BS Structured Summary

Article: Quadriceps vs. Hamstring in Adolescent ACLR — Graft Rupture and Subsequent Meniscal Tear

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Structured Summary: Quadriceps vs. Hamstring in Adolescent ACLR — Graft Rupture and Subsequent Meniscal Tear

Original Article: Differences in Graft Rupture and Subsequent Meniscal Tears Following Adolescent ACL Reconstruction Using Quadriceps Tendon Versus Hamstrings Autograft — A Retrospective Study With Minimum 2-Year Follow-up

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Journal: OJSM – Orthopaedic Journal of Sports Medicine

Year: Vol. 14, Issue 3 — March 2026, article 23259671251414139

DOI: 10.1177/23259671251414139

INTRODUCTION / BACKGROUND

Anterior cruciate ligament (ACL) ruptures are among the most common knee injuries in the adolescent population, with the per capita incidence of ACL reconstruction (ACLR) peaking around 175 per 100,000 individuals at ages 16-17. Rates of ACL injury in young patients have been on a consistent rise over recent decades, partly associated with early sports intensification and sports specialization, which underscores the urgent need for high-quality outcomes research in this demographic.

The literature demonstrates that ACLR with autograft in adolescents offers good functional outcomes and high return-to-sport rates. However, studies consistently find significantly higher graft rupture rates in adolescents and young adults compared with older adults. The estimated graft rupture risk decreases by approximately half between ages 16 and 30. In the STABILITY trial (Getgood et al.), in patients <25 years treated with hamstring autograft, 11% had graft rupture at 2 years — and the clinical failure rate (rupture or significant rotatory laxity) reached 40% in the subgroup without lateral extra-articular procedure. Cruz et al.'s meta-analysis estimated 16.6% rupture in patients ≤19 years with hamstring graft.

In contrast, progressive studies have shown promising early- and mid-term results for ACLR with quadriceps tendon (QT) autograft in adolescents, with meta-analyses identifying rupture rates around 7.5%. Direct comparisons suggest lower rupture rates and better functional outcomes for QT versus hamstring (HS), fueling growing interest in quadriceps use in this age group. Prior research has also identified a protective effect of ACLR against subsequent

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meniscal injuries, evidencing that the ACL-deficient knee has increased risk of injury to secondary stabilizers, including the menisci.

Given this scenario, both graft rupture itself and subsequent meniscal tear may be signs of ACL graft insufficiency. Because most studies focus only on graft rupture as a failure marker, true insufficiency rates may be underestimated. The aim of this Children's Hospital of Philadelphia study was to determine both graft rupture rate and subsequent meniscal tear rate in adolescent patients undergoing ACLR with HS or QT autograft, hypothesizing that QT would be associated with lower rates of both outcomes.

OBJECTIVE

To compare graft rupture rates and subsequent meniscal tear rates after adolescent ACL reconstruction using hamstring tendon (HS) autograft versus quadriceps tendon (QT) autograft.

METHODS

Retrospective review of adolescent patients (10-19 years) undergoing ACLR with HS or QT autograft between 2009 and 2023 at an urban tertiary pediatric care hospital (CHOP). After institutional board approval, demographic, anthropometric, injury, surgical, and follow-up data were cataloged. Exclusion criteria: <2 years of clinical follow-up, congenital ACL absence, or reconstruction with a graft other than HS or QT.

Follow-up events evaluated: ACL graft rupture, subsequent isolated meniscal tear (without graft rupture), and composite outcome (any rupture or new meniscal tear). All events were confirmed by MRI. Subsequent meniscal tear was defined as new tear (if meniscus was stable during primary ACLR) or retear (if the same meniscus had been injured and repaired at primary surgery).

Surgical details: five surgeons contributed cases. Prior to 2020, HS with bilateral suspensory fixation was the standard service technique — 4-strand graft with folded-over gracilis and semitendinosus. In occasional cases, one or both tendons were tripled to increase graft diameter. From 2020 onward, due to accumulated evidence of lower failure rates, the service migrated to routine use of QT with bilateral suspensory fixation. All QT cases were all-soft tissue (without bone block), typically harvested 10 mm wide, partial thickness, resulting in final diameter 9-11 mm. There was no allograft supplementation in any case.

Statistical analysis: descriptive statistics; chi-square and Fisher exact tests for categorical variables; t-tests for normally distributed continuous variables; Mann-Whitney U for non-normal continuous variables. Multivariable logistic regression with backward selection (retention threshold $P \leq 0.20$) was performed to evaluate the relationship between graft failures and relevant variables. Statistical significance at $P < 0.05$.

MAIN RESULTS

Between 2009 and 2023, 2,115 patients aged 10-19 years underwent ACLR with HS or QT autograft at CHOP. After exclusion of 1,647 with <2 years follow-up and 1 with congenital ACL

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absence, 467 patients (22.1% of initial population) were included. Characteristics: 52.0% female, mean age 14.6±1.9 years, median follow-up 3.1 years (range 2.0-13.4). Majority white (69.8%). HS was used in 67.5% of cases and QT in 32.5%. Concomitant meniscal tear at primary surgery was present in 73.7% of the cohort.

Subgroup differences: the QT group more frequently received concomitant anterolateral ligament (ALL) reconstruction or lateral extra-articular tenodesis (LET) (9.2% vs. 1.3%; p<0.001), slightly older age (14.9 vs. 14.5; p=0.04), higher baseline BMI (22.3 vs. 21.7 kg/m²; p=0.01), shorter follow-up (2.8 vs. 3.4 years; p<0.001), and higher frequency of concomitant medial meniscal tear (33.6% vs. 24.8%; p=0.047). All-epiphyseal technique was more common in the HS group (17.5% vs. 2.6%; p<0.001).

Central finding: graft rupture occurred in 84 patients (18.0%), with significantly lower rate in the QT subgroup (7.2% vs. 23.2%; p<0.001) — a difference of more than 3-fold in favor of quadriceps. Subsequent isolated meniscal tear (without graft rupture) occurred in 36 patients, with trend toward lower QT (4.6% vs. 9.2%; p=0.08; half the rate, but without statistical significance). The composite outcome (rupture or subsequent meniscal tear) was experienced by 120 patients (25.7%), also significantly lower with QT (11.8% vs. 32.4%; p<0.001).

Temporal analysis: 86.9% of all graft failures occurred within the first 2 years of primary ACLR. Median time to failure was similar between QT and HS (1.71 vs. 1.77 years; p=0.53). Contralateral ACL injury during follow-up occurred in 95 patients (20.3%), with no significant difference between groups (17.8% QT vs. 21.6% HS; p=0.34).

Multivariable regression: adjusting for other variables, QT use was protective against graft rupture (OR 0.29; p<0.001). Follow-up time (OR 1.16; p=0.045) and lateral meniscal repair at index surgery (OR 0.52; p=0.02) were also predictors. For isolated subsequent meniscal tear, the only statistically significant predictor was concomitant medial meniscal tear at index surgery (OR 2.99; p=0.002). For the composite outcome, QT was protective (OR 0.33; p<0.001), lateral meniscal repair was protective (OR 0.54; p=0.01) and follow-up time was a predictor (OR 1.20; p=0.01). Post-hoc power analysis demonstrated that >1,100 patients would be required to detect a difference in subsequent meniscal tear with 80% power.

AUTHORS' CONCLUSION

Adolescent patients undergoing ACLR with QT autograft have a significantly lower risk of graft rupture compared with those treated with HS autograft (7.2% vs. 23.2%; OR 0.29). Lateral meniscal repair at index surgery and follow-up length were also predictors of rupture. The observed difference in subsequent meniscal tear between QT and HS did not reach statistical significance, although the observed QT rate was approximately half that of HS. Concomitant medial meniscal tear at index surgery was a predictor of subsequent meniscal tear. These findings support the theory that QT graft is more effective in conferring knee stability after ACLR in adolescents.

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💬 BS DISCUSSION

This paper from CHOP — a world reference institution in pediatric sports medicine — delivers a striking data point for those who operate on adolescent ACL: 23.2% graft rupture with HS versus 7.2% with QT, in the same service, with the same surgeons, adjusted for confounders. This is more than a 3-fold difference — a magnitude rarely seen in adult graft comparison literature. Children's Hospital institutionally migrated from HS to QT in 2019-2020 exactly because of this pattern, and the current publication retrospectively systematizes the impact of that change. For BS, the reflection is worth making: is our practice with adolescents aligned with this evidence? Are we preferentially offering QT to skeletally immature patients or adolescents with high athletic demand?

The second provocative finding is the trend (not significant, but clinically important) of lower subsequent meniscal tears in the QT group (4.6% vs. 9.2%). The authors argue — correctly, in my view — that this may reflect more effective rotational stability of the QT graft, not just meniscal healing failure. When the graft is insufficient, even without frank rupture, subtle micro-instabilities demand more from secondary stabilizers (menisci), leading to new injuries. This interpretation is supported in the cited literature (Sanders 2016, Csintalan 2014, Kimura 2020): a functional ACLR protects the menisci. The study was underpowered to detect this difference (>1,100 patients would be needed), but the signal is there. Combined with the reduction in frank ruptures, it strongly suggests a superior "reconstruction quality" with QT.

The risk factor analysis is worth highlighting with practical implications. The strongest predictor of subsequent meniscal tear was concomitant medial meniscal tear at index surgery (OR 2.99; p=0.002). This reinforces extra care with medial meniscal repair in adolescents — a patient who arrives with associated medial injury along with the ACL has nearly 3-fold risk of new meniscal event. Lateral meniscal repair had an unexpected protective effect against graft rupture (OR 0.52; p=0.02). The authors speculate this may reflect a more severe initial injury pattern (with greater pivot-shift displacement) that motivated lateral repair; alternatively, peripheralization of the lateral meniscus through repair could negatively affect its stabilizing function. The explanation remains open and deserves investigation. For BS clinical practice: patients with concomitant medial meniscal tear need more careful counseling about risk of new meniscal event — and perhaps a more conservative rehabilitation protocol.

For BS practice, some practical points deserve attention. First: the study describes all-soft tissue QT grafts (without bone block) 10mm wide, partial thickness, final diameter 9-11mm. This is the CHOP standardized technical "recipe" that supports the published results — worth referencing when discussing technical standardization in our labs.

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Second: the fact that 86.9% of failures occur in the first 2 years reinforces that more rigorous follow-up through 24 months is mandatory. Third: the contralateral ACL injury rate of 20.3% (equal between groups) is a brutal reminder — in 1 of every 5 adolescents operated, the contralateral ACL will also rupture. Graft choice does not change this. Graft choice influences the ipsilateral; the contralateral is a function of the patient (biomechanics, neuromuscular, predisposition). This changes the preoperative conversation and the postoperative neuromuscular prevention strategy.

Important limitations should temper interpretation. Single-center, retrospective study, with 78% of eligible patients excluded for insufficient follow-up (potential selection bias — problematic patients tend to return). Follow-up was systematically shorter in the QT group (2.8 vs. 3.4 years) because the technical migration was recent — although multivariable analysis controls for this, there may be residual effect. The QT group had more concomitant ALL/LET procedures (9.2% vs. 1.3%), which can confound part of the protective effect (literature cited by the authors via Laboudie 2022 and Sonnery-Cottet 2018 shows ALL/LET reduces graft failure). There is also demographic difference (QT older, higher BMI) reflecting the evolution of the patient profile. There were no data on HS graft diameter — a recognized risk factor. For BS Papers, the recommendation stands: treat this study as strong evidence in favor of QT for the adolescent age group, but recognize that comparative pediatric RCT is still needed. Meanwhile, this and other CHOP papers (Bram 2021, DeFrancesco 2020, Petit 2024) consolidate a coherent body of evidence, and the international trend is moving increasingly toward QT in patients <18 years with high athletic demand.

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