$), and non-English or unavailable full text ($n = 2$). Ultimately, 6 studies fulfilled all inclusion criteria and were included in the qualitative synthesis and meta-analysis.

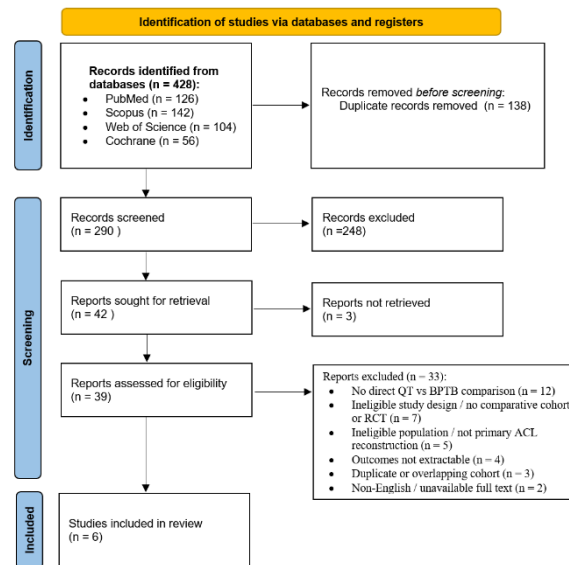


Figure 2. A PRISMA flow diagram showing the results of the database search

3.2 Study Characteristics

A total of six comparative studies met the eligibility criteria and were included in the qualitative and quantitative synthesis. Their principal characteristics are summarized in Table 1, including study design, country, sample size, patient age, follow-up duration, and reported outcomes. The included evidence comprised two randomized controlled trials and four retrospective comparative cohort studies, representing 385 patients overall (169 QT and 216 BPTB) from Denmark, Germany, and the United States. Follow-up duration ranged from 1 year to 10 years, capturing both short-term postoperative recovery and longer-term clinical outcomes. Across studies, the most consistently reported outcome was the International Knee Documentation Committee subjective score, while other commonly assessed domains included Lysholm score, Tegner activity score, graft retear or failure, anterior knee symptoms, arthrofibrosis, contralateral anterior cruciate ligament tear, and return-to-sport outcomes. Collectively, these studies provided a contemporary and clinically relevant dataset for comparing the effectiveness and complication profile of quadriceps tendon and bone–patellar tendon–bone autografts in primary anterior cruciate ligament reconstruction.

Table 1. Baseline Characteristics of Included Comparative Studies of Quadriceps Tendon and Bone–Patellar Tendon–Bone Autografts for Primary Anterior Cruciate Ligament Reconstruction

No	Study	Country	Type of Study	Study Period	Sample Size		Mean Age (SD)		Outcomes
					QT	BPTB	QT	BPTB	
1	Lund (2014) ¹⁵	Denmark	Randomized Controlled Trial	2005-2009	26	25	30 (9)	31 (8)	IKDC subjective; KT-1000 side-to-side laxity; anterior knee pain/kneeling (knee-walking) (plus: KOOS; harvest-site pain; sensory loss)
2	Perez (2019) ¹⁶	USA	Retrospective cohort	2015-2016	28	22	23.07 (NR)	21.68 (NR)	Graft failure/revision; IKDC; Lysholm; anterior knee pain proxy (kneeling difficulty) (plus: Tegner; satisfaction; meniscus surgery; contralateral ACL)
3	Barié (2020) ⁸	Germany	Prospective Randomized Control Trial	NR	30	30	30.5 (7.8)	30.6 (7.5)	Graft re-rupture/revision; IKDC; Lysholm; KT-1000 side-to-side laxity; RTS level (Tegner); anterior knee pain (kneeling/squatting complaints) (plus: radiographic OA/degeneration; satisfaction)

4	Hogan (2021) ⁹	USA	Retrospective cohort	2011-2019	39	80	18.7 (6.3)	21.0 (5.9)	Graft failure/rupture; IKDC (plus: KOOS; PROMIS; SANE; Tegner; Marx; reoperation complications)
5	Renfree (2023) ¹⁷	USA	Retrospective cohort	2015-2019	32	36	17.6 (2.8)	18.3 (2.5)	Graft retear; IKDC; Lysholm; RTS rate (plus: arthrofibrosis; contralateral ACL tear)
6	Herman (2024) ¹⁰	USA	Retrospective cohort	2015-2021	14	23	19.7 (5.4)	18.1 (2.6)	Revision ACLR (graft re-rupture); IKDC; RTS rate (return to soccer) (plus: Tegner; Marx; ipsilateral injury)

3.3 Summary of Systematic Review Finding

Across the included comparative studies, quadriceps tendon (QT) autograft demonstrated clinical outcomes broadly comparable to those of bone–patellar tendon–bone (BPTB) autograft for primary anterior cruciate ligament reconstruction. Randomized and retrospective evidence consistently showed similar patient-reported outcomes, particularly IKDC and, where reported, Lysholm scores, with no clear indication that QT compromises functional recovery. Graft failure, revision, and retear rates were generally low and comparable between grafts across short-, mid-, and longer-term follow-up. In athletic subgroups, including high-demand, cutting/pivoting, and female soccer cohorts, return-to-sport outcomes were likewise similar, supporting QT as a reliable option in physically active populations. The most consistent difference favoring QT was a lower donor-site morbidity burden, especially with respect to kneeling pain, squatting discomfort, harvest-site symptoms, and sensory complaints, whereas BPTB more frequently showed anterior knee–related complaints. Taken together, the included studies suggest that QT provides equivalent subjective and functional outcomes to BPTB while potentially offering a more favorable complication profile, supporting its role as a dependable alternative autograft for primary ACL reconstruction.

Table 2. Summary of Key Findings and Conclusions from Included Comparative Studies Evaluating Quadriceps Tendon (QT) versus Bone–Patellar Tendon–Bone (BPTB) Autografts for Primary Anterior Cruciate Ligament Reconstruction

No	Study (year)	Study Design	SUMMARY OF RESULT	CONCLUSION
1	Lund (2014) ¹⁵	Randomized Controlled Trial	In adults undergoing primary ACL reconstruction, QT-bone and BPTB showed comparable KT-1000 stability and patient-reported outcomes, but QT was associated with lower donor-site morbidity, including less kneeling pain, harvest-site pain, and sensory disturbance. Some clinical stability findings, such as pivot shift, also favored QT.	QT-bone provides comparable stability and subjective outcomes to BPTB for primary ACLR, with lower kneeling-related donor-site morbidity.
2	Perez (2019) ¹⁶	Retrospective cohort	At ~33 months follow-up after primary ACLR, IKDC and Lysholm scores were similar between all-soft tissue QT and BPTB. Overall complication and reoperation events were low, with few graft failures/revisions reported and no clear pattern suggesting worse outcomes with either graft.	All-soft tissue QT demonstrates patient-reported outcomes comparable to BPTB at mid-term follow-up and represents a reasonable graft option for primary ACLR.
3	Barié (2020) ⁸	Prospective Randomized Control Trial	In high-demand athletes undergoing hardware-free press-fit ACL reconstruction, QT and BPTB showed comparable long-term stability and functional outcomes, with rare graft failure. However, BPTB was associated with greater donor-site morbidity, particularly kneeling and squatting complaints.	QT and BPTB yield comparable long-term clinical outcomes in athletes, but QT is associated with less donor-site morbidity.
4	Hogan (2021) ⁹	Retrospective cohort	At a minimum follow-up of 12 months after primary ACL reconstruction, QT and BPTB demonstrated similar improvements in patient-reported outcomes, including IKDC, with low and comparable revision and reoperation rates. Pain was assessed using general PROM domains rather than a specific anterior knee pain measure.	QT and BPTB autografts provide similar patient-reported improvement and similar revision rates, supporting individualized graft selection.
5	Renfree (2023) ¹⁷	Retrospective cohort	In cutting/pivoting athletes at 2-year follow-up, IKDC and Lysholm outcomes were comparable between QT and BPTB. Return-to-sport rates were also reported as similar between groups. Retear events were uncommon, with low overall complication rates and no strong evidence of clinically important differences between grafts.	For cutting/pivoting athletes, QT and BPTB result in similar functional outcomes and RTS, with low retear rates in both groups.
6	Herman (2024) ¹⁰	Retrospective cohort	In an all-female soccer cohort with multi-year follow-up, IKDC outcomes and return-to-soccer rates were similar between QT and BPTB. Revision events were infrequent, and the study did not identify a clear disadvantage of QT. Activity measures (e.g., Tegner/Marx) were used to contextualize postoperative participation.	Among female soccer players, QT and BPTB show similar functional outcomes, supporting QT as a viable alternative graft.

3.4 Patient Reported Outcomes

Pooled analysis of patient-reported outcomes demonstrated no significant differences between quadriceps tendon (QT) and bone–patellar tendon–bone (BPTB) autografts for primary anterior cruciate ligament reconstruction. For the International Knee Documentation Committee (IKDC) subjective score, the pooled effect slightly favored QT, but the difference was not statistically significant (SMD 0.20, 95% CI -0.09 to 0.50; $P = 0.181$), with moderate heterogeneity across studies ($I^2 = 42.5\%$). Similarly, the Tegner activity score was comparable between groups (SMD -0.03, 95% CI -0.31 to 0.25; $P = 0.831$), with low heterogeneity ($I^2 = 12.4\%$). The Lysholm score also showed virtually no between-group difference (SMD 0.01, 95% CI -0.29 to 0.30; $P = 0.949$), with no observed heterogeneity ($I^2 = 0\%$). Collectively, these findings indicate that QT and BPTB autografts provide similar subjective knee function, activity level, and overall patient-reported recovery, with no evidence that QT compromises functional outcomes despite its different harvest profile.

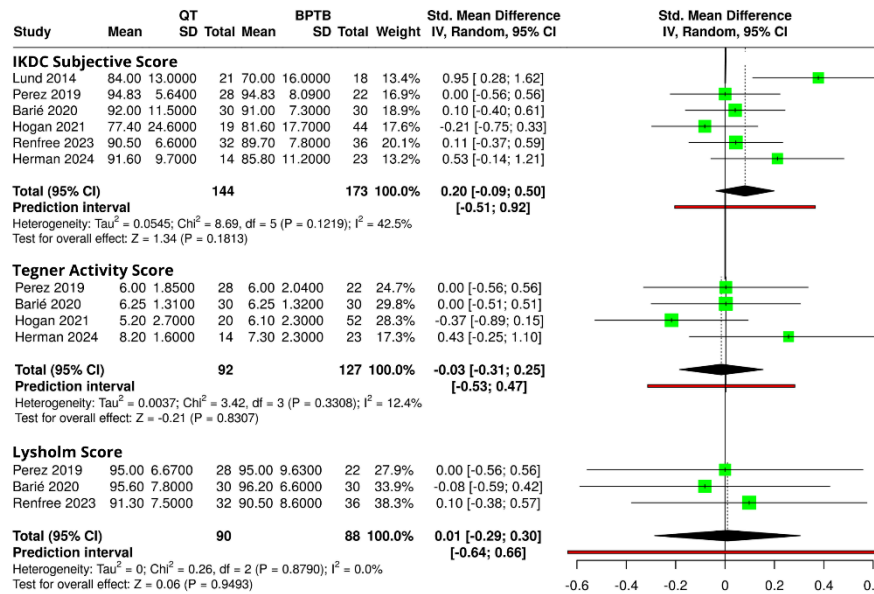


Figure 3. Forest plots of patient-reported outcomes, including IKDC subjective score, Tegner activity score, and Lysholm score, comparing quadriceps tendon and bone–patellar tendon–bone autografts for primary anterior cruciate ligament reconstruction.

3.5 Complications

Pooled analysis of complication outcomes showed a broadly favorable safety profile for quadriceps tendon (QT) autograft, although the strength of evidence varied by endpoint. Graft retear/failure was not significantly different between QT and bone–patellar tendon–bone (BPTB) autografts (RR 0.61, 95% CI 0.19 to 1.95; $P = 0.406$), with no observed heterogeneity ($I^2 = 0\%$), indicating that QT did not appear to compromise graft durability. In contrast, arthrofibrosis occurred significantly less often in the QT group (RR 0.39, 95% CI 0.16 to 0.98; $P = 0.045$), again with no heterogeneity ($I^2 = 0\%$), suggesting a potentially meaningful reduction in postoperative stiffness-related complications. A similar pattern was observed for contralateral anterior cruciate ligament tear, which was significantly less frequent with QT (RR 0.21, 95% CI 0.05 to 0.93; $P = 0.040$). However, this latter finding should be interpreted cautiously, as it was derived from only a small number of studies with sparse event counts, as reflected by the very wide prediction interval. Taken together, these findings suggest that QT provides a complication profile at least comparable to that of BPTB, with possible advantages in selected postoperative complications, particularly arthrofibrosis.

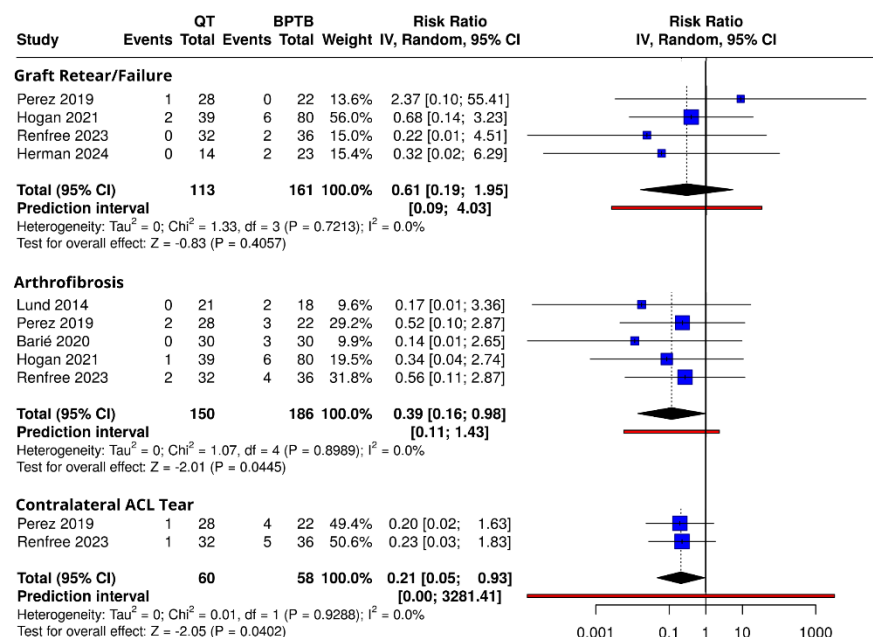


Figure 4. Forest plots of complication outcomes, including graft retear/failure, arthrofibrosis, and

contralateral anterior cruciate ligament tear, comparing quadriceps tendon and bone–patellar tendon–bone autografts for primary anterior cruciate ligament reconstruction.

3.6 Principal Findings

The principal finding of this updated systematic review and meta-analysis is that quadriceps tendon (QT) autograft provides patient-reported outcomes and graft durability comparable to those of bone–patellar tendon–bone (BPTB) autograft in primary anterior cruciate ligament reconstruction, while showing a potentially more favorable complication profile. Across the pooled analyses, International Knee Documentation Committee (IKDC), Tegner, and Lysholm scores were not significantly different between grafts, indicating that QT does not appear to compromise subjective recovery, activity level, or functional outcome relative to the more established BPTB graft. Similarly, graft retear/failure rates were comparable, supporting the view that QT can achieve equivalent graft survival despite longstanding perceptions of BPTB as the benchmark autograft. In contrast, QT was associated with a significantly lower risk of arthrofibrosis, and a lower rate of contralateral anterior cruciate ligament tear was also observed, although the latter finding should be interpreted cautiously given the limited number of contributing studies and sparse event counts. Taken together, these results reinforce the growing body of literature suggesting that QT is not inferior to BPTB in effectiveness, while potentially offering an advantage in selected postoperative complications and donor-site morbidity.⁵

3.7 Interpretation of Patient-Reported Outcomes

The present findings suggest that quadriceps tendon (QT) autograft does not compromise patient-perceived recovery when compared with bone–patellar tendon–bone (BPTB) autograft. Across the pooled analyses, IKDC subjective score, Tegner activity score, and Lysholm score were all comparable between grafts, indicating that the choice of QT over BPTB is unlikely to result in inferior subjective knee function, activity level, or overall postoperative satisfaction. This is clinically important because BPTB has long been viewed as a benchmark graft in primary ACL reconstruction, and any alternative graft must demonstrate not only acceptable structural performance but also equivalent patient-centered outcomes. Our results therefore support the interpretation that QT can achieve a level of subjective recovery similar to that of BPTB, despite differences in graft harvest site and extensor mechanism involvement.^{2,7}

These findings are also consistent with the direction of prior comparative evidence. Earlier systematic reviews and meta-analyses have reported no meaningful differences in validated functional scores between QT and established autograft options, including direct comparisons with BPTB, while more recent head-to-head studies have continued to show similar IKDC and Lysholm outcomes at both mid- and long-term follow-up. The persistence of comparable patient-reported outcomes across randomized and observational data suggests that the biomechanical adequacy of QT is translated into acceptable clinical recovery, rather than merely satisfactory objective stability. Importantly, this equivalence in patient-reported outcomes implies that any potential advantage of QT is more likely to emerge through its complication profile than through superior functional scoring alone. In other words, the current evidence does not indicate that QT produces better subjective outcomes than BPTB, but it strongly suggests that QT can match the functional and symptomatic performance of BPTB without sacrificing patient-reported recovery.¹⁰

3.8 Interpretation of Complications

An important finding of the present review is that graft retear/failure did not differ significantly between quadriceps tendon (QT) and bone–patellar tendon–bone (BPTB) autografts, suggesting that the use of QT does not appear to compromise graft durability relative to the more established BPTB construct. This point is clinically important because BPTB has traditionally been favored when graft strength and long-term survivorship are prioritized. Our pooled estimate indicates that QT can achieve a comparable structural endpoint, which is consistent with prior comparative syntheses showing no clear difference in graft failure or revision risk between QT and BPTB.⁹ At the same time, this result should be interpreted in the context of the evidence base: failure events were relatively infrequent across the included studies, and much of the comparative literature remains observational. Accordingly, the absence of a statistically significant difference should be viewed primarily as evidence that QT does not signal an excess failure risk, rather than proof of superiority or perfect equivalence.¹⁷

In contrast, the lower rate of arthrofibrosis observed with QT may represent a clinically meaningful advantage. Although the mechanism cannot be established definitively from the included studies, this finding is plausibly related to differences in harvest-site morbidity, anterior knee symptoms, early postoperative pain, or rehabilitation tolerance, all of which may influence motion recovery after reconstruction. From a practical

perspective, a reduction in arthrofibrosis is important because postoperative stiffness can delay recovery, impair return to sport, and increase the need for additional procedures. Our findings therefore suggest that QT may offer not only comparable effectiveness, but also a modest complication-related benefit in selected domains. A similarly favorable signal was observed for contralateral anterior cruciate ligament tear; however, this result should be interpreted with considerable caution. It was derived from only a small number of studies and a limited number of events, making the estimate vulnerable to instability and residual confounding related to activity exposure, rehabilitation progression, and return-to-sport behavior. For that reason, the contralateral tear finding is best considered hypothesis-generating rather than definitive, whereas the reduction in arthrofibrosis appears more clinically persuasive within the current dataset.^{2,10,17}

3.9 Comparison with Prior Literature

The findings of the present review are broadly consistent with the contemporary literature comparing QT with established autograft options, particularly BPTB. Previous systematic reviews and meta-analyses have consistently reported that QT achieves comparable functional outcomes, knee stability, and graft survival to BPTB, while often demonstrating lower donor-site morbidity, especially with respect to anterior knee symptoms and kneeling discomfort.³ Our results reinforce that central message but add a more focused, updated head-to-head synthesis of QT versus BPTB specifically, incorporating newer comparative cohorts and sport-specific populations that were underrepresented in earlier reviews. In this context, the absence of significant differences in IKDC, Tegner, Lysholm, and graft retear/failure aligns closely with prior pooled analyses, whereas the lower arthrofibrosis signal observed in our review may further support the notion that the clinical advantage of QT, if present, lies less in superior functional recovery than in a more favorable complication profile.^{5,7} Accordingly, the present study does not overturn earlier evidence, but rather strengthens the growing view that QT is a dependable and increasingly supported alternative to BPTB in primary ACL reconstruction.

3.10 Strengths and Limitations

This review has several strengths, including its updated head-to-head focus on quadriceps tendon (QT) versus bone–patellar tendon–bone (BPTB) autografts, prospective protocol registration, and structured risk-of-bias assessment using design-specific tools.^{13,14} In addition, by examining both patient-reported outcomes and complications, the review provides a clinically relevant comparison of graft performance. However, several limitations should be acknowledged. The number of included studies was small, most were retrospective comparative cohorts, and follow-up duration and outcome definitions varied across studies, introducing potential heterogeneity and bias.^{13,14} Some complication analyses were also based on sparse event counts, which limits the precision of those estimates. Therefore, although the present findings are clinically informative, they should be interpreted in the context of a limited and partly observational evidence base.

3.11 Clinical Implications and Future Directions

From a practical standpoint, bone–patellar tendon–bone (BPTB) remains a benchmark graft for primary anterior cruciate ligament reconstruction because of its long-established clinical track record and accepted durability. However, the present findings support quadriceps tendon (QT) as a dependable alternative autograft, with comparable patient-reported outcomes and graft-failure rates, and a potentially more favorable complication profile, particularly with respect to selected postoperative morbidities.¹⁰ These findings may be especially relevant when graft selection is individualized according to patient priorities, such as minimizing donor-site symptoms while maintaining reliable functional recovery. Nevertheless, the current evidence remains limited by the small number of comparative studies and the predominance of observational designs. Future research should therefore prioritize larger prospective comparative studies, ideally with standardized definitions and reporting of graft failure, donor-site morbidity, and return-to-sport outcomes, so that the comparative benefits and trade-offs of QT and BPTB can be defined with greater precision.⁵

4. Conclusion

In primary anterior cruciate ligament reconstruction, quadriceps tendon autograft demonstrated patient-reported outcomes and graft-failure rates comparable to those of bone–patellar tendon–bone autograft, supporting its effectiveness as a reliable graft option. Importantly, quadriceps tendon autograft was associated with a more favorable complication profile in selected domains, particularly a lower rate of arthrofibrosis, while the observed reduction in contralateral anterior cruciate ligament tear should be interpreted cautiously given the limited number of contributing studies and sparse event counts. Taken together, these findings suggest that quadriceps tendon autograft should not be viewed merely as an alternative when bone–patellar tendon–bone is undesirable, but rather as a dependable contemporary option

for primary anterior cruciate ligament reconstruction. Although bone–patellar tendon–bone remains a well-established benchmark graft, the present evidence indicates that quadriceps tendon can achieve equivalent clinical effectiveness with the potential for reduced postoperative morbidity. Further large, prospective comparative studies with standardized reporting of graft failure, donor-site morbidity, and return-to-sport outcomes are warranted to refine graft selection and confirm these findings.

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