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Technical Pearls and Solutions for All-Inside Anterior Cruciate Ligament (ACL) Reconstruction Using Quadriceps Tendon Autograft

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Abstract

Anterior cruciate ligament (ACL) reconstruction is one of the most common orthopaedic sports medicine procedures, with increasing interest in the quadriceps tendon (QT) autograft. Prior studies have detailed intraoperative pitfalls and management strategies for bone-patellar tendon-bone and hamstring tendon autograft ACL reconstructions. However, to our knowledge, there remains no comprehensive discussion of common intraoperative complications and technical challenges specific to the all-inside ACL reconstruction using QT autograft. The purpose of this study is to detail surgical technique and emphasize pearls and pitfalls associated with all-inside ACL reconstruction using QT autograft, focusing on graft harvesting, tunnel drilling, graft passage, and graft tensioning.

Quadriceps tendon harvest utilizes a cylindrical cutter with proper trajectory from the superior pole of the patella to ensure adequate graft length (65-70 mm). Premature truncation below 60 mm may require allograft augmentation, while borderline graft length (60-64 mm) may warrant shorter femoral sockets (15-20 mm) to preserve adequate tibial fixation length. Full-thickness harvest sites are repaired with absorbable suture, creating a non-watertight closure for arthroscopic outflow. Graft-tunnel width mismatch is addressed through trimming for oversized grafts or allograft overlay for thin grafts. Anatomic femoral tunnel drilling selectively employs a low anteromedial portal with spinal needle guidance to protect the medial femoral condyle. Femoral socket preparation requires incremental drilling with frequent visualization to prevent posterior wall blowout. Tibial tunnel complications include flip cutter entrapment, soft tissue interposition at the cortex, sheath dislodgement, and tibial suture disruption, each requiring appropriate instrumentation and technique to prevent or address. Cortical suspensory fixation uses controlled tensioning to prevent button extrusion, with prophylactic notchplasty performed selectively based on intercondylar notch width and intraoperative assessment to prevent graft impingement.

As QT autograft has become increasingly common in ACL reconstruction procedures, surgeons should familiarize themselves with the typical pitfalls that can arise during these cases and develop a clear understanding of management strategies. These strategies, based on the authors' surgical experience and the available literature, may be helpful to surgeons performing all-inside ACL reconstruction with QT autograft, although they have not been clinically validated.

Categories: Sports Medicine, Medical Education, Orthopedics
Keywords: anterior cruciate ligament (acl) reconstruction, arthroscopy knee, orthopaedic sports medicine, quadriceps tendon graft, surgical technique

Introduction

Anterior cruciate ligament (ACL) injuries are among the most common knee injuries, with an incidence of 68.6 per 100,000 person-years, primarily affecting young, active individuals participating in pivoting sports [1]. ACL reconstruction aims to restore knee stability, prevent secondary injuries such as meniscal tears and osteoarthritis, and facilitate return to pre-injury function [2]. Surgical reconstruction is commonly recommended for active individuals, although management is individualized based on activity demands, associated injuries, and patient goals [3]. Graft options include bone-patellar tendon-bone, hamstring tendon, quadriceps tendon (QT), and allografts, each with distinct biomechanical and clinical profiles [4]. The quadriceps tendon offers favorable biomechanical properties, large cross-sectional area, and low donor site morbidity compared to traditional graft options [5-9]. The all-inside ACL reconstruction technique, characterized by femoral and tibial sockets rather than full tunnels, preserves bone stock, reduces postoperative pain, and enhances cosmesis [10]. Fixation is typically achieved with cortical suspensory buttons seated on the femoral and tibial cortices. With closed-ended sockets, the graft must fall within a narrow range of length and diameter to allow full tensioning, which is particularly relevant with QT grafts given their variable dimensions [10,11]. When paired with quadriceps autograft, this approach leverages the graft's versatility (soft-tissue or bone-tendon options) and the technique's minimally invasive nature [12].

The majority of existing literature for QT autograft ACL reconstruction focuses on post-operative outcomes,

biomechanical analysis, and surgical technique [12-14]. Prior technique manuscripts primarily focus on harvest techniques, including all-soft tissue autografts, bone block constructs, and minimally invasive harvests, as well as graft preparation, augmentation methods, and fixation procedures [5,7,8,15-22]. However, unlike bone-patellar tendon-bone and hamstring tendon autograft, to our knowledge, there remains no comprehensive discussion of common intraoperative complications and technical challenges specific to all-inside QT autograft ACL reconstruction [23,24]. This text provides a detailed description of our all-inside, primarily soft-tissue QT ACL reconstruction surgical technique, emphasizing pearls and pitfalls in graft harvesting, tunnel drilling, graft passage, and graft tensioning, based on our institutional experience and the available literature.

Technical Report

Surgical techniques, pearls, and pitfalls

Graft Harvest Length

During QT graft harvest, the tendon demonstrates greater thickness medially and inserts more laterally; therefore, careful consideration of fiber trajectory is essential for a symmetrical graft. A cylindrical cutter (Quad Tendon Stripper Cutter; Arthrex, Naples, FL, USA) is often used for proximal graft truncation. To avoid premature truncation, the distal aspect of the desired QT graft should be marked. It is important to verify and label harvest dimensions prior to harvesting. Additionally, maintaining adequate tension on the graft with the non-dominant hand before engaging the cylindrical cutter is essential. When freeing the tendon medially, laterally, superficially, and deep, Metzenbaum scissors are used, and the tips must be pointed away from the graft to avoid inadvertent amputation. When using the cylindrical cutter to truncate the graft proximally, it should be advanced up the length of the graft to the desired length, typically 65-70 mm, which provides adequate graft for both sockets while remaining short enough to be fully tensioned [10,11]. In our experience, engaging the safety bar and placing the pinky finger underneath the cutter improves control during advancement. Additionally, an assistant should cover the incision as the cutter is being deployed. This avoids inadvertent contamination of the graft as it is taken under traction. If premature truncation of the graft occurs, subsequent management depends on the length of the remaining graft.

Borderline Graft Length (Approximately 60-64 mm)

If the harvested QT length is between 60 and 64 mm, it is important to avoid over advancing the graft in the femoral socket as this may lead to insufficient graft length distally. For example, assuming an intra-articular length of approximately 25 mm, a 25 mm femoral socket would leave only 10 to 14 mm of a 60 to 64 mm graft within the tibial socket [10]. Although this risk has not been quantified, we are concerned that reduced graft within the tibial socket may increase load on the tibial suspensory fixation and predispose to fixation failure. Therefore, in scenarios where graft length is borderline, we consider a shorter femoral socket, approximately 15 to 20 mm, to preserve adequate graft length for healing and tibial tunnel fixation.

Insufficient Graft Length (Under 60 mm)

If the resultant graft is under 60 mm, in our experience, it is often necessary to supplement the prematurely truncated QT graft with a soft-tissue allograft. The autograft and allograft ends are overlapped and secured with a whipstitch or running suture and fixed with the same suspensory implants used for a standard QT graft. This hybrid graft provides adequate length to span both femoral and tibial sockets but should be considered a salvage option, as it is not standardized or, to our knowledge, biomechanically validated.

Excess Graft Length

If harvested graft length is greater than 70 mm, it is acceptable to cut the graft at the desired length, or consideration for a greater femoral tunnel and/or a full-length tibial tunnel can be employed. In the instance when a full tibial tunnel is utilized, it is recommended that a larger, more robust tibial tunnel fixation device is used.

Harvest Site Repair

If the harvest was full thickness (taken with violation of the underlying joint capsule), then repair is recommended. A scorpion needle passer may be used to accomplish this in either an interrupted or running fashion with high tensile absorbable suture. In our practice, a closure that is not watertight is used, as this functions as an outflow portal for arthroscopy. If the harvest was partial thickness, then an 11 blade can be used to make a stab incision in the capsule just proximal to the superior pole of the patella to serve as an outflow portal during the arthroscopic portion of the procedure.

Protecting the Medial Femoral Condyle During Tunnel Drilling

To achieve an anatomic femoral tunnel trajectory while avoiding damage to the chondral surface of the medial femoral condyle, a separate low anteromedial reaming portal may be established under direct visualization with a spinal needle. After addressing any meniscal pathology, performing ACL remnant removal, and completing a notchplasty if necessary, introduce a spinal needle under direct visualization just above the medial meniscus. Place the tip of the spinal needle at the ACL footprint on the lateral wall, then move the camera just anterior to the medial femoral condyle. Bring the light handle to the 12 o'clock position to determine if adequate clearance is present anterior to the condyle. If clearance is inadequate, the spinal needle should be repositioned before establishing the portal.

Femoral Socket Posterior Wall Blowout

Posterior wall blowout during femoral socket creation is a well-known risk of ACL reconstruction. This loss of osseous containment can compromise suspensory graft fixation, which is commonly employed with QT grafts, and may lead to early graft failure if left untreated. When inserting the femoral guide pin, proper positioning around the 10:30 position on the lateral wall with the knee hyperflexed is essential. Once an appropriate guide pin placement is confirmed, place a cannulated reamer over the guide pin and advance it to a depth of 10 mm (Figure *1*). Withdraw the reamer and use an arthroscopic shaver to clear bone debris from the femoral socket, allowing direct visualization of the posterior wall. If necessary, adjust the guide pin placement at this stage to ensure adequate posterior wall thickness. Then select the appropriate reamer diameter based on graft size and drill the femoral socket to a depth of 25 mm for a 65 mm graft. Pass an Ethibond suture (Ethicon, Inc., Raritan, NJ, USA) through the tunnel using a Beath pin for later graft passage and secure it with a hemostat to avoid an inadvertent pullout. During over-drilling of the guide pin, advance the drill bit incrementally through the femoral canal, and then fully reverse it by hand at intervals to allow full visualization of the canal and confirm posterior wall integrity. If posterior wall blowout occurs, suspensory fixation may still be used, as cortical buttons rely on the lateral femoral cortex rather than the posterior wall. Breaches extending no more than 3 to 5 mm into the socket from the aperture may be managed with slight anterior redirection of the reamer and fixation as planned, whereas longer breaches warrant alternative fixation [25]. If the lateral femoral cortex is also compromised, an extended cortical button may be used [25]. However, if a femoral bone block is utilized then a post should be established as an additional fixation point proximally.

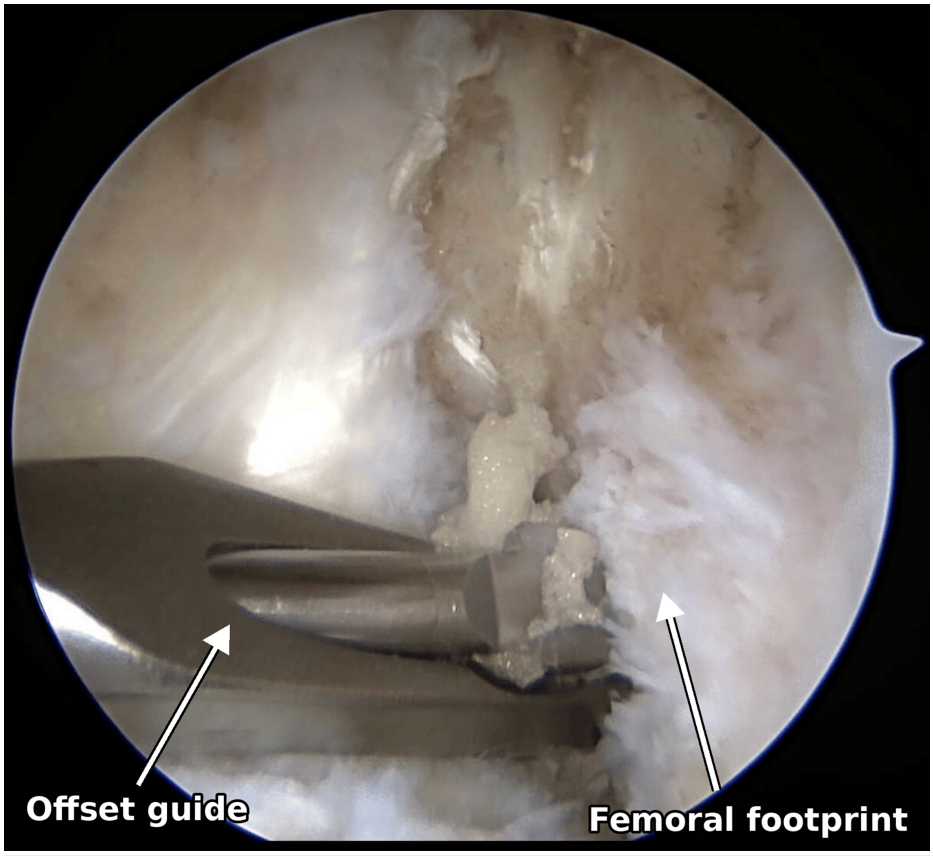


FIGURE 1: Arthroscopic image (left knee) demonstrating anatomic position of femoral tunnel, with over-the-top offset guide being placed with the knee in hyperflexion

The offset guide tip is positioned at the femoral footprint on the lateral wall of the intercondylar notch.

The post technique described by Mitchell et al. in 2016 requires exposure through a longitudinal incision positioned over the distal lateral supracondylar ridge [25]. The iliotibial band is incised, and the vastus lateralis muscle is elevated subperiosteally to provide direct access to the femoral tunnel. A 4.5 mm partially threaded cancellous screw with a washer is inserted approximately 1 cm anterior and distal to the tunnel opening, positioned near the meta-diaphyseal flare and posterior to the lateral intermuscular septum to prevent iliotibial band irritation. Screw selection should ensure adequate cortical purchase while maintaining a sufficient smooth, unthreaded shaft to protect the suture from damage during tensioning. Next, under direct visualization, the graft sutures are passed through the femoral tunnel and looped around the screw-washer post. Appropriate tension is determined based on the amount of graft in the femoral tunnel. Sutures are tied around the post, and the screw and washer are advanced to the cortex to further secure the construct and cover the knot to avoid irritation.

Graft-Tunnel Width Mismatch

Graft-tunnel width mismatch presents a potential intraoperative challenge during quadriceps tendon ACL reconstruction, largely attributed to the inherent variability in graft thickness that depends on harvest technique and individual patient anatomy. Prevention requires meticulous preoperative planning and precise intraoperative sizing of the harvested graft prior to tunnel creation. A systematic review demonstrated that QT autografts used in ACL reconstruction have a mean diameter of 8.9 mm, with considerable variation ranging from 7.8-10.4 mm [26]. Recent studies suggest that grafts below 7 mm are suboptimal due to inadequate strength and increased failure risk, while a femoral tunnel diameter of 9.25 mm or greater may increase complications such as arthrofibrosis, particularly in male patients [27,28]. When excessive graft width is encountered intraoperatively, surgeons can address this through graft trimming to achieve appropriate dimensions or tubularization into a narrower, cylindrical configuration using sutures. Conversely, when confronted with an inadequately thin graft (<7 mm), augmentation with an allograft overlay may be used to achieve appropriate graft size.

Flip Cutter Entrapment in the Tibial Tunnel

A potential intraoperative complication during tibial socket preparation is the entrapment of the flip cutter within the tibial tunnel. Given the typically larger graft diameter and corresponding tunnel size required for quadriceps tendon autografts, precise operation of the flip cutter is essential to avoid this pitfall (Figure 2). Flip cutter entrapment occurs when the device fails to fully reorient into the inline position during retrieval, potentially causing socket damage and cortical breach. When this complication arises, first carefully advance the flip cutter back into the joint space. If the contralateral lower extremity or operating room table blocks withdrawal and retrograde tunnel creation of the expanded flip cutter, rotate the drill handle so that the battery faces up to increase clearance. Gentle back-and-forth manipulation can help free the device. To avoid unintentional sheath removal from the tibial tunnel, use a mallet to gently tap the sheath, securing it firmly within the tunnel. If bone is stuck within the head of the flip cutter that inhibits full collapse of the head down to 3.5 mm, introduce a probe from the lateral portal to attempt removal of the fragment after expanding the cutter to its widest diameter. If the cutter remains immobile, rotating the flip cutter shaft may allow the blade to fold back inline, permitting safe withdrawal. Throughout this process, consider placing an arthroscopic curette to prevent advancement of the flip cutter into the femoral condyle. Lastly, it is recommended to insert a syringe full of normal saline into the tibial tunnel and perform an in-out plunging technique to simultaneously clear any bony debris with the shaver in the anterolateral portal.

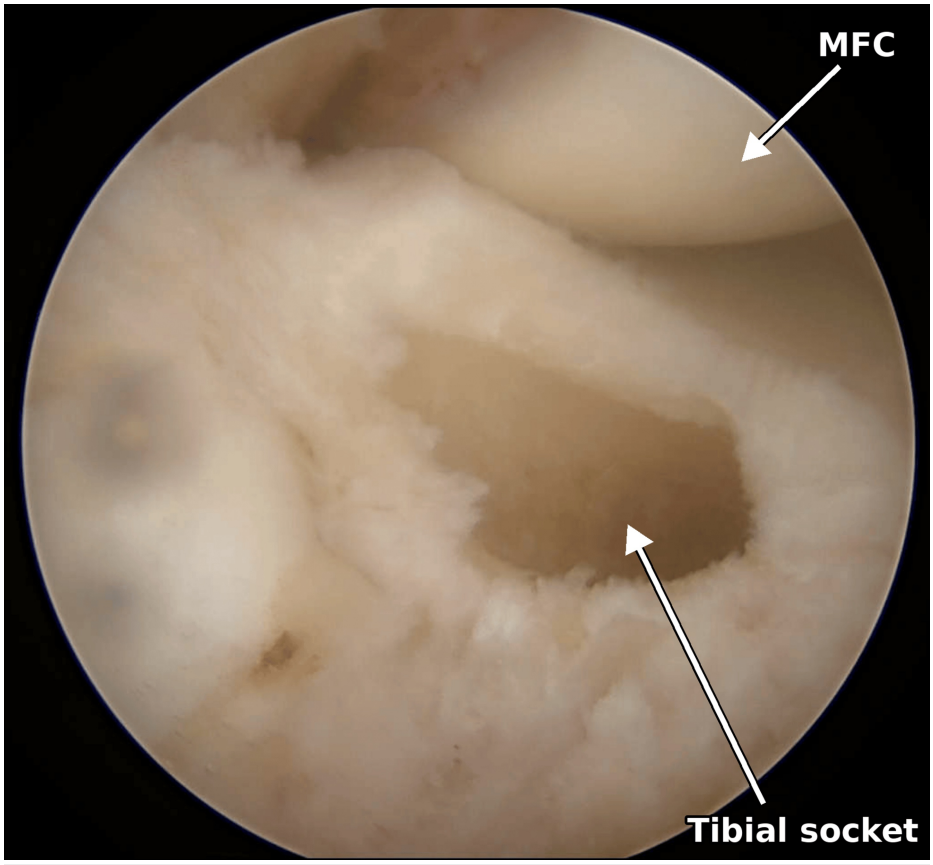


FIGURE 2: Arthroscopic image (right knee) depicting tibial tunnel after reaming with flip cutter

The tibial socket is centered on the ACL tibial footprint. ACL, anterior cruciate ligament; MFC, medial femoral condyle.

Femoral Button Extrusion During Graft Passage or Tensioning

During femoral tunnel graft passage, the implant should be advanced to the most proximal aspect of the femoral tunnel. Both suture limbs attached to the button are grasped in a closed fist, and the fist is rolled against the lateral thigh just proximal to the femoral exit site as the graft is advanced, avoiding pulling the button far laterally into the soft tissues or out of the skin. Button passage and seating are confirmed by tactile feedback and arthroscopic visualization, with radiographs obtained only if extrusion through the iliotibial band is suspected. After passing the graft through the femoral and tibial tunnels, sutures attached to a cortical suspensory fixation button may be used to tension the graft. The two ends of the suture are separated and equally pulled in a shuffle technique. A useful technique at this stage is to mark each end of the white tensioning suture at an equal length once the femoral implant passes through the tunnel and engages in the lateral femoral cortex. This ensures even tension during sequential cinching and facilitates

symmetric advancement of the graft to the desired depth, typically around 20 mm. Additionally, pulling the sutures in line with the femoral tunnel can facilitate smooth graft advancement (Figure 3). A common pitfall during this step occurs if sutures are pulled too forcefully or unevenly; the button can track beyond the lateral cortex, through the surrounding soft tissues, and exit through the skin of the lateral thigh. Once the button has exited the skin, attempts to redirect it back into the femoral tunnel are time-consuming and often unsuccessful in re-establishing proper cortical fixation. If extrusion does occur, one option is to dissect down to the button and directly visualize appropriate implant position, or to completely remove the graft construct from the joint, thread a new cortical suspensory fixation button onto the femoral end of the graft, and carefully repeat the passage and tensioning process to ensure appropriate deployment and seating of the button against the lateral femoral cortex.

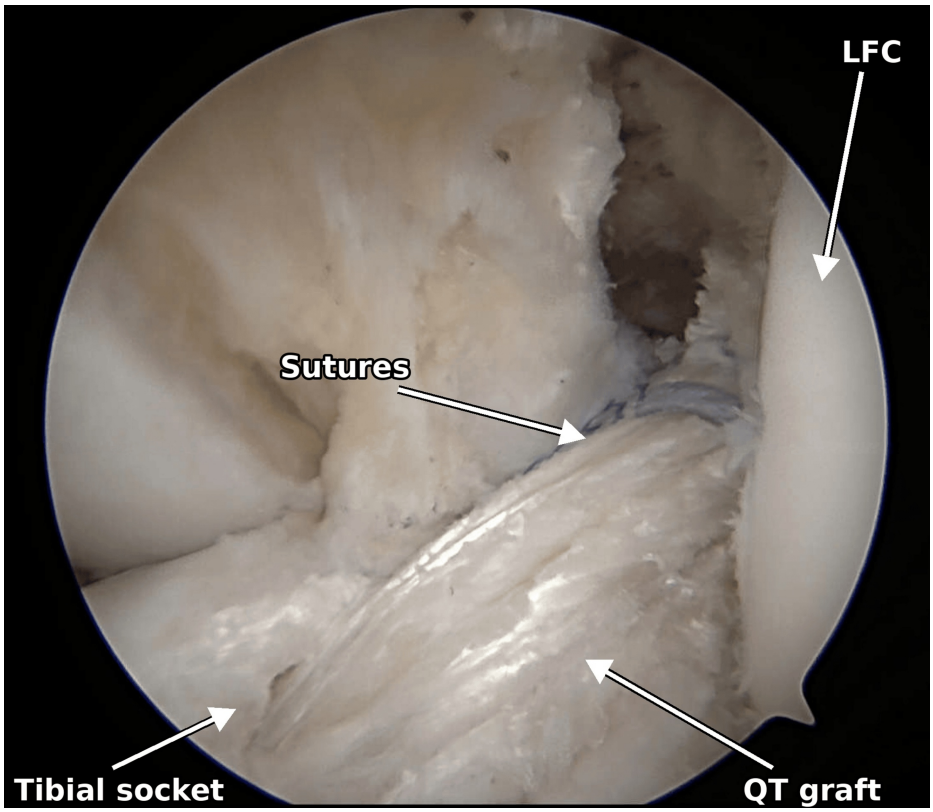


FIGURE 3: Arthroscopic image (left knee) demonstrating ACL reconstruction with quadriceps tendon autograft

The QT graft and its sutures are seen following passage, with the tibial socket and LFC labeled. ACL, anterior cruciate ligament; LFC, lateral femoral condyle; QT, quadriceps tendon.

Tibial Button Soft Tissue Clearance and Suture Management

To avoid soft tissue interposition between the tibial suspensory implant and the anteromedial tibial cortex, use a small key elevator to clear soft tissue down to the cortex (Figure 4). This ensures proper implant seating and avoids potential fixation compromises. If the tibial sutures are inadvertently cut while clearing anteromedial soft tissues prior to cinching down the tibial button, the tibial aspect of the graft can be pulled through the anteromedial portal, and a new tibial implant may be sutured onto the graft. Alternatively, if insufficient graft length precludes re-suturing outside the joint, a small lateral thigh incision can be made at the level of the deployed button. The entire graft construct can then be removed, and new implants sutured onto the graft.

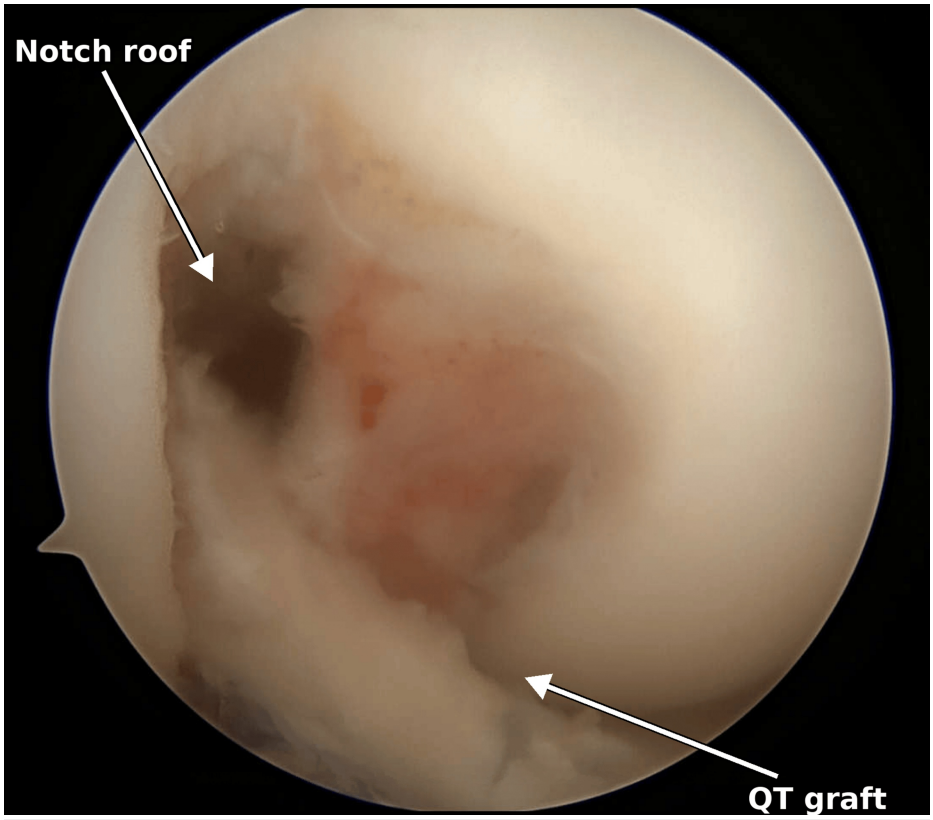


FIGURE 4: Arthroscopic image (right knee) demonstrating quadriceps tendon autograft ACL reconstruction with femoral and tibial suspensory fixation and lateral femoral condyle notchplasty

The QT graft is seen below the notch roof following notchplasty. ACL, anterior cruciate ligament; QT, quadriceps tendon.

Graft Impingement/Arthrofibrosis

Graft impingement against the intercondylar notch represents a well-recognized pitfall in anterior cruciate ligament reconstruction, particularly with larger-diameter quadriceps tendon autografts [29]. To prevent this, it is important to tighten the tibial fixation with the knee in full extension; however, there are additional measures that can be taken. When indicated by intraoperative findings, notchplasty prior to graft passage and fixation may help prevent this pitfall [30-32]. With the knee positioned in hyperflexion to maximize visualization of the intercondylar notch, a shaver or burr can be employed at the femoral notch, the most common site of impingement, to create adequate clearance. Throughout the process, frequently assess the lateral femoral condyle to avoid excessive resection that could compromise the condyle or tunnel position. With quadriceps tendon grafts, inspecting potential impingement after graft passage and fixation is particularly important.

While prophylactic notchplasty has been shown to improve graft clearance and prevent extension loss in ACL reconstruction, most authors advocate selective application based on intraoperative findings rather than routine use [30-32]. A notch width below 16 mm has been associated with a fivefold higher graft failure rate after bone-patellar tendon-bone or QT autograft ACL reconstruction, although it was not an independent predictor after adjusting for age [33].

If impingement is discovered after graft fixation, notchplasty can still be performed, but with extreme caution and precision. To execute this salvage procedure, the knee must first be brought into extension to identify the precise location of graft-notch contact, followed by flexion to displace the graft away from the intercondylar notch. This approach should be considered a last resort, as performing notchplasty around a fixed graft increases both technical difficulty and risk to the graft itself.

Discussion

Intraoperative complications during all-inside ACL reconstruction using QT autograft can compromise graft integrity, fixation, and surgical outcomes if not avoided or promptly recognized and addressed (Table *1*).

Attention to graft diameter is particularly relevant with QT autograft, as reported diameters vary considerably depending on harvest technique and patient anatomy, ranging from 7.8-10.4 mm; this variability makes graft-tunnel mismatch a meaningful intraoperative consideration given its downstream implications for fixation strength and arthrofibrosis risk [26-28]. The larger cross-sectional area of QT grafts relative to other autograft options also raises the importance of assessing for notch impingement, particularly given a reported association between narrower intercondylar notch width and graft failure [33]. When standard suspensory fixation is compromised, such as with posterior wall blowout, alternative techniques such as the femoral cortical post described by Mitchell et al. offer a salvage option [25]. This report has several limitations. The recommendations are based on institutional experience and the available literature, without formal case review, systematic literature review, outcome data, or complication rates, and those without supporting evidence are identified as the authors' technical preference. Several steps describe specific instrumentation (Arthrex) and may need to be adapted for other systems. Closure of the QT harvest defect has not been shown to affect patellar height, but, to our knowledge, the effect of a non-watertight closure on fluid extravasation, hematoma, quadriceps function, and wound morbidity has not been evaluated [34]. These considerations may not be generalizable to all surgical settings or patient populations.

Pitfall	Description and Mechanism	Prevention	Management
Insufficient graft harvest	Premature truncation during QT harvest can leave inadequate graft length.	Align the cutter with the superior pole of the patella. Maintain tension before engaging the blade. Use Metzenbaum scissors with tips pointed away when freeing the tendon. Advance the cutter with the safety bar engaged.	If length is borderline (60-64 mm), drill a shorter femoral tunnel (15–20 mm). If <60 mm, supplement with allograft.
Medial femoral condyle damage	Damage to the medial femoral condyle during femoral tunnel drilling.	Establish a low anteromedial portal under direct visualization just above the medial meniscus using a spinal needle. Place the tip at the ACL footprint on the lateral wall, then verify adequate clearance anterior to the medial femoral condyle.	If adequate clearance is not confirmed, reposition the spinal needle before establishing the portal.
Posterior wall blowout	Femoral socket posterior wall loss compromises graft fixation.	Proper guide pin positioning (around the 10:30 position, knee hyperflexed). Incrementally advance the drill, then fully reverse it to confirm posterior wall integrity.	Breaches ≤3–5 mm into the socket: redirect reamer anteriorly and fix as planned. Longer breaches: alternative fixation (lateral cortical screw and washer post or extended cortical button).
Graft-tunnel width mismatch	Mismatch between QT graft diameter and prepared tunnel size.	Careful preoperative planning and intraoperative sizing of harvested graft before drilling femoral and tibial tunnels.	For excessive graft width, trim graft to appropriate diameter or tubularize with sutures. For inadequate graft width, consider augmenting graft with soft-tissue allograft.
Flip cutter stuck in tibial tunnel	Entrapment occurs if the flip cutter fails to fully reorient inline during retrieval.	Avoid obstruction from contralateral leg or OR table by rotating drill handle (battery up) to improve clearance.	Advance cutter into the joint space, then gently manipulate. Gently secure the sheath within the tunnel using a mallet. If bone is lodged, use probe via lateral portal to clear. Rotate shaft if stuck. Use arthroscopic curette to protect femoral condyle during retrieval.
Femoral button extrusion during graft passage or tensioning	Uneven or excessive tensioning can cause the button to track through soft tissue and exit the skin, losing cortical fixation.	Grasp both button suture limbs in a fist and roll the fist along the lateral thigh, just proximal to the femoral exit site, during passage. Use shuffle technique with even, symmetric tension. Mark sutures at equal lengths once button reaches femoral cortex. Pull in line with femoral tunnel axis.	Dissect down to the button to confirm position, or remove graft construct, thread a new button, then repeat passage and tensioning carefully.
Tibial button soft tissue clearance and suture management	Soft tissue interposition between the tibial button and anteromedial cortex can compromise fixation, and accidental suture transection during soft tissue clearance may necessitate graft revision.	Use a small key elevator to clear soft tissue down to the cortex prior to tibial button deployment.	If tibial sutures are inadvertently cut, pull the graft through the anteromedial portal and suture a new tibial implant. If insufficient graft length precludes re-suturing outside the joint, make a small lateral thigh incision, remove the entire construct, and re-suture new implants onto the graft.
Graft impingement	Larger QT grafts are at increased risk of intercondylar notch impingement, which can lead to extension loss.	Selective notchplasty before graft passage with hyperflexed knee. Resect bone from anterior-inferior notch, avoiding over-resection.	If impingement persists after fixation, carefully perform a notchplasty. Extend the knee to locate the impingement, then flex to displace graft and resect bone.

TABLE 1: Pearls and pitfalls summary for graft harvesting, tunnel drilling, graft passage, and graft tensioning

ACL, anterior cruciate ligament; OR, operating room; QT, quadriceps tendon.

Conclusions

This technique report highlights common intraoperative challenges particularly relevant to QT autografts, including issues with graft length, graft-tunnel mismatch, tunnel creation, fixation, and device-related complications, while providing practical approaches to avoid or manage them. As QT autograft utilization has become increasingly common in ACL reconstruction procedures, surgeons should familiarize themselves with the typical pitfalls that can arise during these cases and develop a clear understanding of management strategies to maintain operative proficiency. These strategies, based on the authors' surgical experience and the available literature, may be helpful to surgeons performing all-inside ACL reconstruction with QT autograft, although they have not been clinically validated.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Aziz Shittu, Christina Freiberger, Michael Wilk, Johann Braithwaite, Michael Letter, Lee Kaplan

Drafting of the manuscript: Aziz Shittu, Christina Freiberger, Michael Wilk

Critical review of the manuscript for important intellectual content: Aziz Shittu, Christina Freiberger, Michael Wilk, Johann Braithwaite, Michael Letter, Lee Kaplan

Supervision: Lee Kaplan

Disclosures

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