Technical Note

Repair of a Chronic Quadriceps Tendon Re-rupture With Semitendinosus Tendon Autograft Augmentation

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Abstract: The quadriceps tendon (QT) functions as one of the primary knee extensor mechanisms. The risk of QT tendinopathy increases with age, which also impacts the risk of QT rupture. This injury typically occurs as a result of an abrupt eccentric contraction with knee hyperflexion. A QT rupture has detrimental effects on quality of life and function. Surgical repair provides improved outcomes, but the risk of re-rupture is still present, with limited literature discussing outcomes. This technical note describes the repair of a chronic QT re-rupture fixated with suture anchors and semitendinosus tendon autograft augmentation.

The extensor mechanism of the knee primarily consists of the quadriceps muscle, quadriceps tendon (QT), patella, and patellar tendon, with support from both the medial and lateral patellar retinacula.[1] The risk of QT tendinopathy increases as patients age and is also associated with an increasing risk of QT rupture in the active population.[2,3] QT injury typically occurs as a result of an abrupt eccentric contraction with knee hyperflexion.[1,4] When the QT is disrupted, it can have detrimental effects on knee function and quality of life, but outcomes and function are improved with surgical repair.[1,4] Repair is quite successful, with a low incidence of recurrent tearing (2%-6%), providing limited outcomes for QT re-rupture in the literature.[5,6] Documented surgical techniques for re-ruptures of the QT include end-to-end sutures, patellar suture anchors, and graft augmentation.[7,8] This technical note details the repair of a recurrent chronic rupture of a QT fixated with suture anchors and semitendinosus tendon autograft augmentation.

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Surgical Technique

Our technique for repair of a QT re-rupture is detailed in Video 1. A step-by-step guide and surgical pearls are presented in Table 1.

Patient Evaluation

The patient evaluation begins with a thorough clinical examination evaluating quadriceps function, including whether the extensor mechanism is intact, in addition to quadriceps atrophy, palpable defects, extensor lag, patella baja, and asymmetrical knee range of motion (ROM). Radiographic assessment and diagnostic magnetic resonance imaging should be used to evaluate the QT and any concomitant injuries (Fig 1).

Anesthesia and Positioning

The patient is placed in the supine position on the operating table and induced under general anesthesia. A knee examination is performed to validate clinical examination findings. The surgical leg undergoes application of a well-padded, high thigh tourniquet and is then placed in a leg holder (Mizho OSI, Union City, CA), and the nonsurgical leg is placed in an abduction stirrup (Birkova Product, Gothenburg, NE). For infection prophylaxis, 2 g of perioperative cefazolin is administered.

Autograft Harvest and Preparation

First, an incision is created on the anteromedial aspect of the tibia over the pes tendons (Fig 2). Dissection is carried down until the semitendinosus is

Table 1. Step-by-Step Guide and Surgical Pearls and Pitfalls for Repair of Recurrent QT Rupture With Semitendinosus Autograft

Step-by-Step Guide	Surgical Pearls and Pitfalls
An incision is created over the pes tendons, and dissection is carried down until the semitendinosus tendon is identified.	Identification of the sMCL is critical during dissection of the pes tendons to ensure that the sMCL is not inadvertently injured.
The semitendinosus tendon is harvested with an open hamstring harvester.	Gentle force should be applied with the harvester directed toward the ischial tuberosity to minimize the risk of graft amputation.
A second incision is created from the superior pole of the patella to approximately 8 cm proximal on the thigh over the QT.	Using the previous surgical incision will help with future suture closure and assist in preventing wound healing problems and cosmetic defects.
Dissection is carried down to the fascia overlying the QT, and the scarred portion of the QT is mobilized with a Cobb elevator.	Tag suturing the medial and lateral aspects of the QT will help with manipulation and evaluation of future tendon position and avoid possible tendon shortening.
The midpoint of the patella is identified, and the medial and lateral midline aspects of the patella are decorticated with a rongeur.	To properly identify the midpoint of the patella, a spinal needle may be placed at the inferior pole of the patella and a ruler may be use to help identify the midpoint.
A Beath pin is drilled through the patella from lateral to medial with the aid of an ACL tibial guide, followed by reaming with a 4.5-mm EndoButton reamer.	During Beath pin drilling, it is important to identify the MPFL patellar attachment to avoid iatrogenic MPFL injury while drilling and reaming. The Beath pin should be drilled through the middle of the patella to avoid superior or inferior fracture.
The autograft is passed from medial to lateral, leaving equal limb lengths exiting each side of the patella.	The autograft can be sutured at each aperture with a No. 2 nonabsorbable suture to prevent future graft movement with tension.
The distal QT is split vertically by approximately 3 cm with a scalpel.	This step creates more pronounced medial and lateral flaps, which then can be manipulated and tensioned.
A soft-tissue tunnel is created through both the medial and lateral QT flaps.	Soft-tissue tunnel creation starts adjacent to each patellar aperture, dives inferior to the retinaculum and QT, and ends near the proximal aspect of the vertical QT incision.
The superior pole of the patella is decorticated with a scalpel and rongeur.	Adequate decortication of the superior patellar pole is required to help remove scar tissue and sutures from the previous repair and optimize a healing surface for the revision tissue repair.
Three Q-Fix anchors are placed at the decorticated superior pole of the patella.	Adequate space is needed between each Q-Fix anchor. Placing a finger on the patellar facets while placing the Q-Fix will improve the trajectory and avoid intra-articular placement.
Arthroscopy is initiated after the creation of the medial and lateral portals.	
Arthroscopy is used to create an anterior interval release with fat pad debridement.	Performing an anterior interval release allows the patella to migrate proximally.
The medial and lateral flaps of the QT are tensioned in a crossover manner.	Tensioning is helpful to approximate the tissue defect and ensure that there is adequate coverage with the medial and lateral QT flaps.
Two Q-Fix anchors are sutured into the lateral QT flap, and the other Q-Fix anchor is sutured into the medial QT flap.	Positioning the patella proximally while tensioning the quadriceps tag sutures helps restore the extensor mechanism and prevent patella baja.
The medial and lateral QT flaps are sutured together.	It is useful to suture the medial and lateral QT flaps in a pants-over-vest fashion with No. 2 nonabsorbable sutures.
The hamstring autograft limbs are crossed over each other from the proximal apertures of the soft-tissue tunnel, distal toward the patella.	Whipstitching each limb into the QT provides fixation for the autograft and provides further support.
The deep and superficial tissues are closed with sutures, and adhesive skin closure strips are applied over the incision.	After the application of sterile dressings, the patient may be placed in a knee immobilizer in full extension.

ACL, anterior cruciate ligament; MPFL, medial patellofemoral ligament; QT, quadriceps tendon; sMCL, superficial medial collateral ligament.

identified, and any adhesions are removed with a Cobb elevator. Then, an open hamstring harvester is used to harvest a semitendinosus tendon graft (Fig 3). The semitendinosus tendon autograft should subsequently be prepared with 2 whipstitches on each end, enabling it to fit through 4.5-mm-diameter tunnels (Fig 4).

Incision and Quadriceps Approach

Next, an incision is made incorporating the incision from the primary QT repair, starting at the superior pole of the patella and extending approximately 8 cm proximal on the thigh (Fig 5). A slow and meticulous dissection down to the retracted remnant QT is

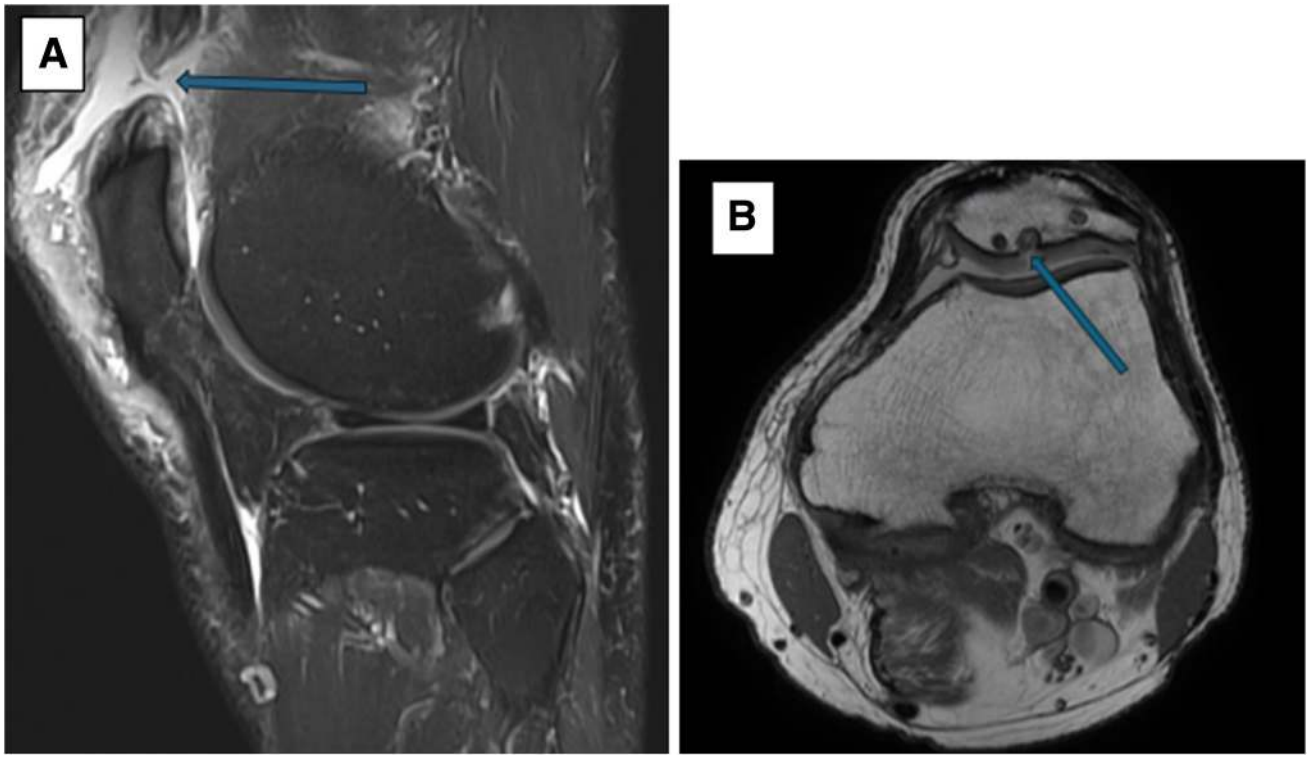

Fig 1. Preoperative magnetic resonance imaging (MRI) of left knee: sagittal and axial views. (A) MRI shows a chronic quadriceps tendon re-rupture (blue arrow). (B) MRI shows a chronic quadriceps tendon rupture with evidence of failed suture anchors (blue arrow) within the patella from the primary quadriceps tendon repair.

performed. The QT should be mobilized off the anterior femur with a Cobb elevator as this assists in mobilizing the medial and lateral aspects of the QT distally from their proximally retracted positions (Fig 6). The medial and lateral aspects of the QT are then tagged with a suture (Fig 7).

Fig 2. Incision for semitendinosus tendon autograft harvest with repair of quadriceps tendon re-rupture via semitendinosus tendon augmentation in the left knee with the patient in the supine position. The incision (blue arrow) is overlying the pes anserine tendons by approximately 2 to 3 cm on the anteromedial aspect of the tibia.

Fig 3. Semitendinosus tendon isolation for quadriceps tendon re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. The semitendinosus tendon (blue arrow) can be isolated from the other pes anserine tendons with a tonsil clamp, ensuring that the superficial medial collateral ligament is not injured.

Fig 4. Semitendinosus tendon graft preparation for quadriceps tendon re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. The semitendinosus tendon graft (blue arrow) is prepared on the back table by whipstitching each end of the tendon approximately 25 mm in length, enabling it to fit through a 4.5-mm-diameter tunnel.

Fig 5. Primary skin incision for quadriceps tendon re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. The incision (blue arrow) starts at the superior pole of the patella and is extended approximately 8 cm proximal while the incision from the primary quadriceps tendon repair is used.

Fig 6. Quadriceps tendon (QT) mobilization off of the anterior femur for QT re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. A Cobb elevator (blue arrow) is used to mobilize the scarred QT that is adhered to the anterior femur, which allows for identification of the medial and lateral aspects of the QT.

Fig 7. Identification and suture tagging of the medial and lateral aspects of the quadriceps tendon (QT) for QT re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. The medial and lateral aspects of the QT are tagged with sutures (blue arrow) to help identify the appropriate tension and positioning of the QT for fixation later in the case.

Fig 8. Identification of landmarks for patellar drilling and reaming for quadriceps tendon re-rupture repair with semitendinosus augmentation in the left knee with the patient in the supine position. A spinal needle (blue arrow) is placed at the inferior pole of the patella, and a ruler (green arrow) is used to identify the midpoint of the patella.

Fig 9. Patellar tunnel drilling using a drill guide for quadriceps tendon re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. An anterior cruciate ligament tibial drill guide is used to drill a Beath bin (blue arrow) from lateral to medial through the midpoint of the patella. This is followed by reaming with a 4.5-mm EndoButton reamer and passage of sutures with a Hewson suture passer.

Tunnel Preparation and Graft Placement

A spinal needle is placed at the inferior pole of the patella. The midpoint of the patella is then identified with a ruler (Fig 8). The location for the tunnel across the patella is identified, and the medial and lateral aspects of the patella are dissected and cleaned with a rongeur. An anterior cruciate ligament tibial drill guide (Arthrex, Naples, FL) is used to drill a horizontally placed Beath pin from lateral to medial (Fig 9). This is over-reamed with a 4.5-mm EndoButton reamer (Smith & Nephew, London, England). A Hewson suture passer (Smith & Nephew) is used to place a passing stitch. The semitendinosus tendon autograft is then passed from medial to lateral with equal lengths of autograft exiting on each side of the patella (Fig 10). The autograft at each aperture is whipstitched with No. 2 nonabsorbable suture to ensure there is no movement. Approximately 3 cm of the QT is split vertically with a scalpel through the center to provide adequate medial and lateral flaps (Fig 11). Then, medial and lateral soft-tissue tunnels are created adjacent to each patellar aperture deep to the retinaculum and native QT. The tunnels exit through the proximal healthy QT, and the limbs are passed through their respective soft-tissue tunnels (Fig 12). The superior pole of the patella is then decorticated with a scalpel and rongeur, removing any remnant QT and sutures from the previous repair. Three Q-Fix anchors (Smith & Nephew) are placed at the decorticated superior pole of the patella.

Fig 10. Semitendinosus tendon graft passage for quadriceps tendon re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. The semitendinosus tendon graft is passed from medial to lateral through the patellar tunnel, with equal lengths seen between the medial (blue arrow) and lateral (green arrow) limbs.

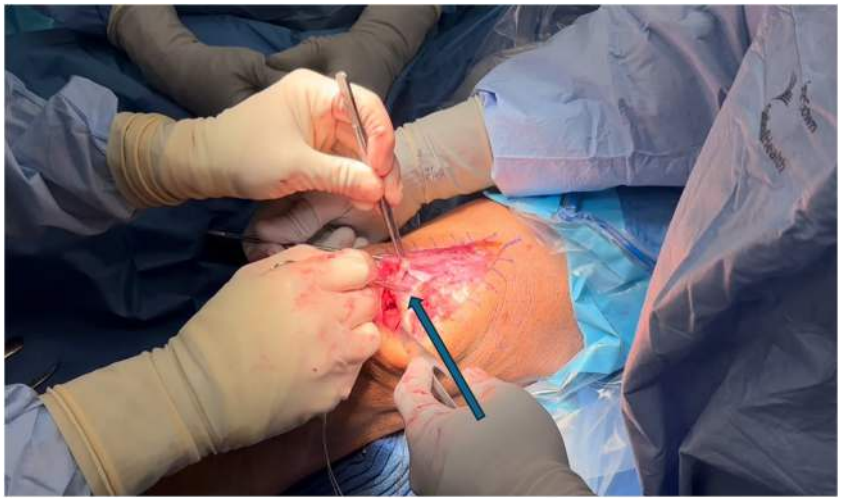

Fig 11. Quadriceps tendon (QT) vertical incision for QT re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. A vertical incision (blue arrow) is created from the distal aspect of the remnant QT and extended approximately 3 cm proximal to create medial and lateral QT flaps.

Arthroscopy

The medial and lateral portals are created, and the camera is inserted. Extensive anterior fat pad and anterior interval debridement is performed to release the patella as it is adhered to scar tissue distally. This allows the patella to migrate proximally into a closer anatomic position. The knee compartments and other intra-articular structures are then evaluated for possible pathology.

QT Fixation

Next, the medial and lateral tag sutures are tensioned in a crossover manner to evaluate the approximation of the QT tissue to adequately cover and repair the defect. Then, 2 Q-Fix anchors are sutured with a running, locking stitch into the medial QT flap and another Q-Fix anchor is sutured similarly into the lateral QT flap, all located at their respective approximating borders. This provides approximation of the 2 flaps side by side and appropriate coverage of the defect. As the Q-Fix anchor sutures are tied, the QT suture tags should be pulled distally while the patella is positioned proximally to gain patellar height after the anterior interval release (Fig 13). The medial and lateral QT flaps are then approximated with tag sutures in a pants-over-vest fashion and are sutured side to side with No. 2 nonabsorbable sutures with the lateral QT aspect on top of the medial aspect. Next, both limbs of the autograft are crossed over each other and whipstitched, starting proximally and working down the length of the QT, for further support (Fig 14). Evaluation of knee flexion ROM without suture failure can be performed to aid in rehabilitation planning.

Postoperative Rehabilitation

The patient remains non–weight-bearing on the surgical limb for 6 weeks. Knee flexion ROM is limited to 45° for the first 2 weeks, with slow increases in knee

Fig 12. Semitendinosus tendon graft passage through the quadriceps tendon (QT) soft-tissue tunnels for QT re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. Medial and lateral soft-tissue tunnels are started adjacent to the apertures of the patellar tunnels. The tunnels run deep to the retinaculum and native QT and exit through the healthy proximal QT. This is followed by passage of both the medial (green arrow) and lateral (blue arrow) limbs of the semitendinosus autograft through their respective soft-tissue tunnels.

Fig 13. Q-Fix anchor suture fixation for failed quadriceps tendon (QT) repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. Two Q-Fix anchors are sutured with a running, locking stitch into the medial QT flap at the approximating border. Then, another Q-Fix anchor is sutured similarly into the lateral QT flap at the approximating border. If patella baja is present, the Q-Fix anchor sutures are tied (blue arrow) while the patella is pushed proximally (red arrow) and the QT suture tags are pulled distally (green arrow) to try to gain patellar height.

flexion as tolerated by the patient. A special emphasis on patellar mobility should be considered if there is significant scar tissue in the anterior interval.

Discussion

In situations in which individuals experience a QT re-rupture with associated functional deficits, repair of the QT with hamstring autograft augmentation can be considered. Re-ruptures of the QT are a relatively rare occurrence, and QT tendinopathy may be a significant contributor. At a microscopic level, tendinopathy causes microscopic changes, leading to disorganized fiber alignment and collagen alterations, leading to functional limitations and tendon degeneration.[9,10]

Oliva et al.[7] performed a systematic review of surgical procedures and outcomes of QT ruptures and specifically evaluated re-ruptures. Re-ruptures occurred at a mean time of 322.5 days, with a mean age of 70 years. These re-ruptures were treated with end-to-end sutures in 4 cases (44%), autograft in 3 (34%), allograft in 1 (11%) and the Codivilla V/Y technique in 1 (11%). The autograft choice for repair was most frequently hamstring or peroneus longus tendon autograft. After repair, 3 re-rupture patients (34%) experienced an extensor lag, with a mean extensor lag value of 7.3°.[7]

The use of autograft or allograft is typically considered when tissue quality is inadequate or when scar tissue prevents appropriate lengthening, although the documented outcomes are scarce owing to the rarity of recurrent chronic QT tears.[7,11] A case report by McCormick et al.[11] described a repair in an individual 10 months after a re-rupture of the QT. The repair was performed with bilateral semitendinosus and gracilis autografts that were weaved into the QT via a Mason-Allen technique. After the grafts were introduced into the QT, the authors used 3 vertical patellar tunnels in the superior pole to fixate the autografts. At the 1-year follow-up, the patient had no extensor lag and had

Fig 14. Semitendinosus tendon autograft fixation to the quadriceps tendon (QT) for QT re-rupture repair with semitendinosus tendon augmentation in the left knee with the patient in the supine position. Both limbs from the semitendinosus tendon graft are crossed over each other (blue arrow) and whipstitched, starting proximally and working down the length of the QT, to provide further support for fixation.

Table 2. Advantages and Disadvantages of Repair of Recurrent QT Rupture With Semitendinosus Autograft

Advantages
Adequate visualization of the re-ruptured QT is provided.
This technique is appropriate when nonoperative management fails.
Potentially improved patellar mobility and positioning are provided.
Graft augmentation assists the knee extensor mechanism and decreases the risk of subsequent rupture after repair.
The repair provides the patient with the opportunity to regain knee function to perform ADLs.
Disadvantages
There is potential for loss of terminal knee flexion ROM due to tightness after the QT repair.
Potential iatrogenic damage to the patellar facets can occur while reaming and placing suture anchors.
Harvesting the semitendinosus autograft increases the risk of iatrogenic sMCL damage and knee flexion weakness.
Tunnel drilling of the patella increases the risk of possible iatrogenic fracture.
The technique requires the patient to be non–weight-bearing for 6 wk.

ADL, activity of daily living; QT, quadriceps tendon; ROM, range of motion; sMCL, superficial medial collateral ligament.

ROM of 0° to 100°, and at the 2-year follow-up, the patient had returned to full activity with no pain or other symptoms.[11]

In the setting of a chronic QT repair failure, the described technique using a semitendinosus autograft to augment the QT repair is recommended. The technique is easy to reproduce, restores the knee extensor mechanism, and provides improved functional outcomes. The advantages and disadvantages of this surgical technique are listed in Table 2.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: R.F.L. reports a consulting or advisory relationship with Ossur, Smith & Nephew, and Responsive Arthroscopy; receives funding grants from Ossur, Smith & Nephew, Arthroscopy Association of North America, and American Orthopaedic Society for Sports Medicine; receives travel reimbursement from Smith & Nephew; receives speaking and lecture fees from Foundation Medical; and has a patent with royalties paid to Ossur. All other authors (B.J.W., L.V.T., D.R.L., M.T.R.) 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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Video 1. Repair of chronic quadriceps tendon (QT) re-rupture with semitendinosus tendon autograft augmentation. The patient is positioned supine on the operating table and induced under general anesthesia. An incision is created on the anteromedial aspect of the left tibia over the pes anserine tendons and carried down until the semitendinosus tendon is identified. Any adhesions attached to the semitendinosus tendon are then removed with a Cobb elevator. The semitendinosus tendon is harvested with an open hamstring harvester and prepared to fit through a 4.5-mm-diameter tunnel. Another incision is then made starting at the superior pole of the patella and carried approximately 8 cm proximal using the incision from the primary QT repair. Dissection down to the QT reveals retraction of the remnant tendon. A Cobb elevator is used to mobilize and identify the tendon. The medial and lateral aspects of the QT are then tagged. Next, a spinal needle is placed at the inferior pole of the patella, and a ruler is used to measure the midpoint of the patella. A rongeur is used to decorticate the medial and lateral aspects of the patella. Then, an anterior cruciate ligament tibial drill guide is used to assist in drilling a Beath pin from lateral to medial through the patella at the previously identified midpoint. The pin is reamed with a 4.5-mm EndoButton reamer, and a Hewson suture passer is used to place a passing stitch, which will then assist in passing the semitendinosus tendon autograft from medial to lateral. With symmetrical lengths of autograft exiting each patellar aperture, the autograft is whipstitched at the aperture to prevent translation. Then, approximately 3 cm of the QT is split vertically to create medial and lateral flaps. Medial and lateral soft-tissue tunnels are created adjacent to each patellar aperture. First, they dive inferior to the retinaculum and QT, and both end near the proximal aspect of the vertical QT incision. Then, both limbs of the autograft are passed into their respective soft-tissue tunnels. The superior pole of the patella is decorticated with a rongeur and scalpel, removing the remnant QT and the failed sutures from the previous repair. Three Q-Fix anchors are then placed at the decorticated superior pole of the patella. Arthroscopy is initiated, and extensive anterior interval and fat pad debridement is performed to release the patella and allow proper restoration of patellar height. The knee compartments and intra-articular structures are evaluated at this time. Next, the medial and lateral QT tag sutures are tensioned in a crossover fashion to evaluate the QT for proper approximation and defect coverage. Then, 2 Q-Fix anchors are sutured with a running, locking stitch into the medial QT flap and another Q-Fix anchor is sutured similarly into the lateral QT flap, all located at their respective approximating borders. As the Q-Fix anchor sutures are tied, the patella is positioned proximally while the QT tag sutures are pulled distally to gain patellar height. The QT tag sutures are then tensioned in a pants-over-vest fashion with the lateral aspect of the QT on top of the medial aspect. The lateral and medial borders are sutured side to side with No. 2 nonabsorbable sutures. The medial and lateral limbs of the autograft are then whipstitched, starting proximally and working down the length of the QT, for further support. The knee is carried through its range of motion to evaluate suture tightening and determine postoperative rehabilitation.