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Brinkman JC,  
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Economopoulos KJ

# Quadriceps Tendon (QT) ACL Reconstruction Scientific Update

A review of the design rationale, techniques, and outcomes

QT ACL reconstruction (ACLR) continues to be one of the fastest growing ACLR techniques performed worldwide. The clinical benefits of the QT technique—including robust and predictable graft sizing, superior biomechanics, equal or better clinical outcomes, low morbidity, and improved cosmesis—are now supported in a number of clinical and biomechanical studies and systematic reviews. This update summarizes the scientific support for successful outcomes with the QT technique.

## In Vivo Studies: Clinical Outcomes

ACL reconstruction with quadriceps soft tissue autograft versus bone-patellar tendon-bone autograft in cutting and pivoting athletes: outcomes at minimum 2-year follow-up. *Orthop J Sports Med.* 2023;11(9):23259671231197400. doi:10.1177/23259671231197400

- Retrospective review comparing clinical outcomes in young cutting and pivoting athletes following ACLR with QT autograft versus bone-patellar tendon-bone (BPTB) autograft.
- 68 athletes (32 QT, 36 BPTB) participating in soccer, American football, lacrosse, or basketball were included in the analysis. Average age was 17.6 years for QT patients and 18.3 years for BPTB patients.
- The 2-year IKDC score (QT, 90.5 vs BPTB, 89.7) and Lysholm score (QT, 91.2 vs BPTB, 90.5) were similar between both groups. The percentage of athletes able to return to sports within the follow-up period was also similar (QT 88% vs BPTB 83%). The BPTB group had a 6% retear rate, while QT had 0 retears.
- There were 4 contralateral ACL ruptures (11%) and 4 patients requiring lysis of adhesions for arthrofibrosis (11%) in the BPTB group. QT resulted in a single contralateral ACL tear (3%) and fewer cases of arthrofibrosis (6%).

## Takeaway

QT autograft resulted in an earlier return to sport, similar patient-reported outcomes, lower retear rate, and fewer postoperative complications compared to BPTB autograft.



Petit CB,  
Slone HS,  
Diekfuss JA,  
Barber Foss KD,  
Warren SM,  
Montalvo AM,  
Lamplot JD,  
Myer GD,  
Xerogeanes JW

[Sex-specific outcomes after anterior cruciate ligament reconstruction using an all-soft tissue quadriceps tendon autograft in a young active population.](#) *Am J Sports Med.* 2024;52(10):2450-2455. doi:10.1177/03635465241262018

- Clinical outcomes following ACLR with all-soft-tissue quadriceps tendon (ASTQT) were compared between active young males and females.
- 395 patients (174 males, 221 females; avg age, 17.8 years) with a mean follow-up of 73 months were included.
- ASTQT resulted in a high RTS (male, 87.7%; female, 82.8%). Male and female patients had similar rates of revision ACLR (male, 12.6%; female, 10%) and contralateral ACL injuries (male, 13.8%; female, 11.3%).
- Both male and female patients demonstrated a high return-to-sport rate and similar rates of ipsilateral and contralateral ACL injuries.

#### Takeaway

“These results help one to better understand the utility of ASTQT grafts to support successful ACLR in young athletic populations, for which ASTQT grafts appear to yield favorable outcomes.”

Daniel AV,  
Smith PA

[Primary all-soft tissue quadriceps tendon autograft anterior cruciate ligament reconstruction with suture tape augmentation resulted in satisfactory patient outcomes and a low graft failure rate in high school and collegiate athletes.](#) *Arthroscopy.* Published online March 20, 2024. doi:10.1016/j.arthro.2024.02.047

- This retrospective case series evaluated patient outcomes in skeletally mature high school and college athletes after primary ACL reconstruction using an all-soft-tissue QT autograft augmented with suture tape.
- A total of 60 athletes with a mean age of 16 years and average final follow-up of 37 months were included.

#### Takeaway

Patients demonstrated promising postoperative outcomes, **most notably the 0% rerupture rate.** Additionally, at 7.5 months **90% of patients had returned to an equivalent level of competition,** 80% of whom returned to pivoting sports.



Lavender CD,  
Schaver AL,  
Taylor S,  
Peluso R,  
Berdis G,  
Singh V,  
Cipriani K,  
Jasko J,  
Hewett TE

[Anterior cruciate ligament \(ACL\) reconstruction augmentation with bone marrow aspirate, demineralized bone matrix, and suture tape demonstrates no difference in outcomes, but faster functional recovery, versus non-augmented ACL reconstruction.](#) *Arthroscopy*. 2024 Jul 22;S0749-8063(24)00492-4. doi:10.1016/j.arthro.2024.06.042

- Level II randomized controlled trial comparing patient outcomes following standard ACLR versus biologically augmented ACLR with concentrated BMA (cBMA), demineralized bone matrix (DBM), and the *InternalBrace*™ procedure.
- 59 patients with a minimum 2-year follow up underwent all-inside ACLR with either QT autograft (43) or FGL allograft (16) depending on skeletal maturity (< 25 years old = QT autograft; > 25 years old = allograft). 29 ACLRs included cBMA, DBM and *InternalBrace* ligament augmentation repair. (Group A), while 30 were performed in standard fashion (Group NA).
- 6-month CT scans revealed **significantly less bone tunnel enlargement** on average for patients in Group A compared to NA.

### Takeaway

Functional outcomes, including early ROM and limb symmetry, were significantly improved in patients who received biologically augmented ACLRs combined with suture tape augmentation. Both groups had similar IKDC scores (A = 91.05 vs NA = 85.32) and zero reruptures.

Hunnicutt JL,  
Haynes WB,  
Sloane HS,  
Prince JA,  
Boden SA,  
Xerogeanes JW

[The all-soft tissue quadriceps tendon autograft in revision ACL reconstruction: early and intermediate-term outcomes in 100 patients.](#) *Arthroscopy*. 2021;S0749-8063(21)00258-9. doi:10.1016/j.arthro.2021.03.035

- This retrospective review of prospectively collected data from consecutive patients sought to examine early- to intermediate-term clinical outcomes and complications of revision ACLR using QT autografts.
- One hundred patients undergoing revision ACLR with all-soft-tissue QT autografts were included. All procedures were performed by a single surgeon (Xerogeanes), using minimally invasive harvest technique and suspensory fixation.
- Importantly, in the patients with prior bone-patellar tendon-bone (BPTB) surgery, secondary insult to the extensor mechanism via QT autograft harvest does not adversely affect strength compared to patients with hamstring tendon (HT) autograft in the primary operation.

### Takeaway

It was concluded that revision ACLR using QT autografts has acceptable early- and intermediate-term outcomes with reasonable complication rates.

The *InternalBrace* surgical technique is intended only to augment the primary repair/reconstruction by expanding the area of tissue approximation during the healing period and is not intended as a replacement for the native ligament. The *InternalBrace* technique is for use during soft tissue-to-bone fixation procedures and is not cleared for bone-to-bone fixation.



Horstmann H,  
Petri M,  
Tegtbur U,  
Felmet G,  
Krettek C,  
Jagodzinski M

[Quadriceps and hamstring tendon autografts in ACL reconstruction yield comparably good results in a prospective, randomized controlled trial.](#) *Arch Orthop Trauma Surg.* 2021;10.1007/s00402-021-03862-8. doi:10.1007/s00402-021-03862-8

- This prospective, randomized controlled trial study compared functional outcomes after ACLR using HT and QT grafts with follow-up at 3, 6, 12, and 24 months.
- Both grafts demonstrated significantly improved knee stability measured by manual side-to-side displacement at all time intervals with no difference between the two study groups in muscle strength and outcome scores.
- Of note was that patients receiving a QT graft exhibited a faster average return to preinjury activity level than those receiving a HT graft, and patients receiving a QT graft did not exhibit any extension strength deficit.

#### **Takeaway**

The most important finding of this study was that QT grafts yield good results compared to HT grafts in primary autograft ACLR at 2-year follow-up.

Lind M,  
Strauss MJ,  
Nielsen T,  
Engelbrechtsen L

[Low surgical routine increases revision rates after quadriceps tendon autograft for anterior cruciate ligament reconstruction: results from the Danish Knee Ligament Reconstruction Registry.](#) *Knee Surg Sports Traumatol Arthrosc.* 2020;10.1007/s00167-020-06220-0. doi:10.1007/s00167-020-06220-0

- This study used data entered in the Danish Knee Ligament Reconstruction Registry (DKRR) from 2012 to 2019 to compare revision rates in patients who received ACLR with QT, HT, and PT grafts.
- The study determined that revision rates for QT autograft ACLR performed at high-volume clinics (>100 procedures) were significantly lower (2.9%) compared to low-volume clinics (0 to 100 procedures).

#### **Takeaway**

The authors concluded that the most important finding of the present study was that the high-volume clinics obtained similar revision outcomes for QT, HT, and PT grafts. This is in contrast with a recent study from the same authors that found a high revision rate for QT grafts compared with HT and PT grafts.



Runer A,  
Csapo R,  
Hepperger C,  
Herbort M,  
Hoser C,  
Fink C

[Anterior cruciate ligament reconstructions with quadriceps tendon autograft result in lower graft rupture rates but similar patient-reported outcomes as compared with hamstring tendon autograft: a comparison of 875 patients.](#) *Am J Sports Med.* 2020;48(9):2195-2204. doi:10.1177/0363546520931829

- This was a prospective Level 3 cohort study of 875 patients at 2-year follow-up to compare QT and HT autograft in terms of rates of graft and collateral ACL rupture as well as patient-reported outcome measures.
- The authors found that graft type, age group, and activity levels were significant predictors of the need for a revision surgery.
- “The odds of revision surgery were 5.5 times greater in children younger than 15 years than in adults older than 45 years, 3.6 times greater in patients with high activity levels than low activity levels, and 2.7 times greater in patients receiving an HT autograft as compared with a QT autograft.”

#### Takeaway

“Patients treated with HT autografts have a significantly higher, activity-dependent risk of revision surgery and experience more ipsilateral graft ruptures than subsequent contralateral ACL injuries when compared with patients treated with QT autografts.”

Lind M,  
Nielsen TG,  
Soerensen OG,  
Mygind-Klavsen B,  
Faunø P

[Quadriceps tendon grafts does not cause patients to have inferior subjective outcome after anterior cruciate ligament \(ACL\) reconstruction than do hamstring grafts: a 2-year prospective randomised controlled trial.](#) *Br J Sports Med.* 2020;54(3):183-187. doi:10.1136/bjsports-2019-101000

- This randomized controlled trial (RCT) evaluated QT or semitendinosus and gracilis (STG) HT grafts used for patients undergoing ACLR. The authors compared subjective outcome, knee stability, donor-site morbidity, and function.
- “At 2-year follow-up, there was no difference between the two graft groups regarding subjective patient outcome, knee stability and reoperations. Also, at 2 years, donor site symptoms were present in 27% of patients in the QT group and 50% of patients in the STG group. The donor site morbidity score was 14 and 22 for the QT and STG, respectively.”

#### Takeaway

The authors concluded that “QT graft for ACLR did not result in inferior subjective outcome compared with STG graft. However, QT graft was associated with lower donor site morbidity than STG grafts but resulted in more quadriceps muscle strength deficiency than hamstring grafts. Both graft types had similar knee stability outcome.”



Perez JR,  
Emerson CP,  
Barrera CM,  
Greif DN,  
Cade WH 2nd,  
Kaplan LD,  
Baraga MG

[Patient-reported knee outcome scores with soft tissue quadriceps tendon autograft are similar to bone-patellar tendon-bone autograft at minimum 2-year follow-up: a retrospective single-center cohort study in primary anterior cruciate ligament reconstruction surgery.](#)

*Orthop J Sports Med.* 2019;7(12):2325967119890063. doi:10.1177/2325967119890063

- This retrospective clinical study evaluated the clinical outcomes of primary ACLR using either a soft-tissue QT autograft or a BPTB autograft with a minimum 2-year follow-up.
- Of the 75 patients who met the inclusion/exclusion criteria, 50 patients completed the surveys at a mean follow-up of 33 months.

#### Takeaway

The authors concluded that there was no statistical difference in patient-reported knee outcomes or graft complication rates between the QT and BPTB autograft groups at a minimum 2-year follow-up after primary ACLR. This study highlights that the all-soft-tissue QT autograft may be a suitable graft choice for primary ACLR.

Todor A,  
Nistor DV,  
Caterev S

[Clinical outcomes after ACL reconstruction with free quadriceps tendon autograft versus hamstring tendons autograft. A retrospective study with a minimal follow-up two years.](#)

*Acta Orthop Traumatol Turc.* 2019;53(3):180-183. doi:10.1016/j.aott.2019.03.004

- This retrospective clinical study evaluated the clinical outcomes of single-bundle ACLR using either a free QT autograft or a quadrupled HT autograft with a minimum 2-year follow-up. Eighty-two patients met the inclusion/exclusion criteria, and 72 patients presented to the hospital for follow-up.
- The QT graft was used in 39 patients, and 33 patients received the HT graft. There was no significant difference between the groups for KT-1000 measurements, postoperative Lysholm, modified Cincinnati, or general SF-36 scores. Less side-to-side thigh diameter difference was seen in the QT group.

#### Takeaway

This study concluded that similar clinical outcomes, in terms of stability and subjective measures, can be achieved using either a free QT autograft or 4-strand HT autograft.

Tirupathi SY,  
Goyal D,  
Jvs V

[A comparative study on functional outcome of ACL reconstruction: quadriceps versus hamstring tendon autograft.](#) *JAJIS.* 2019;6(1):61-64. doi:10.1016/j.jajs.2018.09.005

- This comparative clinical study of 96 patients evaluated functional outcomes of ACLR between QT and HT autografts. Of the original 48 QT patients, 4 were lost to follow-up, and 6 of the original 48 HT patients were lost to follow-up at 12 weeks.
- The IKDC scores at the 2-year follow-up for the QT tendon group were 114 in 40 patients and 100 in 4 patients (mean IKDC score of 113). In the HT group, IKDC scores were 119 in 38 patients and 113 in 4 patients (mean IKDC score of 118).

#### Takeaway

This study showed no statistically significant difference between QT and HT autografts following ACLR.



Lee JK,  
Lee S,  
Lee MC

[Outcomes of anatomic anterior cruciate ligament reconstruction: bone-quadriceps tendon graft versus double-bundle hamstring tendon graft.](#) *Am J Sports Med.* 2016;44(9):2323-2329. doi:10.1177/0363546516650666

- This clinical study of 96 patients compared knee joint stability and functional outcomes of anatomic ACLR with double-bundle hamstring tendon (DBHT) and bone-quadriceps tendon (BQT) autografts.
- A variety of assessments were used, including “the manual laxity test, International Knee Documentation Committee subjective evaluation, Tegner activity score, modified Lysholm score, anterior knee pain questionnaire, KT-2000 arthrometer side-to-side difference, Cybex II isokinetic testing, and tunnel position evaluation by quadrant method.”

#### Takeaway

Anatomic ACLR with the BQT autograft demonstrated similar knee stability and functional outcomes scores compared to the DBHT autograft. The authors found better flexor muscle strength recovery in the quadriceps group, which may be a potential advantage of the BQT autograft for ACLR.

Buescu CT,  
Onutu AH,  
Lucaciu DO,  
Todora A

[Pain level after ACL reconstruction: a comparative study between free quadriceps tendon and hamstring tendons autografts.](#) *Acta Orthop Traumatol Turc.* 2017;51(2):100-103. doi:10.1016/j.aott.2017.02.011

- This clinical study of 48 patients compared pain levels and analgesic consumption after single-bundle ACLR with QT compared to HT autograft.
- “In the HT group, supplementary analgesic drug administration proved significantly higher, with a median (interquartile range) of 1 (1.3) dose, compared to the group of subjects treated with a quadriceps graft, median = 0.5 (0.1.25) (P = .009).”
- “A significantly higher number of subjects with a quadriceps graft did not require any supplementary analgesic drug (50%) as compared with subjects with a hamstring graft (13%).”

#### Takeaway

Patients in the QT group had less pain and less analgesic consumption in the immediate postoperative period compared with patients in the HT group.

Xerogeanes JW,  
Godfrey W,  
Gebrelul A,  
Premkumar A,  
Mignemi D,  
Gottschalk MB,  
Dalwadi P,  
Fellow R,  
Slone H

[Clinical outcomes of all soft tissue quadriceps tendon autograft in ACL reconstruction.](#) *Orthop J Sports Med.* 2017;5(7 suppl6):2325967117S00310. doi:10.1177/2325967117S00310

- This study prospectively followed 353 patients undergoing ACLR with QT autograft.
- There was no evidence of early graft failure or lengthening, reaffirming technique and graft choice is sufficient in young, athletic patient population.

#### Takeaway

Low complication and failure rates for those who received QT autograft compare favorably to existing literature on other graft options. The results of this study support using soft-tissue QT autograft in ACLR.



DeAngelis JP,  
Cote M,  
Fulkerson JP,  
Caminiti S

[Central quadriceps tendon for anterior cruciate ligament reconstruction: long-term results \(SS-33\). \*Arthroscopy\*. 2008;24\(6\)\(suppl\):e18. doi:10.1016/j.arthro.2008.04.033](#)

- This study describes the outcomes of ACLR using central quadriceps free tendon (CQFT) in 124 patients at a minimum of 2 years postreconstruction.

#### Takeaway

The authors concluded that “CQFT is a reliable, low-morbidity autograft for ACL reconstruction with stable outcomes at an average of 5+ years.”

Cavaignac E,  
Coulin B,  
Tscholl P,  
Nik Mohd Fatmy N,  
Duthon V,  
Menetrey J

[Is quadriceps tendon autograft a better choice than hamstring autograft for anterior cruciate ligament reconstruction? a comparative study with a mean follow-up of 3.6 years. \*Am J Sports Med\*. 2017;45\(6\):1326-1332. doi:10.1177/0363546516688665](#)

- This is a comparative study of 95 patients who underwent isolated ACLR; 50 patients underwent ACLR with QT and 45 underwent ACLR with HT.
- Of the 95 patients, 86 were reviewed with a mean follow-up of  $3.6 \pm 0.4$  years.
- Assessment methods included various parameters: surgical revision, functional outcomes, joint stability, anterior knee pain, and isokinetic strength.

#### Takeaway

The authors concluded that the “use of a QT graft in ACL reconstruction leads to equal or better functional outcomes than does the use of an HT graft, without affecting morbidity.”

Lund B,  
Nielsen T,  
Faunø P,  
Christiansen SE,  
Lind M

[Is quadriceps tendon a better graft choice than patellar tendon? a prospective randomized study. \*Arthroscopy\*. 2014;30\(5\):593-598. doi:10.1016/j.arthro.2014.01.012](#)

- This prospective, randomized controlled study compared quadriceps tendon-bone (QTB) and BPTB reconstructions.
- The study included 51 patients; 26 patients received QTB grafts and 25 received BPTB.

#### Takeaway

The authors concluded that use of QTB results in less kneeling pain, graft-site pain, and sensitivity loss than BPTB. Similar anterior knee stability and subjective outcome scores were reported.

Runer A,  
Wierer G,  
Herbst E,  
Heppinger C,  
Herbert M,  
Gföller P,  
Hoser C,  
Fink C

[There is no difference between quadriceps- and hamstring tendon autografts in primary anterior cruciate ligament reconstruction: a 2-year patient-reported outcome study. \*Knee Surg Sports Traumatol Arthrosc\*. 2018;26\(2\):605-614. doi:10.1007/s00167-017-4554-2](#)

- In this 2-year patient-reported outcomes study, 80 patients were evaluated; 40 patients underwent ACLR with QT and 40 underwent ACLR with HT.

#### Takeaway

There was no significant difference between PRO scores in either QT or HT autografts. Both QT and HT show acceptable and comparable PRO scores, thereby reaffirming QT as a reliable graft choice for primary ACLR.





Iriuchishima T,  
Ryu K,  
Okano T,  
Suruga M,  
Aizawa S,  
Fu FH

[The evaluation of muscle recovery after anatomical single-bundle ACL reconstruction using a quadriceps autograft.](#) *Knee Surg Sports Traumatol Arthrosc.* 2017;25(5):1449-1453. doi:10.1007/s00167-016-4124-z

- Twenty patients were included in the study and were evaluated for muscle recovery at pre-op and at 3, 6, 9, and 12 months post-op.
- No donor-site complications were reported.

#### Takeaway

Authors found that “anatomical single-bundle ACL reconstruction using a quadriceps autograft resulted in equivalent level of muscle recovery and knee stability when compared with previously reported ACL reconstruction using hamstrings tendon with no donor site complications.”

Geib TM,  
Shelton WR,  
Phelps RA,  
Clark L

[Anterior cruciate ligament reconstruction using quadriceps tendon autograft: intermediate-term outcome.](#) *Arthroscopy.* 2009;25(12):1408-1414. doi:10.1016/j.arthro.2009.06.004

- This clinical study of 191 patients (198 reconstructions) compared the intermediate-term outcomes of ACLR using BTBP graft, BQT, and QT.
- A variety of assessments were used, including a side-to-side comparison of range of motion, arthrometer values, presence of effusion, anterior knee pain, and numbness. The QT autograft showed significantly better results when compared to BTB with less anterior knee pain, less anterior numbness, a higher percentage of arthrometer measurements showing a side-to-side difference of 0 mm to 3 mm, and better extension.

#### Takeaway

This study concluded that ACLR using QT autograft, either with or without a bone plug, is an effective surgical option for reducing donor-site morbidity. The authors found that QT autografts produce “equivalent results when compared directly with BTB autografts in arthroscopically assisted ACLR.”

Ma Y,  
Murawski CD,  
Rahnemai-Azar AA,  
Maldjian C,  
Lynch AD,  
Fu FH

[Graft maturity of the reconstructed anterior cruciate ligament 6 months postoperatively: a magnetic resonance imaging evaluation of quadriceps tendon with bone block and hamstring tendon autografts.](#) *Knee Surg Sports Traumatol Arthrosc.* 2015;23(3):661-668. doi:10.1007/s00167-014-3302-0

- This comparative study evaluated 26 patients for potential differences associated with graft maturity on MRI between quadriceps tendon with BQT and HS autografts at 6 months after ACLR.
- The signal/noise quotient was calculated to evaluate the difference between BQT and HT autografts.

#### Takeaway

The QT tendon with bone block demonstrated better maturity when compared to HT at 6 months post-ACLR. The authors concluded that “this study is clinically relevant in that modifying the individual rehabilitation according to the extent of graft maturity may be necessary to optimize patient function and prevent re-injury of the ACL graft.”



Martin-Alguacil JL,  
Arroyo-Morales M,  
Martín-Gomez JL,  
Monje-Cabrera IM,  
Abellán-Guillén JF,  
Esparza-Ros F,  
Lozano ML,  
Cantarero-Villanueva I

[Strength recovery after anterior cruciate ligament reconstruction with quadriceps tendon versus hamstring tendon autografts in soccer players: a randomized controlled trial.](#) *Knee*. 2018;25(4):704-714. doi:10.1016/j.knee.2018.03.011

- A randomized controlled trial placed 56 patients into either the HT or QT group.

#### Takeaway

ACLR with QT graft demonstrated similar functional results with a better isokinetic hamstring/ quadriceps ratio compared to ACLR with HT graft.

### Systematic Reviews and Meta-analysis

[No increased complication rate with the use of soft tissue quadriceps tendon autograft for primary ACL reconstruction - a systematic review.](#) *Orthop Traumatol Surg Res*. Published online July 16, 2024. doi:10.1016/j.otsr.2024.103926

- Systematic review analyzing functional outcomes following primary ACL reconstruction (ACLR) using all-soft-tissue quadriceps tendon (s-QT) grafts in skeletally mature patients. These outcomes were then compared to those with other autografts, including HT and BPTB.
- Fourteen studies were eligible for review, including 3 randomized control studies and 11 non-randomized comparative studies. In total, 1543 patients with mean follow-up of 23.6 months underwent ACLR with either s-QT (682), HT (498) or BPTB (174).
- “There was no significant difference in functional outcome score, knee stability, and range of motion (ROM) between S-QT, HT and BPTB.” Failure rates were also similar among all graft options, with s-QT demonstrating an overall graft failure rate of 3%.

#### Takeaway

s-QT is a potentially advantageous graft choice for ACLR, resulting in less donor site morbidity without compromising functional outcomes compared to other autograft options.

[Quadriceps tendon autograft versus bone-patellar tendon-bone and hamstring tendon autografts for anterior cruciate ligament reconstruction: a systematic review and meta-analysis.](#) *Am J Sports Med*. 2021;3635465211030259. doi:10.1177/03635465211030259

- A meta-analysis comparing QT to BPTB and HT autografts for ACLR, including 24 randomized controlled trials and observational studies with data on 19,196 patients.
- The authors noted that surgical incisions to the anteromedial knee, including BPTB and HT harvest, are associated with an elevated risk of iatrogenic damage to the infrapatellar branch of the saphenous nerve, which innervates the skin of the anterior part of the knee, the proximal lateral part of the lower leg, and part of the knee joint, resulting in increased donor-site morbidity.

#### Takeaway

No significant differences were noted between QT and BPTB or HT in graft failure, IKDC scores, or side-to-side difference in stability. However, there was a significant reduction in donor-site morbidity in the QT group compared to both the BPTB and HT groups.

Khalefa MA,  
Aujla RS,  
Aslam N,  
Boutefnouchet T,  
D'Alessandro P,  
MacDonald PB,  
Malik SS

Dai W,  
Leng X,  
Wang J,  
Cheng J,  
Hu X,  
Ao Y



Crum RJ,  
Kay J,  
Lesniak BP,  
Getgood A,  
Musahl V,  
de Sa D

[Bone versus all soft tissue quadriceps tendon autografts for anterior cruciate ligament reconstruction: a systematic review.](#) *Arthroscopy.* 2021;37(3):1040-1052. doi:10.1016/j.arthro.2020.10.018

- This study examined existing literature for patient-reported and objective outcomes as well as complications after ACLR with bone-quad-tendon (B-QT) or soft tissue-quad tendon (S-QT) to further evaluate how both graft types perform.
- The work of 24 studies was evaluated after screening an initial 1346 for information about primary ACLR using QT.
- No differences were found in graft retear rates. The rate of B-QT patellar fracture in this review is like that of BPTB (0.2% to 2.3%)

#### Takeaway

The main findings were that B-QT patients demonstrated more postoperative rotatory instability, as assessed by pivot shift, than S-QT patients. Increased rotatory instability is associated with poorer patient outcomes.

Nyland J,  
Collis P,  
Huffstutler A,  
Sachdeva S,  
Spears JR,  
Greene J,  
Caborn DNM

[Quadriceps tendon autograft ACL reconstruction has less pivot shift laxity and lower failure rates than hamstring tendon autografts.](#) *Knee Surg Sports Traumatol Arthrosc.* 2020;28(2):509-518. doi:10.1007/s00167-019-05720-y

- HT autograft ACLR or QT autograft ACLR were searched in Embase and PubMed with appropriate inclusion criteria to compare QT and HT anterior laxity, pivot shift laxity, and failure rates.
- “Greater knee laxity and failure rates may be related to a combination of HT autograft diameter and configuration variability and fixation mode.”

#### Takeaway

The authors concluded QT autografts had less pivot shift laxity and lower failure rates than HT regardless of suspensory or compression femoral fixation.

Yang XG,  
Wang F,  
He X,  
Feng JT,  
Hu YC,  
Zhang H,  
Yang L,  
Hua K

[Network meta-analysis of knee outcomes following anterior cruciate ligament reconstruction with various types of tendon grafts.](#) *Int Orthop.* 2020;44(2):365-380. doi:10.1007/s00264-019-04417-8

- Meta-analysis (PubMed, Embase, CENTRAL) to compare short-term ( $\leq 2$ -year) ACLR outcomes of various tendon grafts for restoring knee stability and regaining preinjury activity levels.
- Included 32 trials involving 2962 patients and 17 grafts.
- BPTB autografts outperformed 4-strand HT autografts.
- While safe to use, nonirradiated allografts were found to provide lower knee stability compared to autografts.

#### Takeaway

The QTB autograft was recommended over BPTB and 4-strand HT autografts.



Mouarbes D,  
Menetrey J,  
Marot V,  
Courtot L,  
Berard E,  
Cavaignac E

[Anterior cruciate ligament reconstruction: a systematic review and meta-analysis of outcomes for quadriceps tendon autograft versus bone-patellar tendon-bone and hamstring-tendon autografts.](#) *Am J Sports Med.* 2019;47(14):3531-3540. doi:10.1177/0363546518825340

- A systematic search of the literature was performed to identify clinical studies relevant to ACLR with a QT autograft comparing to BPTB and HT.
- Twenty-seven studies including 2856 patients met the inclusion criteria and were included.
- Clinical and functional outcomes and graft survival rate were comparable between QT, BPTB, and HT autografts.

#### Takeaway

QT showed significantly better functional outcome scores compared to HT and significantly less harvest-site pain compared with BPTB.

Heffron WM,  
Hunnicuttl JL,  
Xerogeanes JW,  
Woolf SK,  
Slope HS

[Systematic review of publications regarding quadriceps tendon autograft use in anterior cruciate ligament reconstruction.](#) *Arthrosc Sports Med Rehabil.* 2019;1(1):e93-e99. doi:10.1016/j.asmr.2019.09.001

- This systematic review of publications focused on QT autografts in ACLR using qualitative and quantitative analysis. The authors sought to define regional variability, type of publication, level of evidence, journal of publication, and type of QT graft used.
- More than 60% (115 of 187) of the publications focusing on QT for ACLR were published after 2009, and 30% (56 of 187) were published in the last 3 years. Most articles (80%) were published in North America or Europe, with the United States leading all countries with 59 publications. The journals with the most publications were *Arthroscopy* (32), *Knee Surgery Sports Traumatology Arthroscopy* (25), and the *American Journal of Sports Medicine* (16). 72% of the clinical outcome studies were Level of Evidence III, and 14% were Level I or II.

#### Takeaway

The authors found increasing interest in the scientific evaluation of QT as a source of autograft tissue for ACLR. An increase in high-quality research will allow surgeons to feel more confident using QT as an autograft option during ACLR.

Kanakamedala AC,  
de Sa D,  
Obioha OA,  
Arakgi ME,  
Schmidt PB,  
Lesniak BP,  
Musahl V

[No difference between full thickness and partial thickness quadriceps tendon autografts in anterior cruciate ligament reconstruction: a systematic review.](#) *Knee Surg Sports Traumatol Arthrosc.* 2019;27(1):105-116. doi:10.1007/s00167-018-5042-z

- A systematic review comparing outcomes and complication profiles of ACLR between full-thickness (FT-Q) and partial-thickness (PT-Q) QT autografts.
- Twenty studies met the inclusion/exclusion criteria. "Due to heterogeneous reporting, data were not combined in a meta-analysis and were summarized descriptively."

#### Takeaway

"[T]here appeared to be no difference in outcomes or complications between either FT-Q or PT-Q in primary ACL-R. Moreover, primary ACL-R using QT autografts appears to have successful outcomes with a low rate of graft failure, irrespective of tendon thickness. While further comparative studies are needed to better delineate the optimal thickness of quadriceps tendon for primary ACL-R, these data suggest that, in primary ACL-R, either FT-Q or PT-Q is efficacious and, in the clinical setting, surgeons may be justified in using either graft thickness."



Hurley ET,  
Calvo-Gurry M,  
Withers D,  
Farrington SK,  
Moran R,  
Moran CJ

[Quadriceps tendon autograft in anterior cruciate ligament reconstruction: a systematic review.](#) *Arthroscopy*. 2018;34(5):1690-1698. doi:10.1016/j.arthro.2018.01.046

- This study systematically reviewed current evidence to ascertain whether QT is a viable option for ACLR.
- Identified 15 clinical trials with 1910 patients.
- In all included studies, QT resulted in lower anterior knee pain than BPTB. There was no difference in graft rupture between QT and BPTB or HT in any of the reported studies.

#### **Takeaway**

In conclusion, that current literature suggests QT is a viable option in ACLR.

Belk JW,  
Kraeutler MJ,  
Marshall HA,  
Goodrich JA,  
McCarty EC

[Quadriceps tendon autograft for primary anterior cruciate ligament reconstruction: a systematic review of comparative studies with minimum 2-year follow-up.](#) *Arthroscopy*. 2018;34(5):1699-1707. doi:10.1016/j.arthro.2018.01.047

- This systematic review of the literature compares outcomes of patients who underwent primary ACLR with a QT autograft compared with a BPTB or HT autograft.
- The authors found that patients who underwent primary ACLR with a QT, HT, or BPTB can be expected to experience improved clinical outcomes.

#### **Takeaway**

“QT patients experienced less knee laxity postoperatively compared with HT patients, although no significant differences were found in graft failure rate between groups.”

Slone HS,  
Romine SE,  
Premkumar A,  
Xerogeanes JW

[Quadriceps tendon autograft for anterior cruciate ligament reconstruction: a comprehensive review of current literature and systematic review of clinical results.](#) *Arthroscopy*. 2015; 31(3):541-554. doi:10.1016/j.arthro.2014.11.010

- This study provides an in-depth review of QT anatomy, histology, and biomechanics and synthesizes reported clinical outcomes on ACLRs using QT autografts.
- The authors performed a comprehensive review of the literature and a systematic review of clinical studies (Level of Evidence I-III), evaluating ACLR outcomes using QT autografts.

#### **Takeaway**

In conclusion, use of QT autografts for ACLR is supported by the current orthopedic literature. “It is a safe, reproducible, and versatile graft that should be considered in future studies of ACL reconstruction.”



Mulford JS,  
Hutchinson SE,  
Hang JR

[Outcomes for primary anterior cruciate reconstruction with the quadriceps autograft: a systematic review.](#) *Knee Surg Sports Traumatol Arthrosc.* 2013;21(8):1882-1888. doi:10.1007/s00167-012-2212-2

- The purpose of this systematic review was to determine the suitability of QT autografts for primary ACLR.
- Seventeen articles met the inclusion criteria with 1580 reconstructions studied.

#### Takeaway

The authors concluded that a QT autograft “is a promising alternative for primary ACL reconstructions with good outcomes and minimal donor site morbidity.”

Todor A,  
Nistor D,  
Roman M,  
Nistor D,  
Roman M,  
Rusu O,  
Prejbeanu R,  
Predescu V,  
Bătagă T

[Autograft options for ACL reconstruction. which is best?](#) *J Interdiscip Med.* 2017;2(s3):32-34. doi:10.1515/jim-2017-0042

- This clinical update reviews ACL autograft options, highlighting the main characteristics and clinical data for each autograft.

#### Takeaway

The authors concluded that “autografts for ACL reconstruction provide similar functional outcomes.” QT are versatile grafts with results similar to BTB but with less donor-site morbidity.

### In Vitro Studies: Biomechanical Validation

[Adjustable-length loop cortical button versus interference screw fixation in quadriceps tendon anterior cruciate ligament reconstruction: a biomechanical in vitro study.](#) *Clin Biomech (Bristol, Avon).* 2018;60:60-65. doi:10.1016/j.clinbiomech.2018.10.001

- This biomechanical cadaveric in vitro study evaluated and compared the “dynamic elongation behavior and ultimate failure strength of tibial adjustable-length loop cortical button versus interference screw fixation in quadriceps tendon-based anterior cruciate ligament reconstruction.”
- Tibial interference screw fixation showed no statistically significant differences in the initial, dynamic, and total elongation compared to adjustable-loop device fixation.

#### Takeaway

QT ACLR using a tibial adjustable-loop cortical button “provides for comparable dynamic stabilization of the knee with increased ultimate failure-load at decreased stiffness compared to screw fixation.”

Karkosch RF,  
Ettinger M,  
Bachmaier S,  
Wijdicks CA,  
Smith T



Shani RH,  
Umpierrez E,  
Nassert M,  
Hiza EA,  
Xerogeanes J

[Biomechanical comparison of quadriceps and patellar tendon grafts in anterior cruciate ligament reconstruction.](#) *Arthroscopy*. 2016;32(1):71-75. doi:10.1016/j.arthro.2015.06.051

- This study quantified the structural and material properties of 10 mm sections of QT and BPTB grafts.
- The cross-sectional area of the QT graft was nearly twice that of the BPTB graft.
- Biomechanical properties were significantly higher for QT compared to BPTB as measured by ultimate load and stiffness. Variability in cross-sectional area was similar in both graft choices.

**Takeaway**

This study reaffirms that QT is a suitable option for ACLR.

Urchek R,  
Karas S

[Biomechanical comparison of quadriceps and 6-strand hamstring tendon grafts in anterior cruciate ligament reconstruction.](#) *Orthop J Sports Med*. 2019;7(10):2325967119879113. doi.org/10.1177/2325967119879113

- The goal of the study was to compare the biomechanical properties of the QT and the 6-strand HT graft. The measures that were evaluated included graft characteristics, ultimate load-to-failure, load at 3 mm of displacement, and stiffness.
- The mean diameters of the QT and 6-strand HS were 10.16 mm and 11.33 mm. Despite the size disparity, no differences were found in ultimate load or load at 3 mm of displacement. Both grafts were stiffer than the native ACL.

**Takeaway**

The authors concluded that the quadriceps tendon is a reliable alternative to a 6-strand HT graft for ACLR.

Sasaki N,  
Farraro KF,  
Kim KE,  
Woo SL

[Biomechanical evaluation of the quadriceps tendon autograft for anterior cruciate ligament reconstruction: a cadaveric study.](#) *Am J Sports Med*. 2014;42(3):723-730. doi:10.1177/0363546513516603

- This study measured the 6 degrees of freedom knee kinematics and in situ graft forces after ACLR with QT graft compared with quadrupled STG graft.
- Ten human cadaveric knees were tested in 3 conditions: intact, ACL deficient, and after ACLR.
- There were no significant differences between the grafts under any experimental condition.

**Takeaway**

“The positive biomechanical results of the study lend support to the use of QT autograft for ACL reconstruction, as it could restore knee function immediately under applied loads that mimic clinical examinations.”



Stäubli HU,  
Schatzmann L,  
Brunner P,  
Rincón L,  
Nolte LP

[Mechanical tensile properties of the quadriceps tendon and patellar ligament in young adults](#). *Am J Sports Med.* 1999;27(1):27-34. doi:10.1177/03635465990270011301

- The authors analyzed biomechanical properties of 16 full-thickness QT and patellar ligament (PL) grafts from paired knees.
- Preconditioned PL grafts exhibited significantly higher elastic modulus than QT grafts.

#### Takeaway

The QT construct may represent a versatile alternative graft in primary and revision ACL and posterior cruciate ligament (PCL) reconstruction.

### Anatomy and Graft Characteristics

[MRI signal intensity of quadriceps tendon autograft and hamstring tendon autograft 1 year after anterior cruciate ligament reconstruction in adolescent athletes](#). *Am J Sports Med.* 2021;11(13):03635465211040472. doi:10.1177/03635465211040472

- This cohort study used MRI SIR (signal intensity ratio = ACL graft signal intensity / PCL signal intensity) to compare healing of quadrupled hamstring and quadriceps (full thickness, all soft tissue) autografts at 6 and 12 months in patients under 18 years old.
- “A decrease in SIR indicates reduced water content and theoretically better maturity and healing of the graft.” In animal studies, decreasing signal has also been shown to correlate with an increase in the tensile strength, load to failure, and vascularity of grafts. In recent human studies, it has been associated with increased graft volume and higher patient-reported outcomes.
- “There was no significant difference in SIR between groups on the 6-month MRI. However, the SIR of the QTA [quadriceps tendon autograft] group was significantly less than in the HTA [hamstring tendon autograft] group on the 12-month MRI. Within the HTA group, there was no significant difference in the SIR at either MRI timepoint. In the QTA group, there was a significant decrease in SIR between 6-month and 12-month postoperative MRI.”

#### Takeaway

This study demonstrates that QTA may mature more quickly than HTA and support its continued use in pediatric and adolescent patients.

Aitchison AH,  
Alcolombre D,  
Mintz DN,  
Hidalgo Perea S,  
Nguyen JT,  
Cordasco FA,  
Green DW





Panos JA,  
Devitt BM,  
Feller JA,  
Klemm HJ,  
Hewett TE,  
Webster KE

[Effect of time on MRI appearance of graft after ACL reconstruction: a comparison of autologous hamstring and quadriceps tendon grafts.](#) *Orthop J Sports Med.* 2021;9(9):23259671211023512. doi:10.1177/23259671211023512

- The primary aim of this study was to evaluate and compare the MRI appearance of two different autologous soft-tissue grafts, hamstring tendon (doubled over semitendinosus and gracilis) and quadriceps tendon (all soft tissue), at 3 months and 9 months after ACLR.
- While the native ACL appears as a uniform, hypointense (darker than what it is being compared to) structure on MRI, the reconstructed ligament appears relatively hyperintense (brighter than what it is being compared to) within the first year after ACLR surgery, coinciding with the biological processes of cellular proliferation and extracellular matrix remodeling of the graft.
- While there is no overall significant difference in signal intensity between QT and HT grafts between 3- and 9-months post-op, QT demonstrated significant signal intensity decrease between 3 and 6 months.

#### Takeaway

Quad tendon grafts showed a significant decrease in anterior knee laxity from 6 to 12 months. QT graft integration contributed to improved knee laxity while HT grafts observed no difference in knee laxity.

Krebs N,  
Yaish A,  
O'Neill N

[Anatomic evaluation of the quadriceps tendon in cadaveric specimens: application for anterior cruciate ligament reconstruction graft choice.](#) *SMRJ.* 2019;4(1).

- The goal of the study was to evaluate the morphologic properties of the QT and compare findings to recent MRI studies.
- The mean length of the QT was 83.3 mm ± 14.4 mm, ranging from 63 mm to 108 mm. QT thickness was relatively constant, while the width is widest at its insertion on the patella and gradually decreases proximally.

#### Takeaway

Authors concluded that the QT has the anatomical properties to produce a robust autograft for ACLR. During pre-op planning, patient height and technique should be considered as height correlates to overall graft length. MRI can effectively be used to assess QT as an autograft.

Ashford WB,  
Kelly TH,  
Chapin RW,  
Xerogeanes JW,  
Slone HS

[Predicted quadriceps vs. quadrupled hamstring tendon graft size using 3-dimensional MRI.](#) *Knee.* 2018;25(6):1100-1106. doi:10.1016/j.knee.2018.08.001

- A retrospective review of 54 knee 3D MRIs was conducted to compare the cross-sectional area and diameter between the QT and quadrupled HT autografts and to assess the predicted size of the QT graft in patients with insufficient HT autografts.
- It was determined that the mean cross-sectional area of the QT and quadrupled HT grafts were 84.4 mm<sup>2</sup> and 47.2 mm<sup>2</sup>, respectively. There was a statistically significant positive correlation between quadrupled HT graft and QT graft cross-sectional area.

#### Takeaway

All 54 patients had predicted QT grafts diameters >8 mm. However, 17% of these same patients were predicted to have insufficient quadrupled HT grafts for successful ACLR. Therefore, QT grafts are a viable alternative for patients at risk for insufficient quadrupled HT grafts.



Xerogeanes JW,  
Mitchell PM,  
Karasev PA,  
Kolesov IA,  
Romine SE

[Anatomic and morphological evaluation of the quadriceps tendon using 3-dimensional magnetic resonance imaging reconstruction: applications for anterior cruciate ligament autograft choice and procurement.](#) *Am J Sports Med.* 2013;41(10):2392-2399. doi:10.1177/0363546513496626

- This study was an evaluation of MRI scans of 60 skeletally mature patients (30 male and 30 female) to determine if QT “has the anatomical characteristics to produce a graft whose length and volume are adequate, reproducible, and predictable when compared with the other commonly used autografts.”

#### **Takeaway**

The authors concluded that QT has the anatomic characteristics to produce a graft whose length and volume are reproducible and predictable with greater intra-articular volume than patellar tendon grafts.

Hadjicostas PT,  
Soucacos PN,  
Berger I,  
Koleganova N,  
Paessler HH

[Comparative analysis of the morphologic structure of quadriceps and patellar tendon: a descriptive laboratory study.](#) *Arthroscopy.* 2007;23(7):744-750. doi:10.1016/j.arthro.2007.01.032

- This comparative laboratory study analyzed the morphologic structure of quadriceps and patellar tendons.
- Quadriceps and patellar tendons from 20 cadavers were harvested and evaluated by light and electron microscopy, immunohistochemistry, and morphometry.

#### **Takeaway**

The authors concluded that QT graft “can provide approximately 20% more collagen than the patellar tendon graft with same thickness,” which may provide greater ultimate strength.