College of Human Medicine
MICHIGAN STATE UNIVERSITY

Autograft Selection for ACL Reconstruction in Patients Younger Than 20: A Systematic Review and Meta-Analysis

Griffin Gleeson, Charles Woodhams, Adam Haddad, Brian Tani, Humza Salim, Nicolas Medel, Micah Lissy

Michigan State University College of Human Medicine

Background

- ACL reconstruction in children and adolescents is increasing, making graft choice a key surgical decision
- About 1 in 4 young athletes who return to sport sustain a second ACL injury[1]
- Prior meta-analyses are mostly adult, and none has pooled head-to-head QT, HT, and BPTB data in patients under 20[2]

Index Autografts

QT
Quadriceps tendon
Large diameter, favorable donor site

HT
Hamstring tendon
Familiar technique, less anterior knee pain

BPTB
Bone-patellar tendon-bone
Bone-to-bone healing, lower revision risk

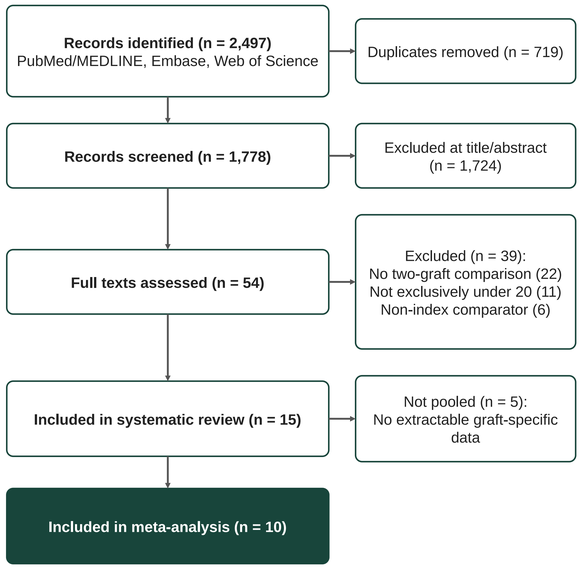
Objective & Hypothesis

- **Objective:** compare graft failure and strength symmetry among QT, HT, and BPTB autografts in patients under 20
- **Hypothesis:** graft choice is associated with meaningful differences in both

Methods

- **Design:** systematic review and meta-analysis following PRISMA 2020[3]
- **Search:** PubMed/MEDLINE, Embase, Web of Science (2006–2026)
- **Inclusion:** age under 20, primary ACLR, at least two index autografts compared within the same cohort
- **Outcomes:** graft failure (risk ratio) and quadriceps and hamstring limb symmetry index (LSI, mean difference)
- **Analysis:** DerSimonian-Laird random effects with HKSJ 95% CI as primary inference
- **Risk of bias:** ROBINS-I, two independent reviewers

Study Selection



Included Studies

15 studies | 2014–2026 | Level II–IV evidence

Study	Design	N	Grafts
Persson 2014	Pro cohort	3,719*	HT vs BPTB
Nelson 2016	Retro cohort	534	HT vs BPTB vs Allo
Dekker 2017	Retro cohort	85	HT vs BPTB vs Hybrid
Ekeland 2020	Retro cohort	3,790*	HT vs BPTB
Ouweleen 2021	Retro case-control	378	QT vs HT vs BPTB
Weaver 2022	Retro cohort	201	QT vs HT
Kilkenny 2022	Retro comparative	358	HT vs BPTB
Kay 2023	Cross-sectional	119	QT vs HT
Rakauskas 2023	Pro comparative	68	QT vs HT
Bram 2024	Retro cohort	84	QT vs HT
Greenberg 2024	Retro cohort	75	QT vs HT
Rigamonti 2024	Retro cohort	272	HT vs BPTB
Meena 2025	Retro cohort	157	QT vs HT
Rakauskas 2025	Pro comparative	54†	QT vs HT
Swanson 2026	Retro cohort	467	QT vs HT

*Shaded rows were included in the meta-analysis. *Adolescent subgroup. †Completed follow-up. Allo, allograft. Pro, prospective. Retro, retrospective.*

Secondary Outcomes

- **Return to sport:** high and similar across grafts, about 9–11 months to return[4,5]
- **Patient-reported outcomes:** mostly no difference between grafts
- **Complications:** more wound or infection events with QT in one study (20.0% vs 2.3%)[5]

Results

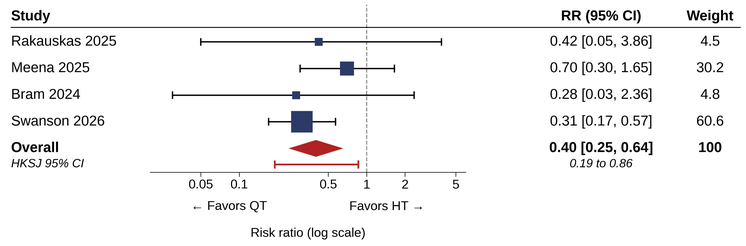
Graft Failure: QT vs HT
RR 0.40
95% CI 0.19–0.86 | Favors QT
Significant (P = .032)

Graft Failure: HT vs BPTB
RR 3.22
95% CI 0.96–10.78 | Favors BPTB
Not significant (P = .053)

Quadriceps LSI: QT vs HT
−9.5 pts
95% CI −14.6 to −4.5 | Favors HT
Significant (P = .009)

Hamstring LSI: QT vs HT
+2.7 pts
95% CI −4.6 to 9.9 | Isokinetic
Not significant (P = .254)

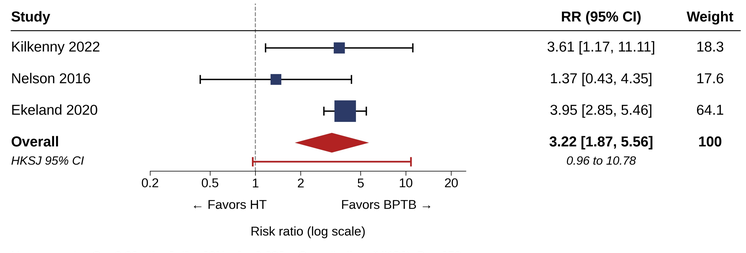
Figure 1. Graft failure, QT vs HT



Heterogeneity: Q = 2.41, df = 3, I² = 0%, τ² = 0. Overall effect (HKSJ): P = .032

Largest cohort (Swanson 2026[6]) carried 61% of the weight. Direction favored QT in every leave-one-out iteration.

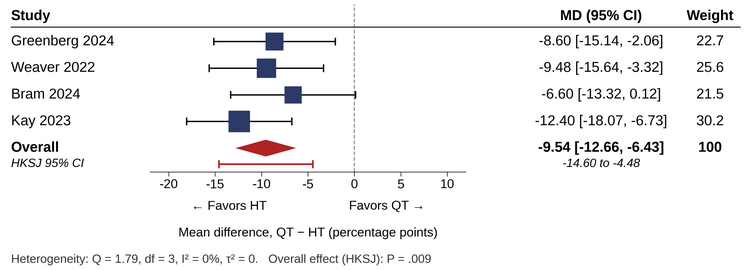
Figure 2. Graft failure, HT vs BPTB



Heterogeneity: Q = 2.99, df = 2, I² = 33%, τ² = 0.093. Overall effect (HKSJ): P = .053

Driven by the Norwegian registry (Ekeland 2020[7], 64% of the weight). Excluding it: RR 2.24 (0.87–5.79).

Figure 3. Quadriceps LSI, QT vs HT



Heterogeneity: Q = 1.79, df = 3, I² = 0%, τ² = 0. Overall effect (HKSJ): P = .009

Lower quadriceps symmetry with QT in all four studies. Fewer QT patients reached 90% symmetry by 12 months.[8]

Conclusions

- No single best graft: selection is a trade-off
- **QT:** lower failure than HT, but weaker quadriceps at 6–12 months
- **HT:** higher failure than QT, with a trend toward higher failure than BPTB
- **BPTB:** durable, but physeal and donor-site concerns
- Individualize by skeletal maturity and sport demands, with quadriceps-focused rehab after QT

Limitations

- Only 3–4 studies per outcome, mostly retrospective
- HT vs BPTB driven by one national registry
- Strength data limited to the first postoperative year

References

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Acknowledgements

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