Technical Note

Patellar Tendon Reconstruction for a Chronic Extensor Mechanism Deficit Using an Achilles Tendon Allograft With Hamstring Autograft and Suture Augmentation

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Abstract: Patellar tendon ruptures are the third most common injury to the extensor mechanism. These injuries are debilitating to the patient, and delays in treatment can present a challenge to the treating surgeon. Chronic patellar tendon injuries are rare and are more difficult to manage given proximal patellar retraction, scarring, and atrophy of surrounding tissues. There is no consensus on the optimal approach for treatment, and numerous reconstruction techniques have been described using a variety of graft choices and fixation methods. We describe our surgical technique for a 3-fold reconstruction of a chronic patellar tendon rupture using an Achilles tendon allograft augmented with a vascularized ipsilateral hamstring tendon autograft and additional FiberTape augmentation. The aim of this procedure is to restore patellar height and prevent extensor lag.

Patellar tendon ruptures are the third most common injury to the extensor mechanism.[1,2] The knee extensor mechanism consists of the quadriceps tendon, the patellar tendon, the patella, and the insertion of the patellar tendon at the tibial tubercle.[3] Extensor mechanism injuries are debilitating to the patient, and delays in management can present a challenge to the treating surgeon. Ruptures of the patellar tendon can be classified as acute (<2 weeks) or chronic (>2 weeks).[2] Although acute patellar tendon ruptures can usually be managed with suturing of the patellar tendon together or reattachment of the tendon to the bone, chronic patellar tendon injuries are more difficult to manage given proximal patellar retraction, scarring, and atrophy of surrounding tissues.[4] In the case of a chronic patellar tendon rupture, several surgical techniques have previously been described in the literature. When direct repair of the tendon is not possible, the tendon is augmented using either allografts or autografts.[1,4-9] In the absence of any viable patellar tendon tissue, a reconstruction is necessitated. Because chronic patellar tendon injuries are rare, there is no consensus on the optimal approach for treatment. We describe our surgical technique for a 3-fold reconstruction of a chronic patellar tendon rupture using an Achilles tendon allograft augmented with a vascularized ipsilateral hamstring tendon autograft and additional FiberTape (Arthrex, Naples, FL) augmentation.

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Surgical Technique

The technique is shown and discussed in a left knee in Video 1. The surgical steps, pearls, and pitfalls are presented in Table 1.

Preoperative Analgesia and Patient Positioning

Patellar tendon reconstruction is performed with the patient placed on the operating table in the supine position under general anesthesia. A femoral nerve block is recommended. The tourniquet is

Table 1. Surgical Steps and Tips, Pearls, and Pitfalls of Technique

Surgical Step	Tips	Pearls and Pitfalls
Preoperative radiographic imaging	• The Insall-Salvati ratio of the contralateral knee serves as a baseline to restore the patellar height of the operative knee.	• The ratio is measured with the knee in 30° of flexion.
Graft harvesting	• After the pes anserinus insertion is found on the tibia, both the gracilis and semitendinosus tendons are harvested, leaving the distal insertions intact.	• An appropriate open-loop harvester should be used.
Trough preparation for Achilles allograft	• A 1.5-cm × 3-cm × 1-cm (width × length × depth) trough at and below the level of the tibial tubercle is prepared using a small sagittal saw (1 cm) and a 4-mm TPS burr to accommodate an Achilles bone block. • The bone block is fixed in a nonparallel fashion to increase stability and avoid splitting of the bone block.	• A bone block too loose or small may lead to increased risk of nonunion. • Care must be taken when fixating the bone block to avoid fracturing it.
Graft preparation for hamstring autograft	• The proximal ends of both hamstrings are whip-stitched with FiberLoop and TigerLoop sutures, and the combined diameter is measured.	• The tendon should not be prematurely amputated.
Patellar tunnel drilling	• The patellar tunnel is drilled in a transverse fashion in the proximal half of the patella. • The size of the tunnel is determined according to the hamstring diameter.	• Placement of the tunnel in the distal half of the patella should be avoided to prevent any tunnel interference with the Achilles tendon fixation on the inferior pole. • The tunnel should be placed midline from anterior to posterior to avoid cartilage damage.
Hamstring graft passage	• One tendon is inserted from the lateral side while the other tendon is inserted from the medial side to ensure equal tension on the patella.	• Long hamstring tendons may need to be shortened and re-stitched if too long when approaching the screw and/or washer post.
Achilles tendon fixation to patella	• While the knee is in full extension, the tendon is fixed to the patella using 2 double-loaded Corkscrew anchors in the inferior pole of the patella. • A free needle is used to place sutures into the Achilles tendon allograft.	• The Achilles tendon graft must be fixed in extension after the proper patellar height is achieved by tensioning the hamstring grafts under fluoroscopic visualization while the knee is at 30° of flexion.

applied with a small bump under the left buttock. A manipulation under anesthesia may be performed to release underlying adhesions.

Radiographic Imaging

Before sterile draping, fluoroscopy is used to obtain true 30° lateral images of the operative and contralateral knees.

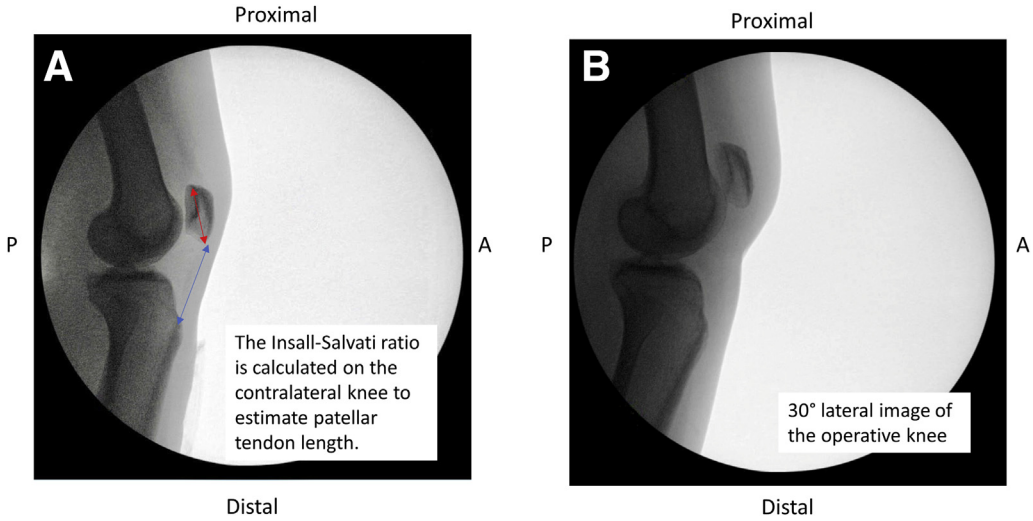

Fig 1. Intraoperative radiographic imaging. Before sterile draping, fluoroscopy is used to obtain true 30° lateral images of the operative and contralateral knees. To appropriately restore patellar height, the contralateral knee is used to calculate the baseline Insall-Salvati ratio and estimate the patellar tendon length. (A) A 30° lateral fluoroscopic image of the contralateral right knee. The red line represents the greatest pole-to-pole patellar length. The blue line represents the patellar tendon length. (B) A 30° lateral image of the operative left knee before restoration of patellar height, showing patella alta and deficiency of the patellar tendon. (A, anterior; P, posterior.)

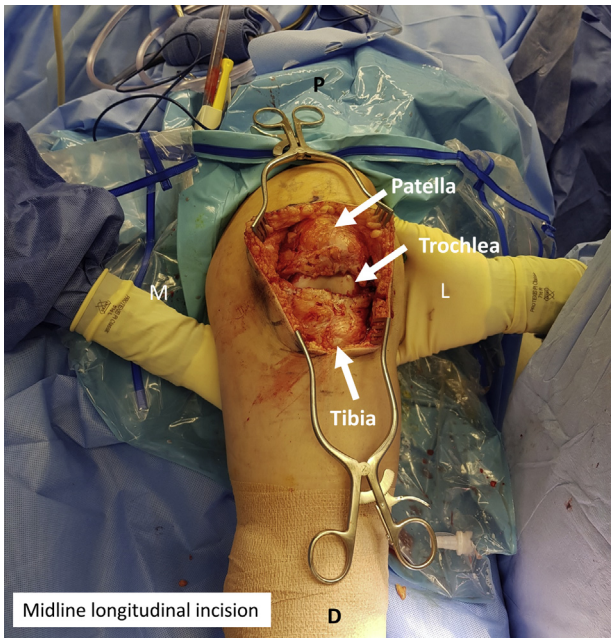

Fig 2. An open approach to the left knee is shown with the patient in the supine position and the knee flexed at about 30°. A midline longitudinal incision is made extending from the superior pole of the patella to the medial aspect of the tibial tubercle. Large medial and lateral flaps are created proximally and extended distally, maintaining an appropriate tissue plane. A large exposure is necessary to allow visualization of the anatomy and pathologic tissue. The underlying trochlea is exposed through the patellar tendon defect. (D, distal; L, lateral; M, medial; P, proximal.)

To appropriately restore patellar height, the contralateral knee is used to obtain the baseline Insall-Salvati ratio and estimate the patellar tendon length (Fig 1).

Surgical Approach

A midline longitudinal incision is used from the superior pole of the patella to the medial aspect of the tibial tubercle (Fig 2). Large medial and lateral flaps are created proximally and extended distally, maintaining an appropriate tissue plane. Nonviable patellar tendon is excised. A diagnostic arthroscopy may be performed at this point.

Achilles Allograft Preparation and Fixation. To accommodate the Achilles bone block, a 1.5-cm × 3-cm × 1-cm (width × length × depth) trough is created at and below the level of the tibial tubercle using a 1-cm sagittal saw and 4-mm TPS burr (Stryker, Kalamazoo, MI). The Achilles bone–tendon allograft is prepared to be the same size (1.5 cm × 3 cm × 1 cm) to allow for press-fit fixation (Fig 3). The bone block is secured using two 3.5-mm cortical screws (Synthes, Warsaw, IN) with washers in a nonparallel fashion to avoid any split in the bone block; a lag technique is used (Fig 3). Fluoroscopy confirms bicortical placement (Fig 4). The Achilles tendon is directed proximally toward the inferior pole of the patella.

Hamstring Harvest. By use of the midline incision, the hamstrings (semitendinosus and gracilis) are harvested using an open-loop hamstring harvester. The distal insertion of the hamstrings is left attached to allow for a vascularized graft. The muscle is resected off the proximal ends, and the free (proximal) ends of the tendon are whipstitched with FiberLoop and TigerLoop sutures (Arthrex); the combined diameter is measured (Fig 5).

Patellar Tunnel Preparation. A 4- to 5-mm transverse tunnel is drilled in the superior half of the patella to avoid interference with the Achilles tendon fixation to the inferior pole of the patella. The tunnel diameter must be large enough to accommodate both hamstring tendons (Fig 6). A guidewire is drilled from lateral to medial and midline in the sagittal plane of the patella using fluoroscopic guidance; the transverse tunnel is reamed through this. The purpose of this tunnel is 2-fold: to allow for (1) augmentation using a vascularized graft and (2) restoration of patellar height symmetrically with the contralateral side based on the preoperative fluoroscopic images.

Patellar Tendon Reconstruction. Video 1 explains the reconstruction technique in detail. The semitendinosus tendon is brought in through the lateral side using a Hewson suture passer and pulled down distally on the medial side. The gracilis is brought in through the medial side and pulled down laterally in the opposite fashion to the semitendinosus. One hamstring tendon should be on either side of the patella. Distal traction is applied to the tendons to allow for a balanced pull on the patella. A FiberTape is passed through the transverse tunnel of the patella to allow for an internal brace reinforcement of the construct.

The knee is flexed to 30°, and traction is placed on the hamstrings distally to reduce the patella to the appropriate patellar height under fluoroscopic visualization (Fig 7). While this patellar height is maintained, the Achilles tendon is approximated to the inferior pole of the patella and a transverse line is marked at the position of intended attachment. The hamstring tendons should also be marked at their respective tunnel entry positions.

The hamstring tendons are relaxed and the knee is placed in full extension to allow for fixation of the

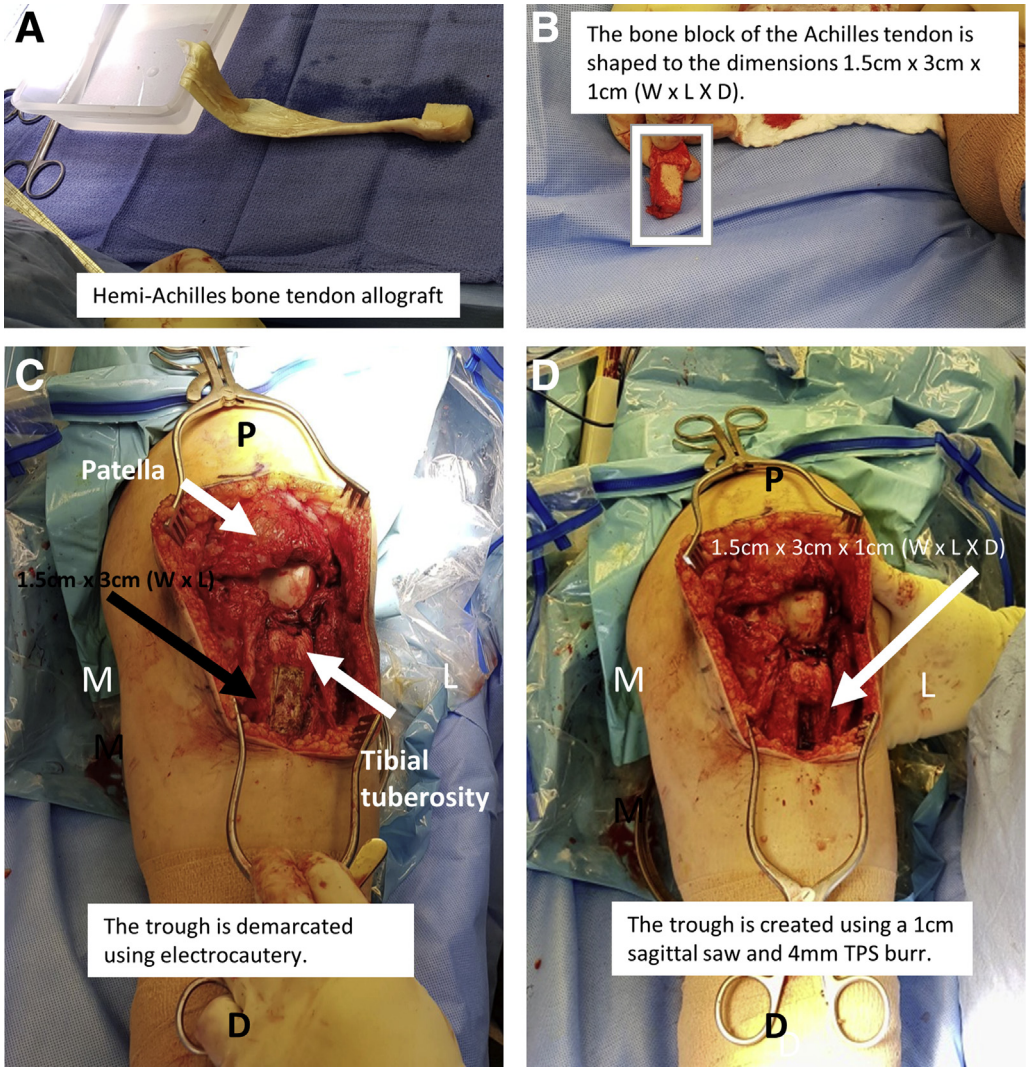

Fig 3. Achilles allograft preparation and trough creation for patellar tendon reconstruction. The Achilles bone block allograft and trough are prepared to allow for press-fit fixation. (A) Hemi-Achilles bone–tendon allograft. (B) The bone block of the Achilles allograft is shaped to the dimensions of 1.5 cm × 3 cm × 1 cm (width × length × depth [W × L × D]). (C) A left knee is shown with the patient in the supine position and the knee flexed about 30°. The trough is demarcated with electrocautery at and below the level of the tibial tubercle using the same dimensions as the bone block (black arrow). (D) The trough (arrow) in the left knee is created using a 1-cm sagittal saw and 4-mm TPS burr (Stryker) to a depth of 1 cm to allow for press-fit fixation. (D, distal; L, lateral; M, medial; P, proximal.)

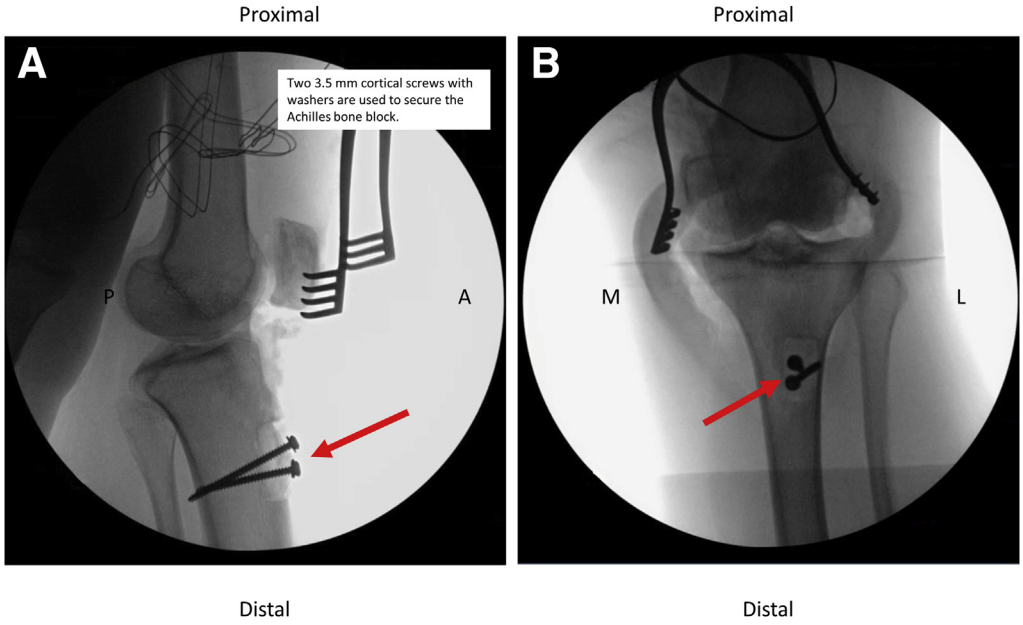

Fig 4. Fluoroscopic views with the left knee in full extension. The bone block is secured using two 3.5-mm cortical screws (Synthes) with washers in a nonparallel fashion to avoid any split in the bone block; a lag technique is used (arrows). Fluoroscopy confirms bicortical placement. (A) Lateral view of left knee. (B) Anteroposterior view of left knee. (A, anterior; L, lateral; M, medial; P, posterior.)

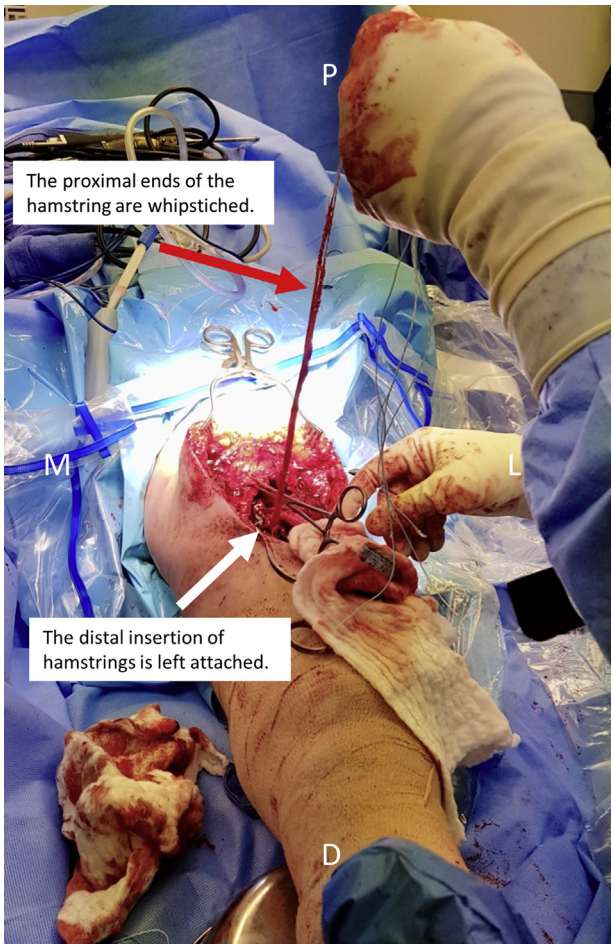

Fig 5. Hamstring tendon harvest. The hamstrings (semitendinosus and gracilis) are harvested from the proximal medial aspect of the left knee using an open-loop hamstring harvester. The distal insertion of the hamstrings is left attached to allow for a vascularized graft (white arrow). The muscle is resected off the proximal ends, and the free ends of the tendon are whipstitched (red arrow) with FiberLoop and TigerLoop sutures; the combined diameter is measured. (D, distal; L, lateral; M, medial; P, proximal.)

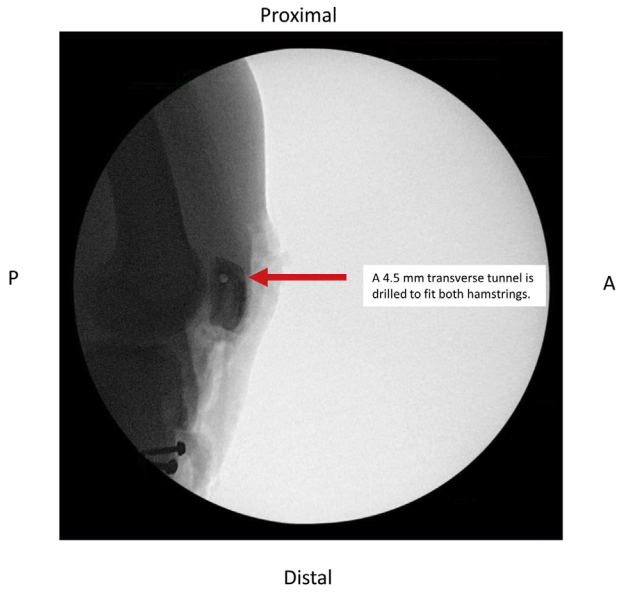

Fig 6. Fluoroscopic view of the left knee in full extension. A 4- to 5-mm transverse tunnel is drilled in the superior half of the patella to avoid interference with the Achilles tendon fixation to the inferior pole of the patella (arrow). The tunnel diameter must be large enough to accommodate both hamstring tendons. A guidewire is drilled from lateral to medial and midline in the sagittal plane of the patella using fluoroscopic guidance; the transverse tunnel is reamed through this. The purpose of this tunnel is 2-fold: to allow for (1) augmentation using a vascularized graft and (2) restoration of patellar height symmetrically with the contralateral side based on the preoperative fluoroscopic images. (A, anterior; P, posterior.)

Achilles allograft tendon to the inferior pole of the patella. The inferior pole is prepared with a curette, rasp, and rongeur. Two double-loaded Corkscrew anchors (Arthrex) are fixed in the inferior pole of the patella (Fig 8). A free needle is used to place all suture pairs into the Achilles tendon allograft. A post suture is passed through the demarcated line, and the other end of each pair is whipstitched to exit at this point as well. Once all 4 suture pairs are passed through the Achilles tendon, the post is tensioned with the knee in full extension, and the sutures are tied to reduce the allograft tendon to the inferior pole of the patella.

The hamstring tendons and the FiberTape are brought anterior to the Achilles tendon allograft. The hamstrings are tensioned to the same level as previously marked at the tunnel entry position. It is important not to over- or under-tension the hamstrings and not to disturb the tensioning of the Achilles allograft. The proximal screw and washer from the Achilles bone block are used as a post for the hamstring tendons and allow for centralizing the extensor mechanism vector. The FiberTape is tied around the distal screw as a post and serves as an internal brace.

The remaining Achilles tendon is spread proximally over the anterior patella and quadriceps mechanism and sutured with FiberWire into the patellar periosteum and the quadriceps tendon to provide continuity to the entire extensor mechanism. The Achilles tendon is folded back down and sutured into the retinaculum on the medial and lateral sides (Fig 9).

Postoperative Rehabilitation

The patient's extremity is initially locked in extension in a hinged-knee brace with no weight bearing for 4 weeks. At week 4, weight bearing in full extension is allowed. At week 8, the brace is unlocked during ambulation, and around week 12, the patient is able to wean off using the brace. Initial rehabilitation focuses on core strengthening and quadriceps stimulation. At 4 weeks, rehabilitation focuses on passive and active-

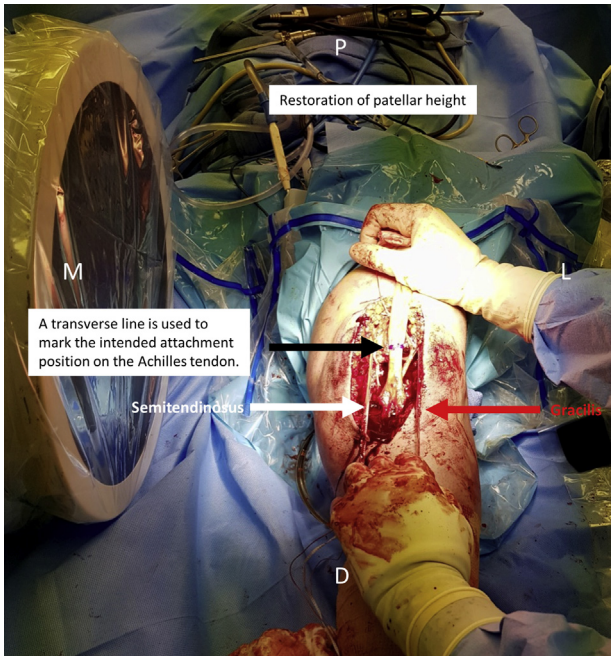

Fig 7. Restoration of patellar height in the left knee. The C-arm is positioned for a lateral view to assess patellar height with the left knee in 30° of flexion. The semitendinosus tendon is brought in through the lateral side using a Hewson suture passer and pulled down distally on the medial side (white arrow). The gracilis is brought in through the medial side and pulled down laterally (red arrow) in the opposite fashion to the semitendinosus. Distal traction is applied to the tendons to allow for a balanced pull on the patella. While this patellar height is maintained, the Achilles tendon is approximated to the inferior pole of the patella and a transverse line is marked at the position of intended attachment (black arrow). The hamstring tendons should also be marked at their respective tunnel entry positions. (D, distal; L, lateral; M, medial; P, proximal.)

assisted range-of-motion and patellar mobility exercises. The patient progresses to open-chain exercises at month 4 with a gradual return to sport around the 6- to 8-month mark.

Discussion

Chronic ruptures of the patellar tendon are difficult problems to manage for both the patient and surgeon. These surgical procedures are challenging because of a lack of viable primary tissue and retraction of the quadriceps, creating patella alta.

Several techniques to reconstruct chronic patellar tendon ruptures have been reported in the literature. Previously described reconstruction techniques include use of autografts, allografts, xenografts, and synthetic material, as well as combinations of thereof.[8-10]

McNally and Marcelli[11] as well as Falconiero and Pallis[12] described reconstruction techniques using an Achilles allograft augmented with a suprapatellar tension-band wire with a subsequent operation to remove the wire. George and Jorgensen[13] described a reconstruction technique using an Achilles tendon allograft bone plug that was shaped to press fit into a tunnel in the tibial tubercle and secured with a bio-composite interference screw. The sutures on the tendinous side of the allograft were passed through 3 holes reamed through the patella.

The technique we describe has 2 major advantages: First, the hamstring serves to protect the main allograft reconstruction because it remains attached at its distal insertion, providing a vascularized graft. Second, the technique uses a sequential method of restoring patellar height while providing 3 methods of fixation (Achilles allograft, hamstring autograft, and FiberTape). The

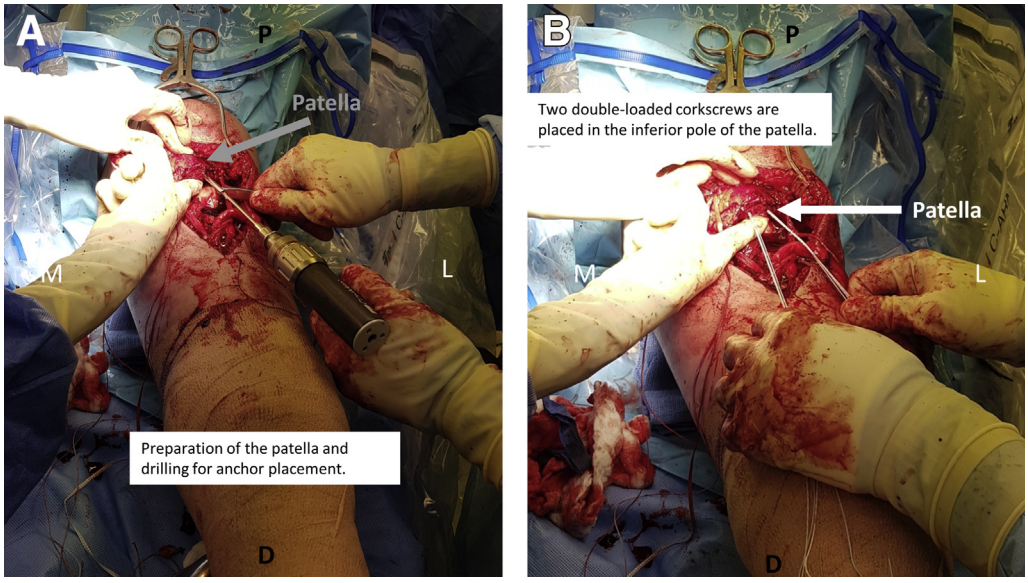

Fig 8. Anchor placement in inferior pole of patella in the left knee. The hamstring tendons are relaxed and the knee is placed in full extension to allow for fixation of the Achilles allograft tendon to the inferior pole of the patella. (A) The inferior pole of the patella (arrow) is prepared with a curette, rasp, and rongeur. A 3.5-mm drill is used to create a socket for the 4.5-mm anchors. (B) Placement of 2 double-loaded Corkscrew anchors in the inferior pole of the patella (arrow). (D, distal; L, lateral; M, medial; P, proximal.)

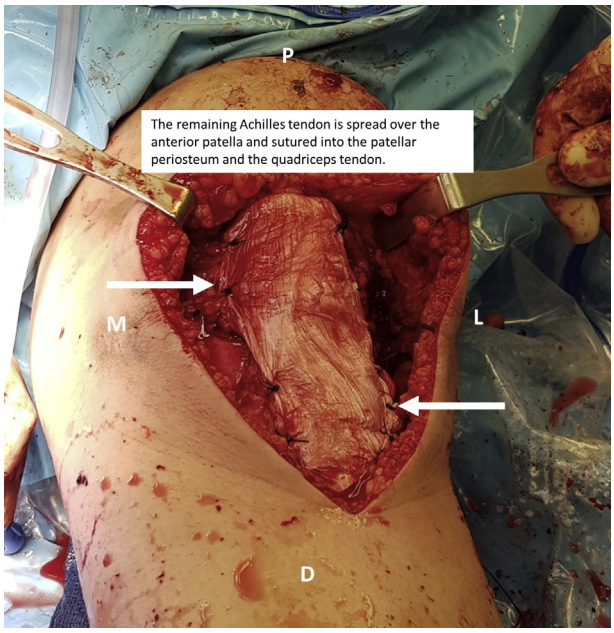

Fig 9. In the left knee, after attachment to the inferior pole, the remaining Achilles tendon is spread proximally over the anterior patella and quadriceps mechanism and sutured with No. 2-0 FiberWire into the patellar periosteum and the quadriceps tendon to provide continuity of the entire extensor mechanism. The Achilles tendon is folded back down and sutured into the retinaculum on the medial and lateral sides (arrows). (D, distal; L, lateral; M, medial; P, proximal.)

FiberTape augmentation provides additional reinforcement to the construct, particularly during the healing phase of the grafts.

Finally, other described techniques have not provided stepwise instructions on restoring patellar height, which is absolutely critical for an optimal outcome. Preoperative assessment of the Insall-Salvati ratio of the contralateral knee is necessary to allow for anatomic restoration of patellar height intraoperatively with fluoroscopy.

Complications related to hardware, including breakage, irritation, and hardware-related stress fractures, have been described with other techniques.[10] Our technique of fixing the hamstring tendons and FiberTape to the screws and washer from the Achilles bone block eliminates the need for additional hardware in the proximal tibia. The advantages, risks, and limitations of the 3-fold reconstruction technique are summarized in Table 2. This technique may help orthopaedic surgeons treat this rare but debilitating injury.

Table 2. Advantages, Risks, and Limitations of Patellar Tendon Reconstruction Using Achilles Tendon Allograft with Hamstring Autograft and FiberTape Augmentation

Advantages
Achilles bone allograft with press-fit fixation is supported by vascularized hamstring tendons.
Fixation of Achilles tendon to the inferior pole of the patella using 2 anchors provides strength.
Proper patellar height is achieved using preoperative and intraoperative fluoroscopy of both knees.
Minimal hardware is used to stabilize the fixation.
Risks
Fractures of patella
Patellar tunnel interference
Injury to patellar cartilage
Nonunion of Achilles bone block and tibia
Rupture of Achilles tendon
Limitations
No hamstring tendons—prior hamstring tendon harvest and/or use

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