Technical Note

Anterior Cruciate Ligament Reconstruction Basics: Quadriceps Tendon (All-Soft Tissue) Autograft Preparation—Part 2

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Abstract: Anterior cruciate ligament reconstruction with quadriceps tendon autograft is a reliable graft option that has recently increased in use. Varying harvesting and graft preparation techniques available and improved technology and implant design continue to make quadricep tendon preparation more efficient and reproducible. In this Technical Note, we describe our preferred technique for all-soft tissue quadriceps tendon autograft preparation after harvest for anterior cruciate ligament reconstruction.

The approach to anterior cruciate ligament reconstruction (ACLR) is dynamic and continues to evolve. A wide variety of autografts and allografts have been successfully used for ACLR, yet controversy remains regarding the best graft option for any given patient. The ideal graft used for ACLR should restore the anatomic and biomechanical properties of the native ligament with the healing capacity to incorporate into the host bone.[1] It is widely accepted that autografts are preferred in young, active patients because of increased failure rates associated with allografts.[2-4] Although each graft has inherent advantages and disadvantages, quadriceps tendon (QT) autografts are regularly used with excellent clinical outcomes.[5-7] Advancements in surgical instrumentation and techniques continue to improve graft preparation. In this Technical Note, we describe our preferred technique for QT all-soft tissue autograft preparation for ACLR (Video 1).

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Surgical Technique

Graft Preparation

On the back table, the harvested QT graft is placed onto a graft preparation board (Fig 1). A FiberTag TightRope II implant (Arthrex, Naples, FL) suture card is loaded into the GraftClamp (Arthrex) tenaculum by sliding the card into the holding slot (Fig 2A), piercing the FiberTag suture with one tooth (Fig 2B), then clasping down on the femoral end of the graft approximately 2 mm from the end (Fig 2C). After appropriately positioning the FiberTag suture on the graft, the tapered needle is passed through the graft at the level of the implant, where the FiberTag suture converts to the FiberLoop suture (Fig 3). Notably, this is at approximately 20 mm. Slack is removed by pulling on the suture perpendicular to the graft rather than the needle itself while pinching the FiberTag suture flush to prevent it from flipping (Table 1). Working toward the suture card, the needle is passed through the FiberTag suture and graft using a whipstitch technique (Video 1). After placing 2 to 3 whipstitches in the graft (the senior author prefers 3), the needle is passed up through the slot in the suture card over the TightRope implant (Fig 4). Next, 2 to 3 additional whipstitches through the FiberTag suture and graft are passed, working away from the suture card. Below the splice of the needle, one "swedge" of the needle's suture is cut (leaving the needle on one limb of the suture, with the other limb "free). The free suture limb is then wrapped around the graft and tied to the limb with the needle. The suture limb without the needle is cut and the knot is buried

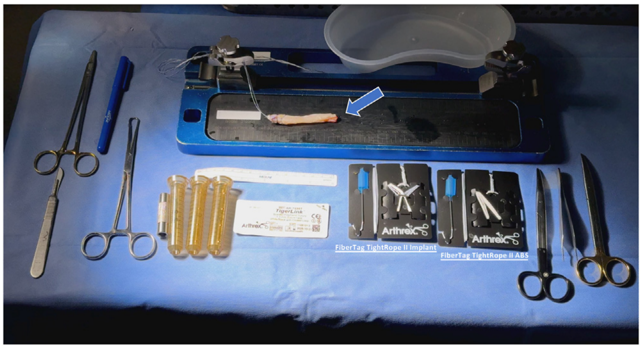

Fig 1. Intraoperative view of the back-table setup for quadriceps tendon graft preparation, including the harvested graft (blue arrow) and the FiberTag TightRope II suture cards.

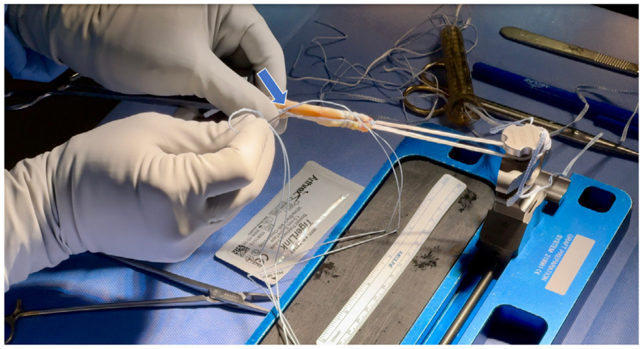

Fig 3. Using the FiberTag TightRope II implant, the initial needle pass is just distal to the FiberTag suture (blue arrow), followed by 3 whipstitches through the FiberTag suture.

with one final pass of the needle through the graft. The suture limb is then cut flush to the graft. For suture management, it is recommended to prepare the tibial side of the graft before unloading the TightRope (Arthrex) implant loops from the suture card (Table 1).

This process is repeated for the tibial end of the quadriceps graft, using the FiberTag TightRope II ABS (Arthrex) suture card. The suture card is loaded into the slot of the tenaculum, the FiberTag suture is pierced with one tooth of the clamp, and the graft is clasped approximately 2 mm from the end. With the FiberTag suture flat on the graft, the needle is passed through the graft only at the tip of the FiberTag suture. Three whipstitches are passed through the FiberTag suture and graft, working toward the suture card. The needle is then passed through the slot in the card to link the TightRope implant. Two more whipstitches are completed, working away from the suture card. The needle is then passed near the distal-most whipstitch and back through the free end of the graft, making sure to avoid piercing any other sutures. The needle is then removed. This provides reinforcement with an extra set of sutures for graft passage through the knee (Table 1).

The suture card contents are unloaded by flipping the card away from the graft 2 times. The femoral suture card is preloaded with a FiberTape suture for the

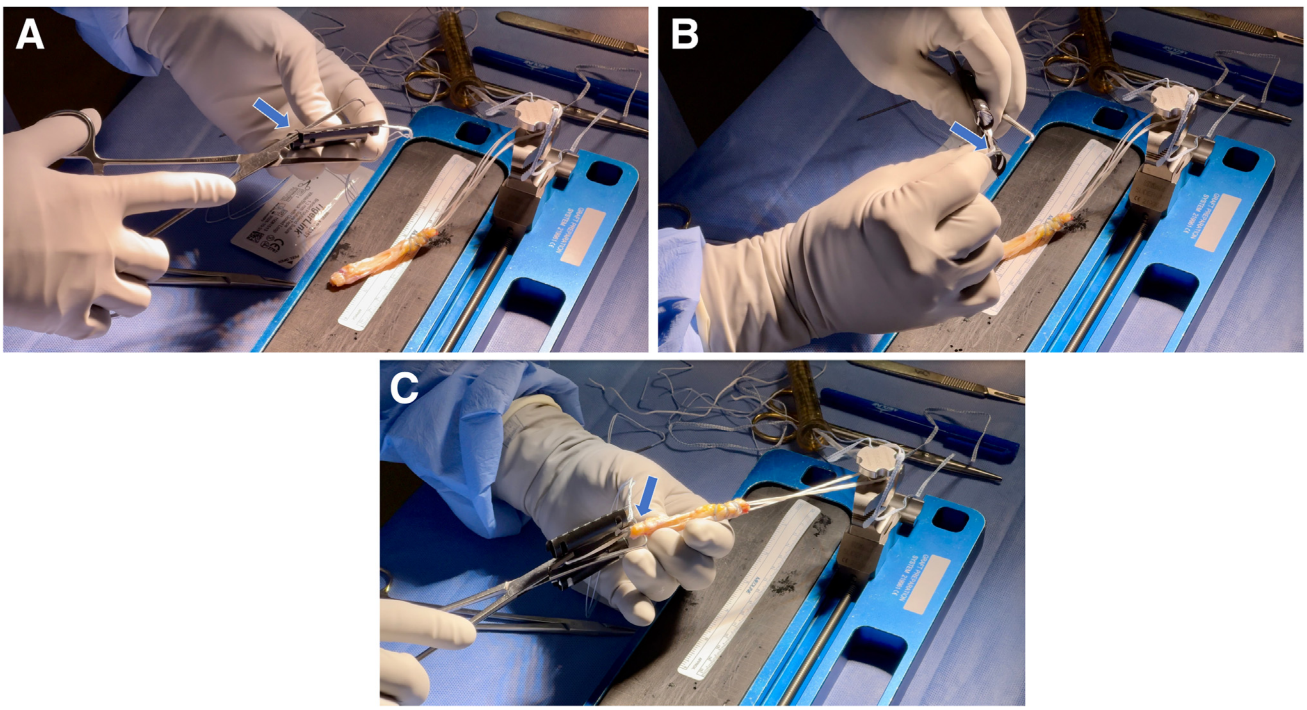

Fig 2. A FiberTag TightRope II suture card is loaded into the GraftClamp tenaculum. (A) The suture card is inserted into the holding slot on the tenaculum (blue arrow). (B) The FiberTag suture is pierced with one tooth of the tenaculum (blue arrow). (C) The tenaculum is clasped onto the graft (blue arrow).

Table 1. Pearls and Pitfalls of Quadriceps Tendon Autograft Preparation Using the FiberTag TightRope II implant

Pearls	Pitfalls
On the tibial side of the graft, use the FiberLoop suture limbs to reinforce graft passage through the knee by passing the needle from the distal-most whipstitch back through the free end of the graft before removing the needle.	The FiberTag suture can flip during the first pass through the graft. Apply pressure to prevent this.
Replace the #5 FiberWire with a 1.3-mm TigerLink suture during the tibial graft preparation to help with ease of passage through the tibial tunnel.	Unloading the suture card before preparing both ends of the graft can make for onerous suture management.

InternalBrace and a cortical button. The white looped sutures loaded into the femoral button are lengthened for ease of graft passage through the femoral tunnel (Video 1). The tibial side includes the ABS button for fixation on the tibia. The #5 FiberWire suture can be replaced with a 1.3-mm TigerLink suture (Arthrex) for ease of graft passage (Video 1). With both suture cards unloaded, the graft and the InternalBrace FiberTape sutures are pulled into various-sized graft tubes until the graft passage is snug to determine the diameter of the femoral and tibial tunnels (Fig 5). Once this is determined, the fully prepared graft (Fig 6) is wrapped in a vancomycin-soaked surgical sponge and securely stored on the graft preparation board under tension while arthroscopy is performed.

Discussion

This Technical Note describes a QT autograft preparation using the FiberTag TightRope II implant. QT autograft offers several advantages over other graft options. The biomechanical properties of QT grafts are favorable, allowing for a greater load-to-failure than bone—patellar tendon—bone (BPTB) grafts.[8] Compared with an intact native patellar tendon, the postharvest strength of the QT has a significantly greater ultimate load to failure, which can theoretically accelerate extensor mechanism recovery.[8] BPTB grafts feature bone plugs at each end, which promotes bone-to-bone healing with early osteointegration. Although integration is slower with an all-soft tissue graft, QT survivorship is comparable with BPTB.[9] Additionally, technical challenges and the potential for graft-tunnel mismatch should be considered with BPTB.

Overall, QT has been shown to be a reliable graft for ACLR. Functional outcomes between QT and BPTB are comparable, with no differences in postoperative range of motion and a similar graft failure rate.[10,11] In addition, QT demonstrates lower knee laxity postoperatively compared with hamstring tendon (HT).[12,13] In a recent systematic review and meta-analysis, Dai et al.[5] reported that QT autografts had significantly lower donor-site morbidity than BPTB and HT autografts with comparable graft survival, functional outcomes, and stability. In a large multicenter study with a cohort of 21,973 patients, Yang et al.[14] substantiated

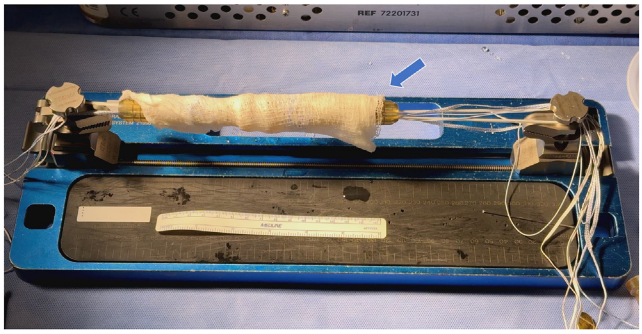

Fig 5. Various-sized graft tubes are tested to determine the diameter of the femoral and tibial tunnels (as depicted here, the corresponding tunnel sizes are femoral tunnel 9 mm, tibial tunnel 9.5 mm) (blue arrow). The fully prepared graft is securely stored on the graft preparation board under tension wrapped in a vancomycin-soaked surgical sponge while the tunnels are drilled.

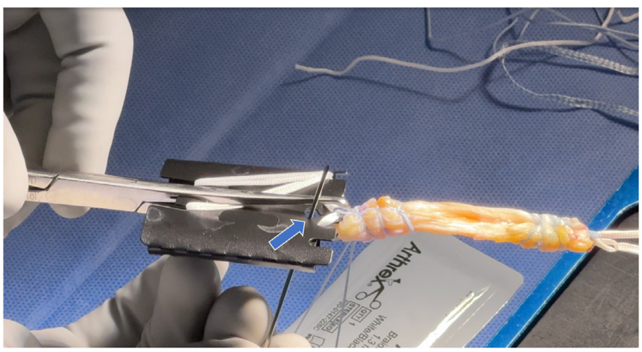

Fig 4. With 3 whipstitches in the graft, the needle is passed up through the slot in the suture card over the TightRope implant (blue arrow).

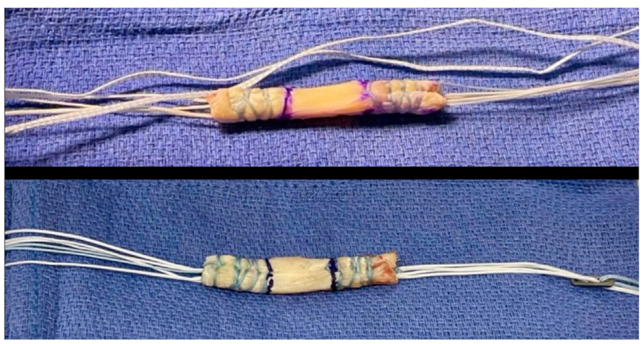

Fig 6. Examples of fully prepared quadriceps tendon autografts with (top) and without (bottom) an InternalBrace.

Table 2. Advantages and Disadvantages of QT Autograft Preparation Using the FiberTag TightRope II Implant

Advantages	Disadvantages
QT autograft has comparable graft survival and clinical outcomes for primary and revision ACLR compared with BPTB autograft.	Technically challenging
The preloaded FiberTag TightRope II implant suture cards facilitate easier suture management.	Poor technique can result in difficulty passing the graft through the tunnels.
The included InternalBrace decreases the risk of graft retear.	Implant costs

ACLR, anterior cruciate ligament reconstruction; BPTB, bone−patellar tendon−bone; QT, quadriceps tendon.

the viability of QT autograft relative to BPTB and HT after finding no difference in the risk of revision.

QT is also a practical option for revision ACLR. In a matched-control cohort study, Meena et al.[15] demonstrated acceptable functional outcomes in both primary and revision cases. Ashy et al.[16] reported that QT autograft resulted in satisfactory patient-reported outcomes, functional and objective stability, return-to-sport rates, and a low failure rate after revision ACLR. HT grafts, in particular, have been associated with a greater tendency for failure in the setting of revision ACLR.[17]

The FiberTag TightRope II implant has improved safety, efficiency, and functionality. The preloaded suture cards facilitate easier suture management (Table 2). The included InternalBrace has shown a significantly decreased risk of graft retear and improved clinical outcomes (Table 2).[18,19] Concern surrounds suspensory fixation for all-soft tissue QT autografts as the result of increased graft motion, which can result in tunnel widening and slower graft integration.[20] However, the FiberTag TightRope II implant contains a knotless fifth locking mechanism with retensioning capabilities to fine-tune the construct after final fixation (Table 2). This increases the strength and resistance of the construct and potentially combats cyclic displacement.

Despite the many advantages, this technique has some limitations. Persistent quadriceps weakness compared with the contralateral knee is a potential complication of QT harvesting (Table 2). In a systematic review and meta-analysis conducted by Johnston et al.,[21] the authors found a lag in knee extensor strength recovery that was asymmetric to the uninjured knee up to 24 months postoperatively. Holmgren et al.[22] reported significantly worse isokinetic quadriceps strength compared with HT and BTB grafts, although contralateral asymmetry was found for each graft type. This emphasizes the importance of rehabilitation to optimize quadriceps restoration. In addition, although the FiberTag TightRope II implant optimizes graft preparation, it may be considered technically challenging by some, requiring a considerable learning period (Table 2). Poor technique can result in difficult graft passage through the tunnels during ACLR (Table 2). Moreover, the preloaded #5 FiberWire can be problematic during graft passage through the tibial tunnel and may require replacement with the smaller 1.3-mm TigerLink suture, which increases overall surgical costs (Table 2).

Overall, orthopaedic sports medicine surgeons must understand all available ACL graft options, indications, and supporting evidence to inform and manage patient expectations and optimize outcomes. The most appropriate graft should be determined on the basis of patient and surgeon preference. This Technical Note describes a QT autograft preparation using the FiberTag TightRope II implant, which provides a vastly simplified, efficient, and reproducible option for ACLR.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: R.M.F. reports board membership for American Academy of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, American Shoulder and Elbow Surgeons, Arthroscopy Association of North America, International Cartilage Regeneration & Joint Preservation Society, International Society of Arthroscopy Knee Surgery and Orthopaedic Sports Medicine, *Journal of Shoulder and Elbow Surgery*, and *Orthopedics Today*; consulting or advisory and speaking and lecture fees from AlloSource; consulting or advisory, funding grants, and speaking and lecture fees from Arthrex; consulting or advisory and speaking and lecture fees from JRF Ortho; and speaking and lecture fees from Ossur. All other authors (D.J.S., T.R.C., B.P.E., K.S., K.K.S.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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