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

Jose R. Perez,* MD, Christopher P. Emerson,* MS, Carlos M. Barrera,* BS, Dylan N. Greif,*† BA, William H. Cade II,* MPH, Lee D. Kaplan,* MD, and Michael G. Baraga,* MD

Investigation performed at University of Miami Sports Medicine Institute, Coral Gables, Florida, USA

Background: Quadriceps tendon (QT)–bone autografts used during anterior cruciate ligament (ACL) reconstruction have provided comparable outcomes and decreased donor-site morbidity when compared with bone–patellar tendon–bone (BPTB) autografts. No study has directly compared the outcomes of the all–soft tissue QT autograft with that of the BPTB autograft.

Hypothesis: Patient-reported knee outcome scores and rates of postoperative complication after primary ACL reconstruction with QT autografts are no different from BPTB autografts at a minimum 2-year follow-up.

Study Design: Cohort study; Level of evidence, 3.

Methods: A total of 75 patients who underwent primary autograft ACL reconstruction with QT or BPTB autografts between January 1, 2015, and March 31, 2016, at a single hospital center were contacted by telephone and asked to complete the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation, Tegner activity level scale, and Lysholm knee scoring scale. Information about the subsequent surgeries performed on the operative knee was also collected. Statistical analysis was performed using the Kruskal-Wallis test and the Fisher exact test for categorical data.

Results: Fifty patients (28 QT, 22 BPTB) completed the surveys at a mean follow-up of 33.04 months (range, 24-44 months). For the QT versus the BPTB group respectively, the median IKDC scores were 94.83 (interquartile range [IQR], 7.61) versus 94.83 (IQR, 10.92) (P = .47), the median Tegner scores were 6 (IQR, 2.5) versus 6 (IQR, 2.75) (P = .48), and the median Lysholm scores were 95 (IQR, 9) versus 95 (IQR, 13) (P = .27). Additionally, 2 QT patients and 3 BPTB patients required follow-up arthroscopy for arthrolysis (P = .64). There was 1 graft failure in the QT group requiring revision surgery.

Conclusion: 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 ACL reconstruction. This study highlights that the all–soft tissue QT autograft may be a suitable graft choice for primary ACL reconstruction.

Keywords: all–soft tissue quadriceps tendon autograft; bone–patellar tendon–bone autograft; anterior cruciate ligament reconstruction; quad tendon anterior cruciate ligament

Anterior cruciate ligament (ACL) reconstruction is one of the most common elective orthopaedic procedures performed annually in the United States.29 Both autografts and allografts have successfully been used for ACL reconstruction, with autografts functioning as the primary graft choice in physically active and younger patients.14 The bone–patellar tendon–bone (BPTB) autograft has traditionally been the gold standard graft choice because of earlier bone-to–bone tunnel healing, better restoration of ligamentous stability demonstrated by instrumented laxity testing, excellent patient-reported outcomes, and ease of harvest.5,10 Long-term results over 2 decades have

This open-access article is published and distributed under the Creative Commons Attribution - NonCommercial - No Derivatives License (http://creativecommons.org/licenses/by-nc-nd/4.0/), which permits the noncommercial use, distribution, and reproduction of the article in any medium, provided the original author and source are credited. You may not alter, transform, or build upon this article without the permission of the Author(s). For article reuse guidelines, please visit SAGE's website at http://www.sagepub.com/journals-permissions.
demonstrated that 83% of patients returned to stable, normal, or near-normal capabilities, with <5% needing a revision surgery. Nevertheless, BPTB has associated risks, which include potential donor-site morbidity, increased risk of patellar fracture, persistent anterior knee pain, and kneeling difficulty.²⁵

Among the graft options that have the potential to provide clinical outcomes similar to the BPTB autograft, with reduced risk of the aforementioned limitations, is the quadriceps tendon (QT) with bone block (QTB) autograft. It has been found to have reduced donor-site morbidity, excellent biomechanical strength compared with a native ACL, a large cross-sectional area that is advantageous for revision surgery, and good tendon-to-bone tunnel healing.¹⁰ Multiple systematic reviews²⁰⁻²²,²⁴ have concluded that the autologous QT graft has clinical outcomes similar to BPTB. The use of the QT as a primary graft choice in ACL reconstruction has been increasing. In a 2014 international summit on ACL reconstruction, among 35 surgeons from 20 countries, 10.6% reported that the QT autograft was their preferred graft choice for ACL reconstruction; these surgeons had averaged greater than 2100 ACL reconstructions throughout their career and reported that 11% of all reconstructions were performed with the QT.²⁶ This is an increase in the utilization of the QT among orthopaedic surgeons, compared with a poll in 2010 at the American Academy of Orthopaedic Surgeons, who at the time reported that only 1% of ACL reconstructions were performed with the QT autograft.³⁴ Current trends indicate that the utilization of the QT as a graft choice will continue to increase.

A majority of the studies on ACL reconstruction with QT autograft have utilized the central QTB from the proximal patella. Although the risk of patellar fracture in QTB is comparable with that in BPTB, an all-soft tissue QT autograft eliminates this risk and could lead to less morbidity, as the bone is not being harvested.⁷ Currently, there is a paucity of available research comparing clinical outcomes between the QT and BPTB autografts in ACL reconstruction. Therefore, the purpose of this study was to compare patient-reported subjective knee outcome scores between QT and BPTB autografts and incidence of graft-related complications.

METHODS

Study Design

After obtaining approval from our institutional review board, we identified all patients who had autograft ACL reconstruction from January 1, 2015, to March 31, 2016, at a single hospital center through an operative log review. Inclusion criteria included isolated primary ACL injuries in adults (>18 years of age) and graft choice of either QT or BPTB autograft as determined by both the patient and the physician. Exclusion criteria were patients with multiligamentous knee injuries, history of previous ACL reconstruction or meniscal repair/reconstruction in the knee of interest, and cartilage defects or patients requiring osteotomies. All ACL reconstructions were performed arthroscopically by 1 of 2 surgeons (L.D.K., M.G.B.) at a single outpatient surgical center. A total of 80 patient records were identified as ACL reconstructions with QT or BPTB autografts; of these, 5 patients were excluded because of revision ACL reconstructions.

Patients (N = 75) were contacted by telephone from January to September 2018 for inclusion in the study. Follow-up was performed at a minimum of 2 years after surgery. Patients were asked to complete the International Knee Documentation Committee (IKDC) subjective knee evaluation, Lysholm knee scoring scale, and Tegner activity level scale.⁶,¹⁹ These measures were used because of their extensive validation in accurately capturing differences in subjective knee outcome scores.¹,²,⁶,¹⁶ Secondary outcomes, collected via a combination of patient surveys and an operative log review, were patient satisfaction and incidence of graft-related complications, which included but were not limited to arthrofibrosis, contralateral ACL injury, patellar fracture, graft failure, and kneeling pain. Arthrofibrosis was defined as patients having symptomatic asymmetric range of motion >5° after 12 weeks of physical therapy, in which case arthrolysis was recommended. Graft failure was defined as a graft retear confirmed on magnetic resonance imaging.

Surgical Technique

The 2 fellowship-trained sports medicine surgeons, experienced in harvesting both BPTB and QT autografts, performed all ACL reconstruction procedures. All patients underwent the procedure under general anesthesia and with the use of a tourniquet. BPTB grafts were harvested from the central third of the patellar tendon, 1 cm in width with bone blocks between 20 and 25 mm in length. Grafts were sized 10 mm in diameter. Harvesting of the QT autograft was performed through a 2- to 3-cm incision, 1 cm proximal to the superior pole of the patella. Central-medial harvest was performed with a width of 10 mm, with the aim to obtain an all-soft tissue graft between 75 and 95 mm in length and 9 to 10 mm in diameter. Care was taken to avoid penetration into the suprapatellar pouch and disruption of the rectus myotendinous junction. Any defects to the suprapatellar pouch were reapproximated with interrupted sutures, although full-thickness closure of the

---

¹Address correspondence to Dylan N. Greif, BA, 5555 Ponce De Leon Blvd, Coral Gables, FL 33146, USA (email: d.greif@med.miami.edu).
²University of Miami Sports Medicine Institute, Coral Gables, Florida, USA.

One or more of the authors has declared the following potential conflict of interest or source of funding: L.D.K. has received royalties from Arthrex and Smith & Nephew and speaking fees from Arthrex. M.G.B. has received educational support from Arthrex and Smith & Nephew and consulting fees from Arthrex and LifeNet Health. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from the University of Miami Human Subject Research Office (reference No. 20170165).
harvest site was not performed. Diagnostic arthroscopy was completed, and any meniscal repairs or partial meniscectomies were completed at this time. Femoral sockets were created through the center of the femoral anatomic footprint using an anteromedial portal technique in all patients. Tibial tunnels were created in the center of the tibial anatomic footprint by placing a 2.4-mm guidepin through an Acufex ACL tip guide set to 50°, followed by the appropriate-sized fully threaded reamer. Femoral and tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used. Tibial fixation of BPTB grafts was performed with titanium interference screws, whereas QT grafts were secured via adjustable loop suspensory cortical fixation and interference screws, whereas QT grafts were used.
the QT autograft groups. While they also demonstrated that the all–soft tissue quadriceps grafts can produce comparable clinical outcomes compared with QTB, the authors did not directly compare the outcomes between soft tissue QT grafts and BPTB grafts. Schulz et al31 went on to report both clinical and functional outcomes at a minimum 2-year follow-up for the QT autograft with the use of bioabsorbable cross-pin fixation. Although this study did not have a comparison group, the authors’ all–soft tissue surgical technique demonstrated that 89.1% of cases had “good or very good” IKDC, Tegner activity, Lysholm, and Gillquist scores at an average 29.5-month follow-up. By demonstrating equivalent patient-reported satisfaction scores and complication rates, the current study is the first to support the use of the all–soft tissue QT graft as a suitable graft option after direct comparisons with the BPTB graft at a minimum of 2-year follow-up.

Use of the central QT grafts as an alternative to BPTB grafts garnered attention after the cadaveric biomechanical study by Harris et al,18 which demonstrated that the QT harvest has 1.8 times the thickness as well as 1.36 times higher load to tendon failure when compared with similarly sized BPTB grafts.20 These findings of stronger structural integrity with QT were supported by Shani et al,33 who reported that the QT had nearly twice the cross-sectional area compared with that of BPTB grafts, 91.2±10 mm² and 48.4±8 mm² (P = .005), respectively. They also concluded that the ultimate load to failure and stiffness are also significantly higher in the QT graft. These findings can be explained in the study by Hadjicostas et al,15 who found 20% more collagen fibers with QTs when compared with patellar tendon grafts of similar thickness.

In addition to the biomechanical advantages associated with QT, the donor-site morbidity pertaining to BPTB grafts such as anterior knee pain and pain with kneeling, as well as the increased risk of patellar fracture, has driven the scientific community to seek alternative graft options.23 While Gorschewsky et al13 reported better subjective clinical outcomes of BPTB over QTB regarding IKDC scores, they also found significantly less morbidity with QTB and no significant differences between Noyes and Lysholm scores between the 2 groups. The latter findings have been backed by several studies that found no difference in patient-reported subjective knee outcomes between QTB and BPTB, with less anterior knee pain, pain with kneeling, and graft site pain in QTB groups.12,14,17,26,28 Objective clinical outcome measurements between QTB and BPTB have also been reported to be similar; both Kim et al24 and Lund et al25 found no mean side-to-side difference in objective knee laxity as measured by KT-2000 and KT-1000 arthrometers, respectively. When looking at only anterior kneeling difficulty, Schulz et al31 found no evidence that QT caused a significant difference compared with literature-reported rates for those of BPTB. The results of the current study demonstrated that there was no difference in anterior kneeling difficulty between the QT and BPTB groups, although the anterior kneeling difficulty results of this study for BPTB were lower than that seen in previous studies.26,27,31

To date, the bulk of the available literature has provided comparisons between QTB and BPTB cohorts, demonstrating QTB to be a suitable alternative to BPTB with comparable outcomes and less morbidity.12,17,25,28,29 When directly comparing QT with QTB, Geib et al12 reported better KT-1000 laxity scores with QT grafts (0.51 vs 1.05 mm), as well as reduced loss of extension (0.41° vs 0.44°), loss of flexion (0.12° vs 0.45°), number of positive pivot shifts (0 vs 3), number of effusions present (0 vs 13), and failure rates (2% vs 6%) with QT grafts. The results of the current study showed that the graft rupture rates were within the previously reported range for QT, QT, and BPTB grafts (Table 3).12,14,17,26,28,31 Overall, although the results of this study are not statistically significant because of limited patient participation, the findings correlate with the conclusion of the previous literature that BPTB may have increased donor-site morbidity because of harvesting, a disadvantage not shared by QTB, and now QT as well.

While the senior authors (L.K.B., M.G.B.) routinely use QT without bone for ACL reconstruction, there are few studies directly comparing QT with QTB. Geib et al12 attempted to stratify their all-inclusive quadriceps group into QTB and QT without bone plug and found no significant differences between the cohorts, which they attributed to a limited sample size. Despite limited direct comparison of long-term patient outcomes in the current literature, QT has gained in popularity over QTB because of decreased surgical time, postoperative anterior knee pain, and risk of patellar fracture.11,23,25 While it has been suggested that a bone block is important for QT in order to increase graft stiffness, length, and anatomic fixation,9 multiple studies have described alternative fixation techniques that

### Table 3: Graft Rupture Rates Between QT, QTB, and BPTB Grafts

| First Author (Year) | Surgical Time Frame | Minimum Follow-Up, mo | QT % Rupture | QTB % Rupture | BPTB % Rupture |
|---------------------|---------------------|-----------------------|--------------|---------------|---------------|
| Gorschewsky13 (2007) | 1995-2000           | 24                    | —            | 2.15          | 4.95          |
| Han17 (2008)        | 1994-2001           | 24                    | —            | 2.80          | 1.39          |
| Geib12 (2009)       | 1996-2006           | 24                    | 2            | 6.001.91      | 3.33          |
| Kim20 (2014)        | 2003-2004           | 24                    | —            | 4.76          | 0             |
| Schulz17 (2013)     | 2007-2008           | 24                    | 0.00         | —             | —             |
| Lund25 (2014)       | 2005-2009           | 24                    | —            | 0.00          | 4.00          |
| Perez (2019, current study) | 2015-2016       | 24                    | 4.00         | —             | 0             |

aBPTB, bone–patellar tendon–bone; QT, quadriceps tendon; QTB, quadriceps tendon with bone plug. Graft rupture was diagnosed on magnetic resonance imaging, arthroscopy, or revision surgery.
maintain appropriate stiffness and anatomic fixation without any reported complications.\(^5,^{10,31,36}\)

**Limitations**

This study is not without limitations. The lack of preoperative data makes it difficult to determine if the comparison groups of this study had an average difference in baseline IKDC or Lysholm data. To this end, determining the impact that graft selection had on patient outcomes was challenging.\(^3\) Therefore, the possibility of recruitment bias exists. Nevertheless, patients in both groups had similar characteristics, came from the same metropolitan area, were only operated on by 1 of 2 surgeons, and underwent the same rehabilitation protocol. Another limitation is the lack of more objective patient data such as instrumented laxity measures or strength assessments. KT arthrometers can be used to identify graft failure when there is a >5 mm side-to-side difference in anterior knee laxity; however, several studies\(^21,28,37\) have questioned the reliability of correlating anterior knee laxity as measured by the KT arthrometer with clinical outcomes. The reliance on subjective data via telephone questionnaires may introduce assessment bias. This study also had a small sample size because of loss to follow-up, with 33% of patients not responding to the telephone questionnaire. Last, this study had a lack of randomization of patients between the 2 groups before surgery and lack of blinding of participants and personnel. Therefore, the possibility of performance and assessment bias exists.

**CONCLUSION**

This study is the first to retrospectively compare subjective knee outcome scores and incidence of postoperative complications between an all-soft tissue QT and BPTB autograft at a minimum of 2-year follow-up. There was no statistical difference in all outcome scores between the 2 groups. Additionally, this study had low rates of postoperative complications comparable with the already published data. Prospectively designed studies are needed to expand upon these initial findings and to further validate that the all-soft tissue QT autograft may be a suitable alternative to the BPTB autograft for primary ACL reconstruction.

**REFERENCES**

1. Briggs KK, Kocher MS, Rodkey WG, Steadman JR. Reliability, validity, and responsiveness of the Lysholm knee score and Tegner activity scale for patients with meniscal injury of the knee. *J Bone Joint Surg Am*. 2006;88(4):698-705.
2. Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. The reliability, validity, and responsiveness of the Lysholm score and Tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. *Am J Sports Med*. 2009;37(5):890-897.
3. 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.
4. Chechik O, Amar E, Khashan M, Lador R, Eyal G, Gold A. An international survey on anterior cruciate ligament reconstruction practices. *Int Orthop*. 2013;37(2):201-206.
5. Clark JC, Rueff DE, Indelicato PA, Moser M. Primary ACL reconstruction using allograft tissue. *Clin Sports Med*. 2009;28(2):223-244.
6. Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). *Arthritis Care Res (Hoboken)*. 2011;63(suppl 11):S208-S228.
7. Ferrer GA, Miller RM, Murawski CD, et al. Quantitative analysis of the patella following the harvest of a quadriceps tendon autograft with a bone block. *Knee Surg Sports Traumatol Arthrosc*. 2016;24(9):2899-2905.
8. Fink C, Lawton R, Forschner F, Glioller P, Herbert M, Hoser C. Minimally invasive quadriceps tendon single-bundle, arthroscopic, anatomic anterior cruciate ligament reconstruction with rectangular bone tunnels. *Arthrosc Tech*. 2018;7(10):e1045-e1056.
9. Franceschi F, Longo UG, Ruzzini L, Papalia R, Maffulli N, Denaro V. Quadriceps tendon-patellar bone autograft for anterior cruciate ligament reconstruction: a technical note. *Bull NYU Hosp Jt Dis*. 2008;66(2):120-123.
10. Frank RM, Higgins J, Bernardoni E, et al. Anterior cruciate ligament reconstruction basins: bone-patellar tendon-bone autograft harvest. *Arthrosc Tech*. 2017;6(4):e1189-e1194.
11. Fu FH, Rabuck SJ, West RV, Tashman S, Irgang JJ. Patellar fractures after the harvest of a quadriceps tendon autograft with a bone block: a case series. *Orthop J Sports Med*. 2019;7(3):235596719829061.
12. 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.
13. Gorschewsky O, Klabow A, Putz A, Mahn H, Neumann W. Clinical comparison of the autologous quadriceps tendon (BQT) and the autologous patella tendon (BPTB) for the reconstruction of the anterior cruciate ligament. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(11):1284-1292.
14. Gottlieb CA, Baker CL Jr, Pellissier JM, Colvin L. Cost effectiveness of anterior cruciate ligament reconstruction in young adults. *Clin Orthop Relat Res*. 1999;367:272-282.
15. 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.
16. Hamblly K, Griva K. IKDC or KOOS: which one captures symptoms and disabilities most important to patients who have undergone initial anterior cruciate ligament reconstruction? *Am J Sports Med*. 2010;38(7):1395-1404.
17. Han HS, Seong SC, Lee S, Lee MC. Anterior cruciate ligament reconstruction: quadriceps versus patellar autograft. *Clin Orthop Relat Res*. 2008;466(1):198-204.
18. Harris NL, Smith DA, Lamoreaux L, Purnell M. Central quadriceps tendon for anterior cruciate ligament reconstruction. Part I: Morphometric and biomechanical evaluation. *Am J Sports Med*. 1997;25(1):23-28.
19. Higgins LD, Taylor MK, Park D, et al. Reliability and validity of the International Knee Documentation Committee (IKDC) Subjective Knee Form. *J Bone Joint Surg Am*. 2007;89(8):694-699.
20. 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.
21. Hyder NU, Bollen SR, Sefton G, Swann AC. Correlation between arthrometric evaluation of knees using KT 1000 and Telos stress radiography and functional outcome following ACL reconstruction. *Knee*. 1997;4:121-124.
22. 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 Arthrosoc*. 2019;27(1):105-116.

23. Kim SJ, Bae JH, Lim HC. Comparison of Achilles and tibialis anterior tendon allografts after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosoc*. 2014;22(1):135-141.

24. Kim SJ, Kumar P, Oh KS. Anterior cruciate ligament reconstruction: autogenous quadriceps tendon-bone compared with bone-patellar tendon-bone grafts at 2-year follow-up. *Arthroscopy*. 2009;25(2):137-144.

25. Lund B, Nielsen T, Fauno 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.

26. Middleton KK, Hamilton T, Irgang JJ, Karlsson J, Harner CD, Fu FH. Anatomic anterior cruciate ligament (ACL) reconstruction: a global perspective. Part 1. *Knee Surg Sports Traumatol Arthrosoc*. 2014;22(7):1467-1482.

27. Poehling-Monaghan KL, Salem H, Ross KE, et al. Long-term outcomes in anterior cruciate ligament reconstruction: a systematic review of patellar tendon versus hamstring autografts. *Orthop J Sports Med*. 2017;5(6):232596717709735.

28. Samitier G, Marcano AI, Alentorn-Geli E, Cugat R, Farmer KW, Moser MW. Failure of anterior cruciate ligament reconstruction. *Arch Bone Jt Surg*. 2015;3(4):220-240.

29. Sanders TL, Maradit Kremers H, Bryan AJ, et al. Incidence of anterior cruciate ligament tears and reconstruction: a 21-year population-based study. *Am J Sports Med*. 2016;44(6):1502-1507.

30. Saper MG. Quadriceps tendon autograft anterior cruciate ligament reconstruction with independent suture tape reinforcement. *Arthrosc Tech*. 2018;7(11):e1221-e1229.

31. Schulz AP, Lange V, Gille J, et al. Anterior cruciate ligament reconstruction using bone plug-free quadriceps tendon autograft: intermediate-term clinical outcome after 24-36 months. *Open Access J Sports Med*. 2013;4:243-249.

32. Scully WF, Wilson DJ, Arrington ED. “Central” quadriceps tendon harvest with patellar bone plug: surgical technique revisited. *Arthrosc Tech*. 2013;2(4):e427-e432.

33. Shani RH, Umpierez E, Naset M, Hiza EA, Xerogeanes J. Biomechanical comparison of quadriceps and patellar tendon grafts in anterior cruciate ligament reconstruction. *Arthroscopy*. 2016;32(1):71-75.

34. 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.

35. Sprowls GR, Robin BN. The quad link technique for an all-soft-tissue quadriceps graft in minimally invasive, all-inside anterior cruciate ligament reconstruction. *Arthrosc Tech*. 2018;7(8):e845-e852.

36. Todor A, Caterev S, Nistor DV, Khallouki Y. Free bone plug quadriceps tendon harvest and suspensory button attachment for anterior cruciate ligament reconstruction. *Arthrosc Tech*. 2016;5(3):e541-544.

37. Wiertsema SH, van Hooff HJ, Migchelsen LA, Steultjens MP. Reliability of the KT1000 arthrometer and the Lachman test in patients with an ACL rupture. *Knee*. 2008;15(2):107-110.