Technical Note

Quadriceps Tendon Reconstruction With Achilles Tendon Bone Block Allograft

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Abstract: Chronic quadriceps tendon ruptures are relatively uncommon albeit debilitating injuries to the knee extensor mechanism. Previous literature demonstrates worse reported outcomes with delayed surgical intervention, and no gold-standard technique currently exists for managing chronic quadriceps tendon ruptures. The goal of this technique is to provide orthopaedic surgeons an additional option that may provide a greater mechanical load to failure and greater allograft acceptance for cases with large tendon gapping or poor tissue quality that may not be viable to other lengthening techniques. We describe the repair of a chronic quadriceps tendon rupture using an Achilles tendon bone block allograft.

Quadriceps tendon (QT) ruptures are uncommon yet disabling injuries that disrupt the knee extensor mechanism and account for 1.3% of all ligamentous and tendinous injuries. The vast majority of QT ruptures occur in male patients older than 40 years of age, with the most common mechanism of injury being a strong eccentric contraction with the knee in a fixed position of flexion. Atraumatic ruptures frequently occur in patients with underlying systemic diseases as well as fluoroquinolone and corticosteroid use.[1-3] The current literature recommends surgical repair within the first 48 to 72 hours to achieve the most successful outcome. Repair of chronic QT ruptures, defined by 3 weeks' postinjury, has been reported to have worse functional outcomes likely due to scar tissue formation, distal retraction of the patella, quadriceps muscle atrophy, and large tendon gapping. Managing chronic QT ruptures thus proposes a technical challenge for orthopaedic surgeons, and there is currently no gold-standard surgical technique. Previously reported techniques include primary repair, tissue lengthening, or advancement with a V-Y plasty and reconstruction with an autograft or allograft.[1,2] With the goal of improving functional outcomes in patients with poor tissue quality and not amenable to lengthening techniques, we describe the repair of a chronic QT rupture with an Achilles tendon bone block allograft.

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Surgical Technique (With Video Illustration)

Patient Evaluation

Patient presentation for QT rupture frequently demonstrates history of an eccentric loading event to the knee. Knee pain, inability to actively extend the knee against gravity, and a suprapatellar gap on physical examination are strong indications of a QT rupture. It is recommended to compare the extensor mechanism with the contralateral side, as the intact patellar retinaculum can aid in knee extension and often presents a false negative for misdiagnosis. Hemarthrosis in the setting of acute rupture also can mask the suprapatellar gap, and the surgeon should consider other findings on physical examination for diagnosis.[1]

Imaging

Preliminary radiographs of the knee with suspected QT rupture will typically demonstrate patella baja with no acute osseous abnormalities. Magnetic resonance

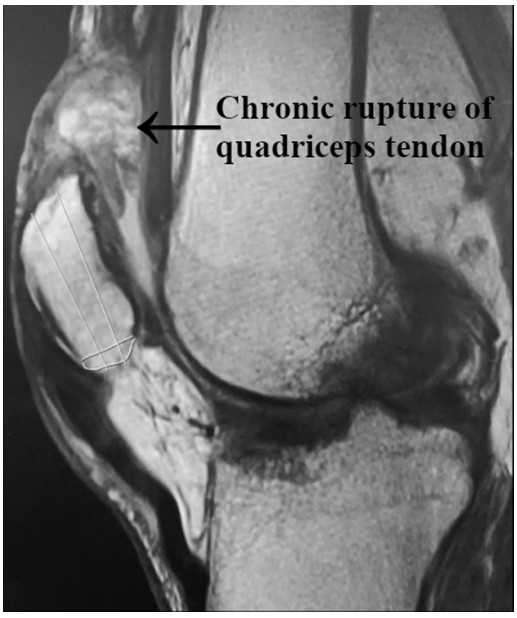

Fig 1. Preoperative T1 sagittal magnetic resonance imaging of the left knee demonstrating a chronic rupture of the quadriceps tendon.

imaging often is obtained upon initial evaluation to assess the extensor mechanism. Significant tendon retraction and scarring in the setting of chronic QT rupture often can be seen on MRI, which can aid the surgeon in preoperative planning (Fig 1).

Indications

This technique is indicated for chronic QT ruptures including re-ruptures with a large tendon gap and poor tissue quality that may not be amenable to primary repair, vastus advancement, or V-Y plasty. Distal retraction of the patella due to patellar tendon contraction may also be an indication for reconstruction due to significant tendon gapping as previously mentioned.[1]

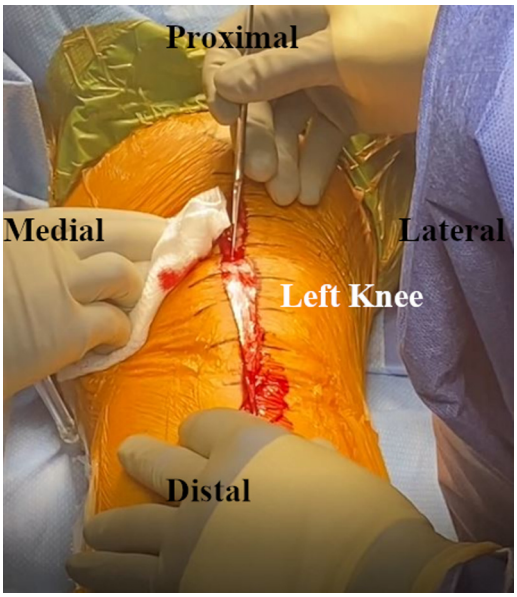

Fig 2. Intraoperative image of the left knee from an anterior viewpoint. A central anterior incision is made from the mid-quadriceps to the patella tendon.

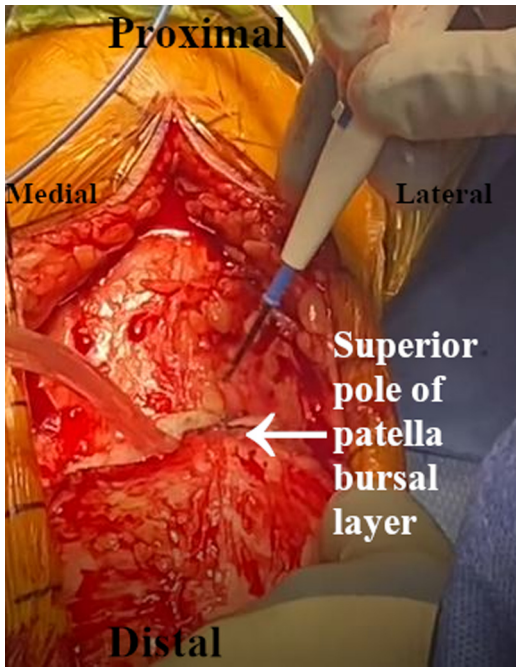

Fig 3. Intraoperative image of the left knee from an anterior viewpoint. The superior pole of the patella is identified and the bursa is excised.

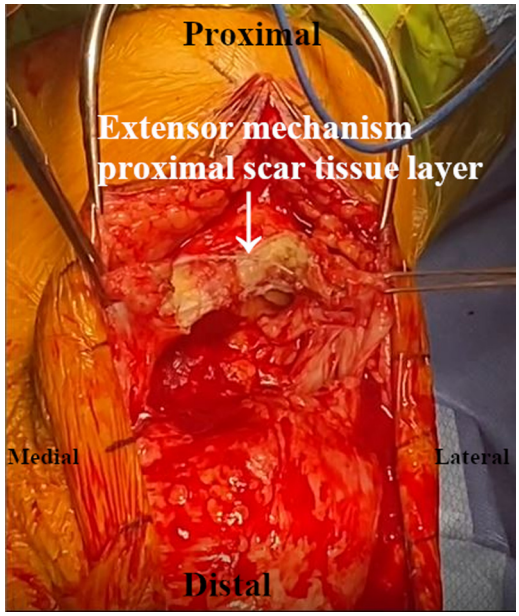

Fig 4. Intraoperative image of the left knee from an anterior viewpoint. The extensor mechanism scar is opened in a horizontal fashion and peeled, creating 2 proximal leaves of the scar tissue layer superiorly to later overly reconstruction.

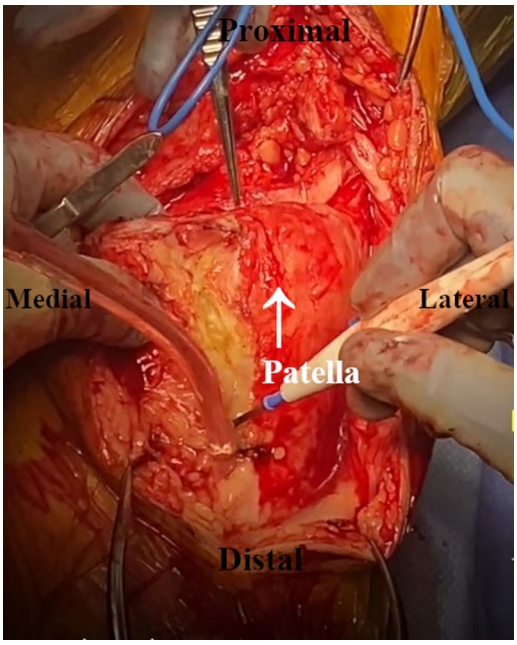

Fig 5. Intraoperative image of the left knee from an anterior viewpoint. A medial arthrotomy is performed and the patella is subluxed laterally.

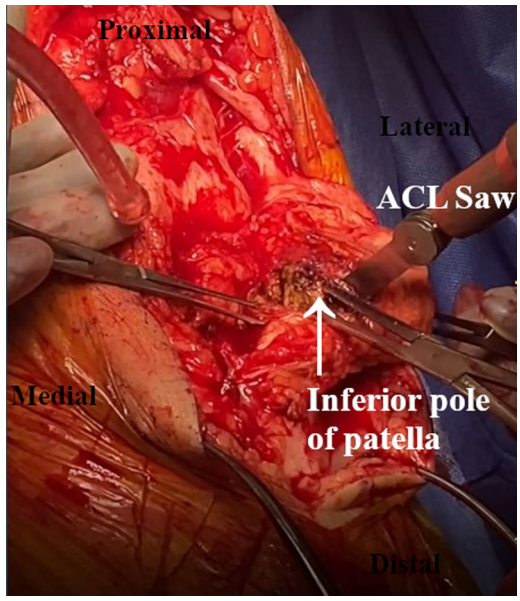

Fig 7. Intraoperative image of the left knee from an anteromedial viewpoint. An ACL saw is used to make a 1 × 1-cm resection at the inferior patellar pole to make space for the bone block allograft.

Materials

The technique uses the following items: curved Mayo scissors, Cobb elevator, ACL saw, Kocher clamp, Achilles tendon bone block allograft (Arthrex, Naples, FL), 3.2-mm drill bit, Stryker power drill, nine #5 FiberWire sutures(Arthrex), ENDOBUTTON (Smith & Nephew, Andover, MA), suture scissors, straight needle, needle driver, and curved free needle.

Patient Positioning

The patient is placed in a supine position with bony prominences and superficial nerves padded. A hip bump to the operative extremity is used as needed to avoid natural external rotation of the knee when supine. A well-padded thigh tourniquet is applied and inflated to 300 mm Hg. The operative lower extremity is prepped and draped in usual sterile fashion.

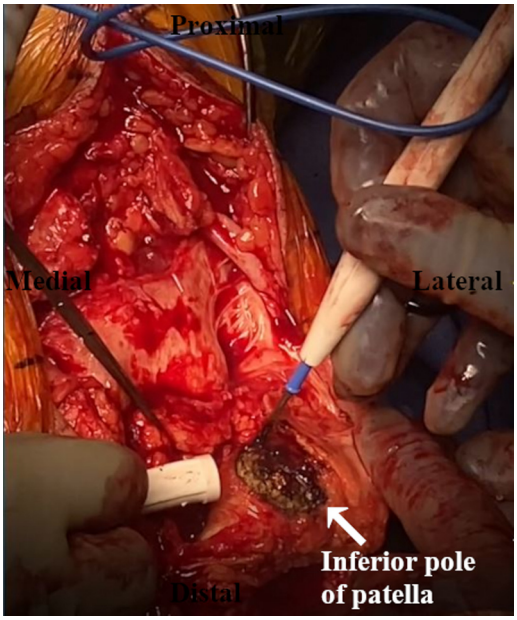

Fig 6. Intraoperative image of the left knee from an anterior viewpoint. The inferior pole of the patella is identified and denuded approximately 1 cm at the inferior patella nose.

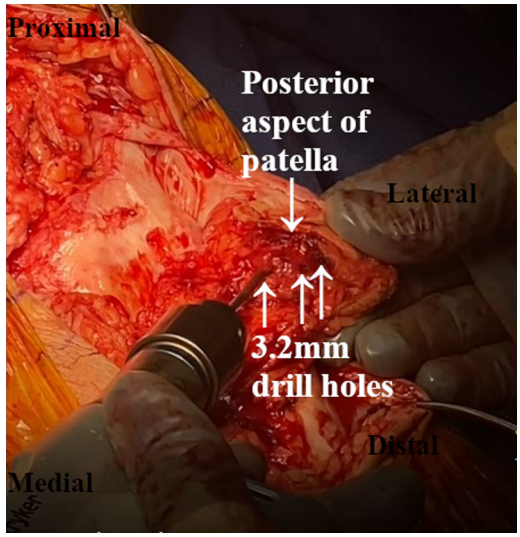

Fig 8. Intraoperative image of the left knee from an anteromedial viewpoint. A total of 3 parallel 3.2-mm drill holes are made in a vertical fashion through the patella.

Fig 9. Intraoperative image of an Achilles tendon allograft. The Achilles tendon allograft is prepared to have a 1 × 1-cm bone block with 2 drill holes that are used for #5 FiberWire sutures.

Approach and Debridement

A central anterior incision from the mid-quadriceps to the end of the patella tendon is performed (Fig 2). The anatomic layer of the extensor fascia is identified and flaps are raised. The superior pole of the patella is identified and the bursa is excised (Fig 3). This showed

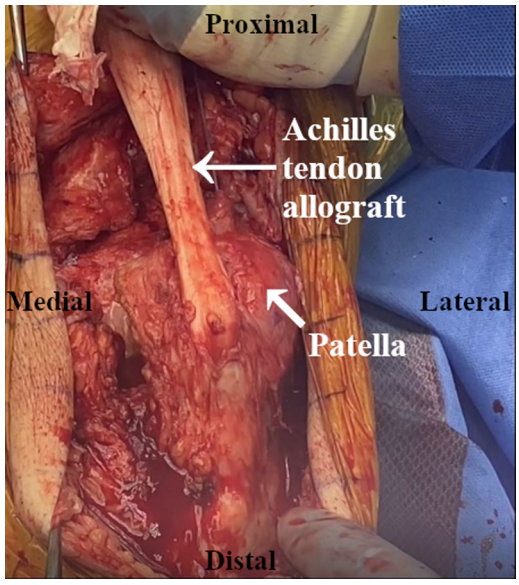

Fig 11. Intraoperative image of the left knee from an anterior viewpoint. The Achilles tendon allograft is shuttled anteriorly through a small slit in the patellar tendon and the bone block is pulled flush against the inferior pole of the patella.

that the entire proximal pole of the patella was denuded. Several anchors and suture material were seen and removed. The scar of the extensor mechanism is opened in a horizontal fashion and 2 proximal leaves of the scar tissue layer are peeled away superiorly (Fig 4). This exposed the remnant of the QT insertion approximately 3 cm proximal to the patella. In order to mobilize the QT, a Cobb elevator is used to completely free the vastus intermedius tendon from the anterior

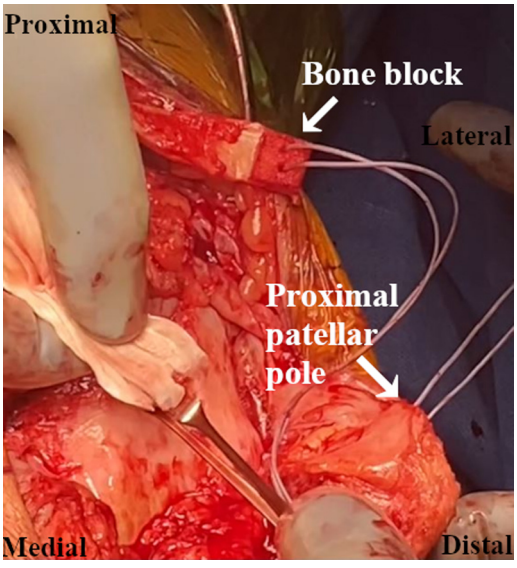

Fig 10. Intraoperative image of the left knee from an anteromedial viewpoint. Two #5 FiberWire sutures are passed through the medial and central patella drill holes, which are subsequently passed through the Achilles bone block.

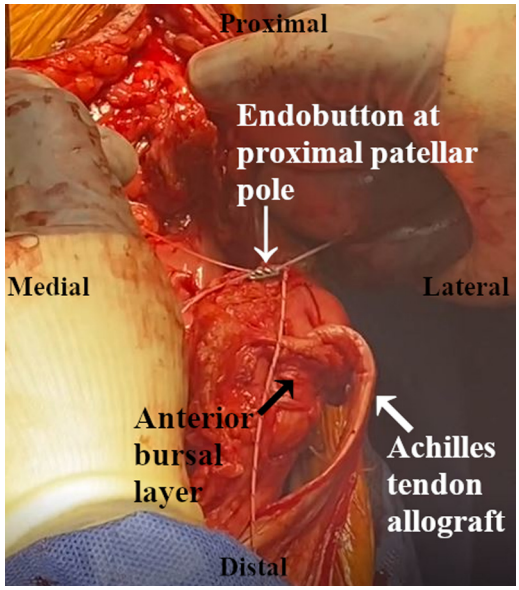

Fig 12. Intraoperative image of the left knee from an anteromedial viewpoint. Sutures from the Achilles bone block are tied over an ENDOBUTTON over the proximal patellar pole.

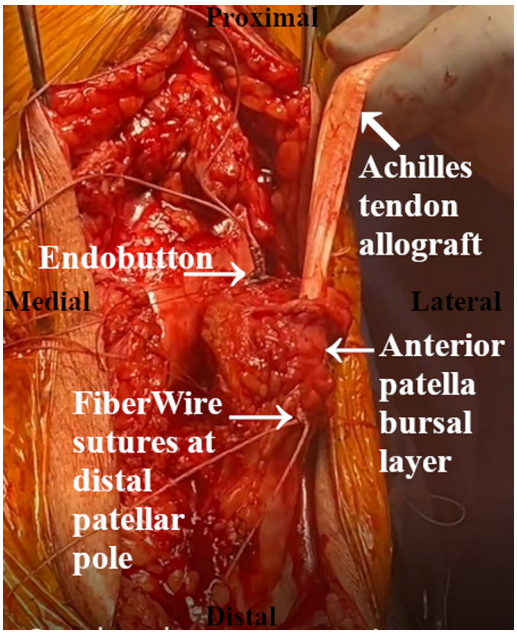

Fig 13. Intraoperative image of the left knee from an anteromedial viewpoint. The second set of #5 FiberWire sutures are secured and tied over the distal patellar pole to incorporate the allograft with the anterior patella bursal layer.

femur. A medial arthrotomy is performed for subluxation of the patella laterally (Fig 5).

Preparation and Insertion of Allograft

The infrapatellar fat pad is exposed and partially resected to free up the patella tendon. Subsequently, the inferior pole of the patella is identified and denuded over approximately 1 cm at the inferior patella nose (Fig 6). A 1 × 1-cm resection was made at the inferior pole and nose area using an ACL saw (Fig 7). Using a 3.2-mm drill, a total of 3 drill holes are positioned in a vertical fashion through the patella (Fig 8). On the back table, the Achilles tendon allograft is prepared to have a 1 × 1-cm bone block with 2 drill holes (Fig 9). Two #5

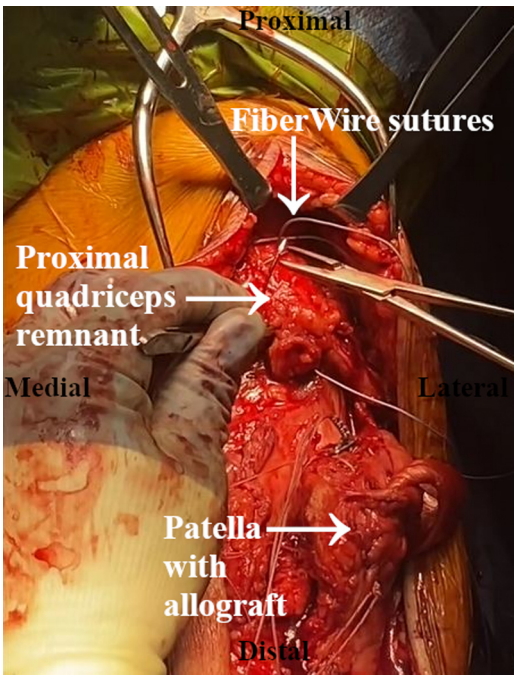

Fig 14. Intraoperative image of the left knee from an anteromedial viewpoint. Four #5 FiberWire sutures are shuttled through the proximal remnant of the quadriceps tendon.

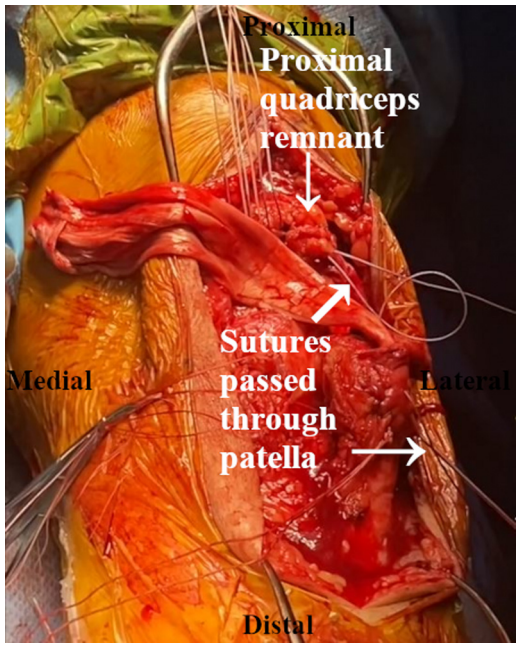

Fig 15. Intraoperative image of the left knee from an anteromedial viewpoint. The sutures from the proximal quadriceps tendon remnant are passed through 3 patellar bony tunnels for a primary repair.

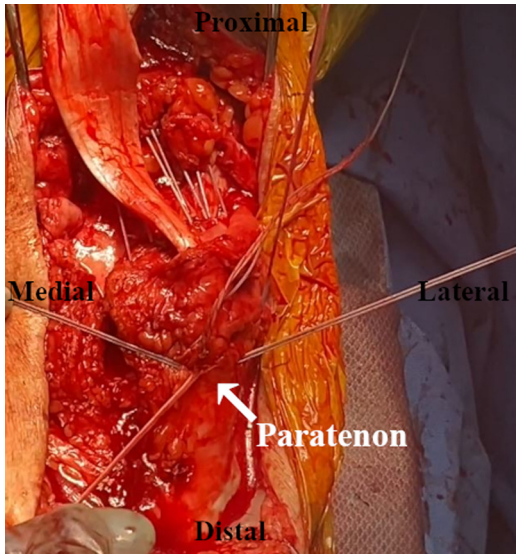

Fig 16. Intraoperative image of the left knee from an anterior viewpoint. Medial and lateral sutures are passed under the paratenon of the patellar tendon in an extraosseous fashion.

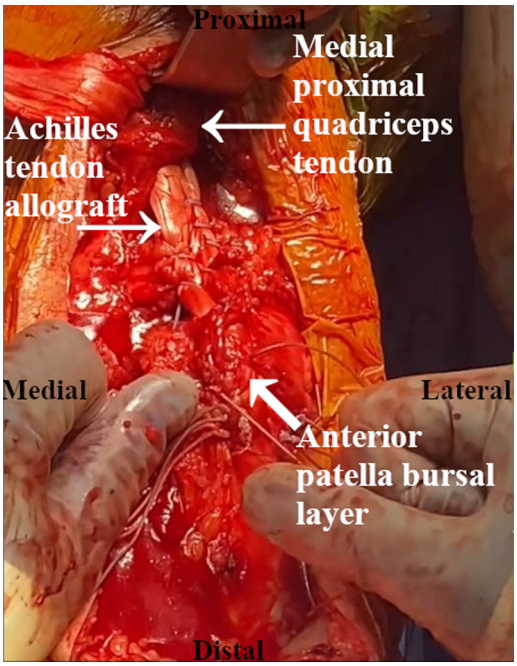

Fig 17. Intraoperative image of the left knee from an anterior viewpoint. The Achilles tendon allograft is used to bridge the gap of the medial quadriceps remnant and is secured with a #5 FiberWire suture.

FiberWire sutures are shuttled through the central and medial drill holes in the patella. The sutures are then passed through the Achilles bone block, such that the suture ends come to lay on the proximal pole of the patella (Fig 10). The Achilles bone block is pulled onto the inferior pole of the patella in a fashion that allows the Achilles tendon to pass through a small slot in the patella tendon anteriorly (Fig 11). The bone block sutures are then tied over an ENDOBUTTON at the proximal pole of the patella (Fig 12). The second set of #5 FiberWire sutures are then secured in a Bunnell technique, incorporating the graft to the anterior patella bursal layer. These are then tied over the distal patellar pole onto the Achilles tendon allograft itself, creating a sling around the patella (Fig 13).

Proximal QT Tensioning and Closure

Four #5 FiberWire sutures are positioned and tensioned into the quadriceps remnant proximally (Fig 14). These sutures are then passed through the 3 patellar bone tunnels for a primary suture repair (Fig 15). Medial and lateral sutures are passed in an extraosseous fashion with a free needle. Sutures are passed under the paratenon of the patella tendon to ensure that knots are not lying superficial and irritable to the patient (Fig 16). In cases with extensive tendon gapping, the medial portion of the QT may not mobilize close enough to the patella. A Strayer-style lengthening technique can be performed at the proximal insertion of the rectus tendon with mobilization of the intermedius tendon from the anterior femur completely to gain additional length (Video 1). If a small gap at the medial aspect still remains, the Achilles tendon allograft can be used to bridge the gap of the medial proximal quadriceps portion with a #5 FiberWire suture using a combination of Bunnell, Mason–Allen and baseball techniques (Fig 17). Copious amounts of saline solution are used to irrigate the entire surgical field. The bursal layer is sutured back over the allograft to close the medial capsule while providing an excellent repair of the entire quadriceps mechanism with no gaps (Fig 18). Postoperative radiographs are obtained to verify proper alignment of the bone block at the inferior patella pole and placement of the ENDOBUTTON onto the superior pole of the patella (Fig 19). A total of 60 cc of anesthetic without Toradol is injected in a pericapsular fashion.

Discussion

QT ruptures are uncommon injuries that can lead to significant disability for the patient and can be technically challenging for the orthopaedic surgeon. Chronic QT ruptures may lead to worse functional outcomes, which are believed to be due to scar tissue formation, distal retraction of the patella, quadriceps muscle atrophy, and large tendon gapping. Due to the rarity of chronic QT ruptures in developed countries due to rapid treatment and early repair, there are very few studies with large sample sizes to evaluate which technique may be superior.[1,2] Primary repair for chronic ruptures is relatively uncommon but can be performed when tendon lengthening is not required. The Scuderi technique has been used infrequently for

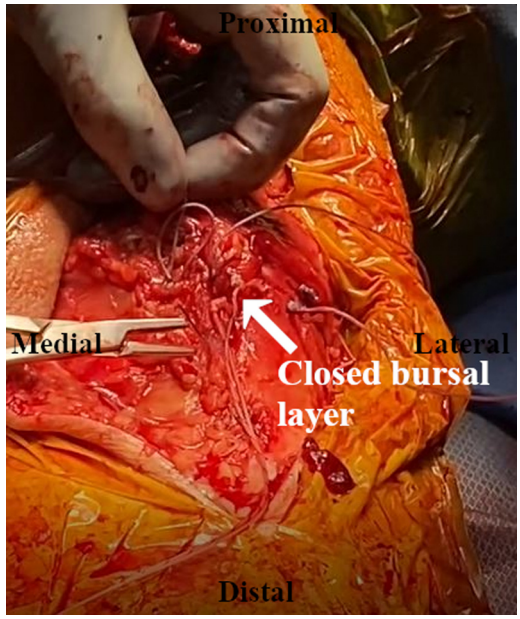

Fig 18. Intraoperative image of the left knee from an anterior viewpoint. The bursal layer is sutured superficially over the allograft for closure of the medial capsule.

Fig 19. Postoperative lateral radiograph of the left knee demonstrating satisfactory ENDOBUTTON fixation at the superior pole and bone block allograft at the inferior pole of the patella.

chronic QT ruptures due to vastus advancement rarely being required. The Codivilla V-Y lengthening technique has been historically used for QT tendon gaps up to 2 cm in length. Reconstruction of the extensor mechanism with the use of synthetic mesh in 2 cases that failed primary QT repair has been reported by Hartline et al. with good outcomes.[4] Reconstruction with autografts and allografts has been primarily indicated for poor tissue quality or large tendon gaps that are not amenable to vastus advancement or V-Y plasty. To our knowledge, there are no studies with large sample sizes for chronic QT repair with autografts or allografts and most of the current literature is composed of individual case reports.[1] Leopardi et al. reported using ipsilateral hamstring autografting for a 5.5-month chronic QT rupture in which the patient demonstrated 5° to 130° of active knee range of motion, mild quadriceps atrophy, along with a 5° extensor lag at 3 years postoperatively.[1,5] McCormick et al. reported a good outcome and full, painless return to sports activity at 37 months postoperatively using an autologous hamstring tendon in a patient with chronic QT re-rupture.[1,6] Alternatively, Watson et al.[7] described a novel technique focusing on restoring patellar height from patellar tendon lengthening and performing a primary repair of the native QT in the setting of chronic rupture without the use of grafts.

Achilles tendon bone block allografts have been commonly used for patellar tendon reconstruction but have been considered a recent novel technique for repair of chronic QT rupture. Forslund et al. describe the use of an Achilles tendon bone block allograft in a patient who previously failed a QT V-Y reconstruction 3 months prior. At 13 months postoperatively, the patient demonstrated a 7° extensor lag and 90° flexion.[1,8] Wise et al.[9] report 17 extensor mechanism reconstructions following total knee arthroplasty using an Achilles tendon allograft, 7 of which were QTs. Their

Table 1. Pearls and Pitfalls

Step	Pearls	Pitfalls
Exposure and capsulotomy	Top of patellar capsulotomy to identify patellar pole for later repair over reconstruction. Also facilitates access of Cobb to elevate vastus adhesions	Failure may result in more difficult soft-tissue coverage at closure
Debridement of scar remnant to prepare for repair	Retain any bleeding soft tissue or scar to optimize biologic healing of the acellular graft	Inadequate debridement or excessive debridement may risk failure or increase risk of infection postoperatively
Inferior patellar nose/pole osteotomy for bone block	Mark out 1 × 1-cm block before resection with oscillating saw	Estimating can cause a size mismatch between bone block and patella, increasing risk of nonunion as well as abnormal shear forces, which can cause mechanical complications
Docking of bone block with ENDOBUTTON	ENDOBUTTON may provide additional stability of reconstruction	Osteoporotic bone may experience cut out from suture, increasing risk of loss of tension and failure of repair
Mobilize quadriceps for repair	Use Cobb elevator to release adhesions off anterior femur	Failure to release adhesions may result in theoretical increased tissue necrosis under high tension, potentiating risk of failure of repair
Final closure	Before retinacular closure, check through medial parapatellar arthrotomy to ensure bone block lies flat	Prominent bone block could result in early chondral injury, potentiating arthritic changes or failure of repair

Table 2. Advantages and Disadvantages

Advantages	• Potentially stronger construct due to fixation of bone block and patella achieving union • Repair option for large tendon gaps and poor tissue quality not amenable to vastus advancement or V-Y plasty • Decreased donor-site morbidity compared with Achilles autograft harvesting • Ability to assess radiographically intact fixation postoperatively due to ENDOBUTTON and bone block • Multilayer repair acts as checkrein which in the setting of failure would occur in series, rather than as a unit theoretically, potentially preserving the repair and function
Disadvantages	• Risk of allograft rejection • Healing time increased with allograft • Technically demanding procedure • Increased operative time to prepare allograft • Increased use of braided suture theoretically raises potential for nidus of infection • ENDOBUTTON within arthrotomy site presents theoretical nidus for biofilm formation in the event of postoperative infection

outcomes for QT reconstruction demonstrated an average extensor lag of 2.9° and 103° flexion with an average quadriceps strength of 4/5 at a minimum follow-up of 2 years. Kunze et al.[10] describe the use of a trapezoidal-shaped Achilles allograft bone plug for revision QT repair in which the bone plug is inserted into a prepared anterior patellar slot and secured with wire fixation. Reported disadvantages to their technique include potential graft mismatch, which may lead to graft laxity, overconstraint, or an extensor lag. Okay et al.[11] report QT reconstruction with Achilles tendon allograft and suture anchors into the superior aspect of the patella in a case that previously failed primary repair. This case demonstrated a satisfactory outcome and graft incorporation at the 6-year follow-up. The goal of our technique is to present surgeons with an additional option for chronic QT repair that may provide a greater mechanical load to failure and greater allograft acceptance. We hypothesize that placing the bone block at the distal patellar pole and passing FiberWire sutures through the patella proximally with the use of an ENDOBUTTON provides a maximal amount of surface area and tension to achieve sufficient bony fixation (Table 1). Furthermore, securing the Achilles tendon allograft with FiberWire sutures at the distal patellar pole with the anterior patella bursal layer may provide a stronger construct to reduce the risk of re-rupture. This multilayer repair can theoretically act as a checkrein and potentially reduce the risk of a complete re-rupture. Disadvantages to this technique include the risk, albeit potentially reduced, of allograft rejection and the technically demanding nature of this procedure (Table 2). Further studies with long-term outcomes are needed to evaluate if this technique can restore the extensor mechanism with reduced re-rupture rates.

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