Quadriceps Tendon (QT) ACL Reconstruction Scientific Update

Quadriceps tendon (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 as well as systematic reviews. This update summarizes the scientific support for successful outcomes with the QT technique.

In Vivo Studies: Clinical Outcomes


- This randomized controlled trial (RCT) evaluated QT or semitendinosus and gracilis (STG) hamstring tendon (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.”

- 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.”


- This retrospective clinical study evaluated the clinical outcomes of primary ACLR using either a soft-tissue QT autograft or a bone-patellar tendon-bone (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.

- 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.
In Vivo Studies: Clinical Outcomes


- 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.

- 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.


- 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).

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


- 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.
In Vivo Studies: Clinical Outcomes


- 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%).”

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


- 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.

- 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.


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


- 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 ± 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.”
In Vivo Studies: Clinical Outcomes


- 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.
- 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.


- In this 2-year patient-reported outcomes study, 80 patients were evaluated; 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 ACLR.


- 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.


- 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.
- 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.”
In Vivo Studies: Clinical Outcomes

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


- 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.
- 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.”


- A randomized controlled trial placed 56 patients 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.
Systematic Reviews and Meta-analysis


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


- 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). 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.


- 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.”
- “[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.”
Systematic Reviews and Meta-analysis


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


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


- 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.
- 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."


- 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.
- The authors concluded that a QT autograft "is a promising alternative for primary ACL reconstructions with good outcomes and minimal donor site morbidity."
In Vitro Studies: Biomechanical Validation


- 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.
- 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."


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


- 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.
- The authors concluded that the quadriceps tendon is a reliable alternative to a 6-strand HT graft for ACLR.
In Vitro Studies: Biomechanical Validation


- 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.
- “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


- 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 posterior cruciate ligament (PCL) reconstruction.
Anatomy and Graft Characteristics


- 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.

- 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.


- 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$^2$ and 47.2 mm$^2$, respectively. There was a statistically significant positive correlation between quadrupled HT graft and QT 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 for patients at risk for insufficient quadrupled HT grafts.


- 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.
Anatomy and Graft Characteristics


- 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.


- 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.” QT are versatile grafts with results similar to BTB but with less donor site morbidity.