

Review Article

Anterior Cruciate Ligament Reconstruction with Quadriceps Tendon Autograft: Two-Year Functional Outcomes

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Abstract

Background: Bone-patellar tendon-bone (BPTB) and hamstring tendon (HT) autografts have long dominated anterior cruciate ligament reconstruction, but quadriceps tendon (QT) autograft has re-emerged as a mainstream option.

Objective: To synthesise evidence on QT biomechanics, harvest, donor-site morbidity, and outcomes through two years and beyond, versus BPTB and HT.

Methods: Narrative review of biomechanical, comparative, meta-analysis, imaging, and registry literature.

Findings: QT provides a large, mechanically robust graft with donor-site pain markedly lower than BPTB and pooled re-rupture rates lower than HT (2.5% vs 8.7%). Two-year IKDC, Lysholm, and KOOS outcomes are comparable across grafts, with a modest Lysholm advantage for QT. Paediatric and revision evidence is encouraging but still maturing.

Conclusions: QT autograft is a validated primary and revision option with favourable donor-site morbidity, though long-term data remain limited.

Keywords: Anterior cruciate ligament reconstruction; Quadriceps tendon autograft; Hamstring tendon; Bone-patellar tendon-bone; Donor-site morbidity

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Keywords: anterior cruciate ligament reconstruction; quadriceps tendon autograft; hamstring tendon; bone-patellar tendon-bone; donor-site morbidity; functional outcomes

Introduction

Anterior cruciate ligament (ACL) rupture is one of the most common serious knee injuries in athletically active populations, with a population-based incidence of roughly 69 per 100,000 person-years and rising annual reconstruction volumes over the past two decades [1]. Graft choice remains the most consequential technical decision in ACL reconstruction, historically framed as a choice between BPTB autograft, prized for bone-to-bone healing and secure fixation, and HT autograft, favoured for lower anterior knee pain but historically associated with a higher failure rate in young, high-demand patients. QT autograft, first described as an alternative cruciate

reconstruction graft three decades ago, has undergone a resurgence driven by refined harvest techniques, all-soft-tissue and bone-block fixation options, and an expanding comparative evidence base [2], summarised in a comprehensive review and systematic analysis of clinical results across the accumulated QT literature [3].

The choice among autografts is rarely dictated by any single outcome measure. BPTB affords rapid bone-to-bone tunnel incorporation but carries a well-documented burden of anterior knee pain, patellar fracture risk, and kneeling discomfort. HT autograft largely avoids anterior knee symptoms but has, in several registry analyses, been associated with a higher revision burden in young and highly active patients, and graft diameter can be unpredictable in smaller patients. QT autograft was proposed specifically to combine a mechanically robust, reproducibly large-diameter graft with a donor site remote from the patellar tendon-fat pad complex, and contemporary harvest instrumentation has made procurement more standardised and less invasive than in earlier descriptions.

This review synthesises the published literature on QT autograft for primary and revision ACL reconstruction: its biomechanical and anatomical rationale, harvest technique, comparative clinical and patient-reported outcomes at two years and beyond, donor-site morbidity, graft maturation on MRI, failure and re-rupture rates, and its use in paediatric/adolescent and revision populations. It is a narrative synthesis of the published literature rather than a report of a single institutional series.

Graft Biomechanics and Surgical Anatomy

Cryosectional and cadaveric studies established that the quadriceps tendon is a thick, broad structure whose central third provides a graft with cross-sectional area and tensile properties comparable to, or exceeding, those of the patellar tendon and considerably larger than a

doubled hamstring strand [4]. Morphometric and biomechanical evaluation of the central quadriceps tendon confirmed adequate length and load-to-failure characteristics for cruciate reconstruction, while highlighting variability in thickness that necessitates individualised harvest planning [5]. Three-dimensional MRI reconstruction has since quantified this anatomical variability across sex and body habitus, informing preoperative graft-size prediction and harvest strategy [6]. Direct biomechanical testing of harvested QT grafts has confirmed structural properties adequate to withstand physiological in vivo loading during the early ligamentization period, supporting its biomechanical equivalence to BPTB and HT constructs (Table 1) [7]. Compared with a four-strand hamstring construct, the QT graft is obtained as a single broad strip rather than multiple smaller strands, reducing the risk of an undersized graft in patients with slender hamstrings and allowing the surgeon to titrate graft width against measured tunnel diameters at harvest.

Table 1: Comparative characteristics of the three principal ACL autograft options, drawn from biomechanical, anatomical, and pooled clinical-outcome literature [4,5,7,15,18].			
Characteristic	Quadriceps tendon	Bone-patellar tendon-bone	Hamstring tendon
Graft form	Single broad strip, +/- bone block	Bone-tendon-bone	Doubled/quadrupled strands
Cross-sectional area	Large, adjustable at harvest	Moderate, fixed by tendon width	Variable, sometimes undersized
Bone-to-bone healing	Only with bone-block variant	Yes, both ends	No
Pooled 2-year Lysholm/IKDC vs BPTB	No significant difference	Reference	No significant difference
Donor-site morbidity vs BPTB	88% lower odds	Reference (highest)	69% lower odds

Harvest Technique

QT graft can be harvested as an all-soft-tissue strip or with

an attached patellar bone block, through open or minimally invasive incisions. A minimally invasive technique using a specialised cutting guide allows harvest of a full- or partial-thickness tendon graft, with or without a bone block, through a short proximal incision that avoids violating the joint or extensor mechanism insertion [8]. Full- versus partial-thickness harvest has not been shown to alter clinical outcomes, giving surgeons flexibility to tailor graft thickness to tunnel requirements. Bone-block fixation permits interference-screw fixation analogous to BPTB, while all-soft-tissue harvest allows suspensory cortical fixation and eliminates patellar fracture risk, at the cost of relying on soft-tissue tunnel healing. Because the harvest incision sits proximal to the joint line, the technique is compatible with concomitant meniscal, cartilage, and multiligament procedures, and avoids disturbing the patellar tendon should a future revision require a BPTB salvage graft.

Comparative Clinical Outcomes: Two-Year Evidence Base

A substantial body of randomised and cohort comparisons now exists (Table 2). Early series comparing QT-bone constructs with BPTB found equivalent IKDC and Lysholm outcomes at two years, with reduced anterior knee pain in the QT group [9,10]. A prospective randomised trial directly comparing QT and patellar tendon autografts found comparable stability, laxity, and functional scores, with less donor-site morbidity favouring QT [11]. Comparable equivalence was reported using a quadriceps-versus-patellar-bone construct in Korean cohorts [12]. Comparative work against HT autograft has similarly found no meaningful clinical difference: a two-year patient-reported outcome study found no difference in KOOS, IKDC, or Lysholm scores between QT and HT [13], while a longer 3.6-year comparative study reported broadly similar clinical performance between the two soft-tissue grafts [14]. The

largest synthesis to date, pooling 27 studies and 2,856 patients, found no significant difference between QT and BPTB in Lysholm score, subjective IKDC, laxity, or graft failure, but significantly less donor-site pain with QT (risk ratio 0.25), and a modest but statistically significant Lysholm advantage for QT over HT (mean difference 3.81 points) [15]. A subsequent meta-analysis restricted to QT-versus-HT comparisons corroborated statistical equivalence in IKDC, Tegner, and graft-failure outcomes [16], and a further large meta-analysis of QT against both alternative grafts reached concordant conclusions [17]. Across these syntheses, QT reconstructs knee stability and restores patient-reported function indistinguishable from BPTB or HT, such that graft selection can reasonably be guided by secondary considerations — donor-site morbidity, fixation preference, revision-graft availability, and surgeon experience — rather than an expected difference in two-year outcome scores.

Table 2: Selected comparative studies of quadriceps tendon (QT) autograft reviewed here [11,12,9,13,14,19,23,26].				
Study	Comparison	Design	Follow-up	Key outcome
Lund 2014	QT vs BPTB	RCT	2 years	Comparable stability/function; less donor-site pain with QT
Han 2008	QT vs BPTB	Comparative cohort	2 years	Equivalent IKDC/Lysholm outcomes
Kim 2009	QT-bone vs BPTB	Comparative cohort	2 years	Equivalent outcomes; less anterior knee pain
Runer 2018	QT vs HT	Prospective cohort	2 years	No difference in KOOS, IKDC, Lysholm
Cavaignac 2017	QT vs HT	Comparative cohort	3.6 years	Broadly similar clinical performance
Barie 2020	QT-bone vs BPTB	RCT	10 years	~90% good/excellent Lysholm both; more BPTB kneeling pain
Yang 2024	QT vs BPTB vs HT	Registry cohort	Up to 4 years	No QT vs BPTB/HT difference in revision risk
Meena 2025	QT vs HT	Retrospective cohort	Not stated (pediatric/adolescent)	Comparable recovery, revision, sports return

Donor-Site Morbidity

Donor-site morbidity is the outcome domain most consistently favouring QT. A network meta-analysis of 21 randomised trials (1,726 patients) found 88% lower odds of donor-site morbidity with QT and 69% lower odds with HT, each relative to BPTB (Figure 1) [18]. Ten-year follow-up of a randomised QT-versus-BPTB cohort using hardware-free press-fit fixation found comparable long-term stability and function (approximately 90% good-to-excellent Lysholm outcomes in both groups) but significantly greater persistent pain on kneeling and squatting in the BPTB group at both one and ten years [19]. These findings are consistent with the anterior knee pain profile documented in the earliest QT clinical series [10] and support QT as the graft with the lowest harvest-related morbidity among the three principal options. Quadriceps strength deficit is the morbidity most specific to QT harvest: early postoperative activation deficits are typically more pronounced than after hamstring harvest, though this has not been shown to translate into inferior strength, hop-test performance, or functional scores by two years, when symmetry indices generally converge across graft types.

Graft Maturation on MRI

Sequential MRI provides a non-invasive window into graft ligamentization. In adolescent athletes, QT autograft signal-intensity characteristics on MRI at one year differed from those of HT autograft, reflecting graft-specific remodelling trajectories rather than a uniform maturation timeline across graft types [20]. In skeletally immature athletes undergoing QT reconstruction, concomitant lateral extra-articular tenodesis was associated with improved graft maturity on MRI at two years, suggesting that adjunct extra-articular procedures may favourably influence the biological remodelling of QT grafts in high-risk younger patients [21]. These imaging findings

complement, but do not yet fully explain, the comparative clinical failure-rate differences discussed below. Because graft maturation on MRI has not consistently correlated with clinical laxity or subjective outcome in mixed-graft cohorts, such findings are best regarded as hypothesis-generating markers of remodelling rather than validated criteria for individualising return-to-sport timing after QT reconstruction.

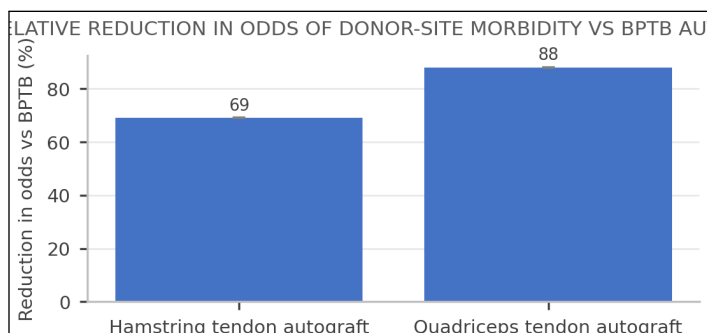


Figure 1: Relative reduction in the odds of donor-site morbidity for hamstring tendon (69%) and quadriceps tendon (88%) autografts compared with bone-patellar tendon-bone autograft, from a network meta-analysis of 21 randomised controlled trials (1,726 patients) [18].

Graft Failure, Re-Rupture, and Return to Sport

Re-rupture is the outcome of greatest concern in young, high-demand patients. A meta-analysis of 15 studies (611 QT, 543 HT patients) found a significantly lower pooled re-rupture rate with QT than HT (2.5% vs 8.7%; Figure 2) [22]. However, a large United States registry cohort of 21,973 primary ACL reconstructions found no significant difference in revision risk between QT and either BPTB (hazard ratio 1.06) or HT (hazard ratio 0.62), while HT carried significantly higher revision risk than BPTB (hazard ratio 1.52), underscoring that graft-specific failure risk estimates vary with study design, population, and surgical technique [23]. A systematic review focused specifically on outcomes at five years or later concluded that long-term comparative data for QT remain insufficient to firmly recommend it over HT or BPTB, despite favourable shorter-term signals [24]. Systematic review of adverse events after primary QT reconstruction

has not identified an excess complication burden relative to historical alternative-graft series [25]. Return-to-sport reporting across the QT literature remains heterogeneous in definition and timepoint, so pooled rates should be interpreted cautiously until reporting is standardised.

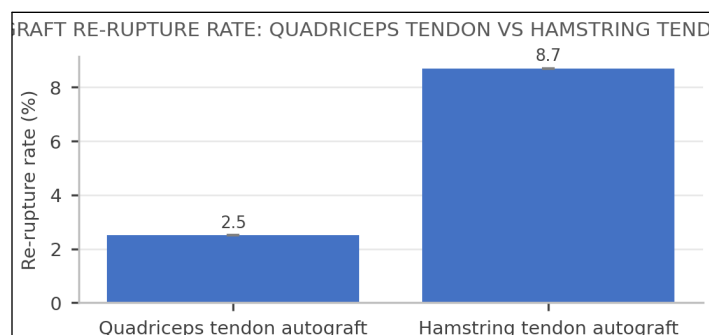


Figure 2: Pooled graft re-rupture rate for quadriceps tendon (2.5%) versus hamstring tendon (8.7%) autograft, from a meta-analysis of 15 studies (611 quadriceps tendon and 543 hamstring tendon patients) [22].

Paediatric/Adolescent and Revision Applications

In skeletally immature and adolescent patients, a retrospective cohort comparison of QT and HT autografts found comparable functional recovery, revision rates, and return to sports participation, supporting QT as a viable option in this population when physeal-sparing technique is used [26]. In the revision setting, all-soft-tissue QT autograft has produced acceptable early and intermediate-term patient-reported outcomes after failed primary reconstruction [27], with comparable outcomes to BPTB autograft in revision ACL reconstruction among athletes at a minimum two-year follow-up [28]. Collectively, these data support QT as a versatile graft across the age and revision-complexity spectrum, complementing rather than replacing BPTB and HT. In skeletally immature patients, physeal-sparing or partial-transphyseal harvest avoids the epiphyseal disruption risk of certain bone-block grafts, while extra-articular tenodesis augmentation may help mitigate the higher baseline re-injury risk in younger patients returning to pivoting sport.

Conclusion

Three decades after its reintroduction as an alternative cruciate reconstruction graft [2], quadriceps tendon autograft has accumulated a robust two-year comparative evidence base demonstrating functional outcomes equivalent to bone-patellar tendon-bone and hamstring tendon autografts, together with a consistently favourable donor-site morbidity profile and, in several meta-analyses, a lower pooled re-rupture rate than hamstring tendon autograft. Its role in paediatric, adolescent, and revision ACL reconstruction is expanding on the strength of encouraging cohort data. The principal evidence gap is long-term durability beyond five years, where comparative data remain sparse; continued long-term follow-up and standardised outcome reporting across graft types should further clarify where quadriceps tendon autograft fits within contemporary ACL reconstruction practice.

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