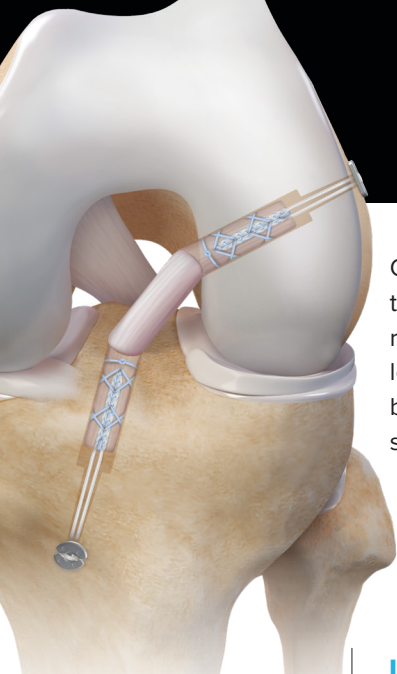


# Quadriceps Tendon (QT) ACL Reconstruction Scientific Update



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

QT ACL reconstruction continues to be one of the fastest growing ACL reconstruction 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 as well as systematic reviews. This update summarizes the scientific support for successful outcomes with the QT technique.

## In Vivo Studies: Clinical Outcomes

[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 \[published online November 8, 2019\]. \*Br J Sports Med.\* doi:10.1136/bjsports-2019-101000.](#)

- This randomized controlled trial (RCT) evaluated quadriceps tendon (QT) or semitendinosus/gracilis hamstring tendon (HT) grafts used for patients undergoing ACL reconstruction (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.”
- 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.”

[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 of 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 a HS 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.
- 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.

Todor A,  
Nistor DV,  
Caterov S

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. Four of the original 48 QT patients 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 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).
- 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.
- 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,  
Todor 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 vs 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) ( $p = 0.009$ ).
- A significantly higher number of subjects with a quadriceps graft did not require any supplementary analgesic drug (50%) as compared with subjects with hamstring graft (13%).
- 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,  
et al

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

- This study prospectively followed 353 patients undergoing ACL reconstruction 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.
- 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 ACL reconstruction.

DeAngelis JP,  
Cote M,  
Fulkerson JP,  
Caminiti S

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

- One hundred twenty-four patients were enrolled in this study, which describes outcomes of ACLR using central quadriceps free tendon (CQFT) at minimum of 2 years postreconstruction.
- 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? Am J Sports Med.](#) 2017;45(6):1326-1332. doi:10.1177/0363546516688665.

- Ninety-five patients who underwent isolated ACLR were enrolled in this comparative study; 50 patients underwent ACLR with QT and 45 underwent ACLR with HT.
- Eighty-six of the 95 patients 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.
- 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 bone-patellar tendon-bone (BPTB) reconstructions.
- Fifty-one patients were included in the study; 26 patients received QTB grafts and 25 received BPTB.
- 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,  
et al

[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.* 2014;30(5):593-598. doi:10.1016/j.arthro.2014.01.012.

- Eighty patients were evaluated during this 2-year, patient-reported outcomes study; 40 patients underwent ACLR with QT and 40 underwent ACLR with HT.
- 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 ACL reconstruction.



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.
- 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.”
- No donor-site complications were reported.

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 ACL reconstruction using bone-tendon-bone patella tendon graft (BTB), quad tendon with bone plug graft (BQT), and quadriceps tendon without a bone plug (QT).
- A variety of assessments were used, including 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.
- 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,  
Maldijan 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 bone block (BQT) and hamstring (HS) tendon autografts at 6 months after ACLR.
- The signal/noise quotient was calculated to evaluate the difference between BQT and HS autografts.
- The quadriceps tendon with bone block demonstrated better maturity when compared to hamstring 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,  
Martin-Gomez JL,  
et al

[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.

- Fifty-six patients were enrolled in randomized controlled trial and placed into either the HT or QT group.
- ACLR with QT graft demonstrated similar functional results with a better isokinetic hamstring/quadriceps ratio compared to ACLR with HT graft.



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

## Systematic Reviews and Meta-analysis

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

- This systematic review of publications focused on quadriceps tendon autografts (QT) in ACL reconstruction (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% of the publications (115 of 187) 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). Seventy-two percent of the clinical outcome studies were Level of Evidence III, and 14% were Level I or II.
- 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,  
et al

[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 and partial thickness quadriceps tendon autografts.
- Twenty studies met the inclusion/exclusion criteria. “Due to heterogeneous reporting, data were not combined in a meta-analysis and were summarized descriptively.”
- “There 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,  
Dan Withers,  
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.

- 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.
- Concluded 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 vs BPTB or HT autograft.
- The authors found that patients who underwent primary ACLR with QT, HT, or BPTB can be expected to experience improved clinical outcomes.
- “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 ACL reconstructions 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 ACL reconstruction outcomes using QT autografts.
- 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 quadriceps tendon autografts for primary ACLR.
- Seventeen articles met the inclusion criteria with 1580 reconstructions studied.
- The authors concluded that QT autograft “is a promising alternative for primary ACL reconstructions with good outcomes and minimal donor site morbidity.”

## In Vitro Studies: Biomechanical Validation

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

[Adjustable-length loop cortical button versus interference screw fixation in quadriceps tendon anterior cruciate ligament reconstruction: a biomechanical in vitro study.](#) *Clin Biomech*. 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.
- Quad tendon 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.”



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 vs BPTB as measured by ultimate load and stiffness. Variability in cross-sectional area was similar in both graft choices.
- This study reaffirms that QT is a suitable option for ACL reconstruction.

Sasaki N,  
Farraro KF,  
Kim KE,  
Woo SL

[Biomechanical evaluation of the quadriceps tendon autograft for anterior cruciate ligament reconstruction.](#) *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 ACL reconstruction with QT graft compared with quadrupled semitendinous and gracilis (QSTG) graft.
- Ten human cadaveric knees were tested in 3 conditions: intact, ACL deficient, and after ACL reconstruction.
- There were no significant differences between the grafts under any experimental condition.
- “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 \[abstract\].](#) *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.
- The QT construct may represent a versatile alternative graft in primary and revision ACL and PCL reconstruction.

## Anatomy and Graft Characteristics

Ashford WB,  
Kelly TH,  
Chapin RW,  
Xerogeanes JW,  
Stone 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 quadriceps tendon (QT) and quadrupled hamstring tendon (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. A statistically significant positive correlation exists between quadrupled hamstring graft and quadriceps tendon graft cross-sectional area.
- 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 in 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.”
- 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.
- 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.

Todor A,  
Nistor D,  
Roman M,  
et al

[Autograft options for ACL reconstruction. Which is best \[abstract\]?](#) *Journal of Interdisciplinary Medicine.* 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.
- The authors concluded that “autografts for ACL reconstruction provide similar functional outcomes.” Quadriceps tendons are versatile grafts with results similar to BTB, but with less donor site morbidity.