Technical Note

Double-Row Suture Anchor Fixation and Achilles Allograft Augmentation for Chronic Patellar Tendon Rupture Repair

William Cregar, M.D., Luc M. Fortier, B.A., Benjamin Kerzner, B.S., Suhas P. Dasari, M.D., Safa Gursoy, M.D., Ph.D., and Jorge Chahla, M.D., Ph.D.

Abstract: Patellar tendon ruptures are functionally devastating injuries that result in failure of the knee extensor mechanism and can lead to a loss of ambulation. Chronic patellar tendon injuries are defined as tears greater than 2 weeks old and are typically more complex to manage than acute tears. Recently, the use of double-row suture anchor configurations has been explored as a technique to provide improved strength in addition to tendon-to-bone compression at the anatomic footprint. The purpose of this article is to describe a surgical technique involving chronic patellar tendon rupture repair using a double-row suture construct augmented with Achilles allograft. Our technique offers a variety of benefits and permits early postoperative mobilization.

Patellar tendon ruptures are functionally devastating injuries that result in failure of the knee extensor mechanism and can lead to a loss of ambulation. Patellar tendon ruptures are relatively rare injuries that typically occur in men younger than 40 years.[1,2] It is estimated that patellar tendon ruptures affect less than 0.5% of the US population annually; they are reported as the third most common injury to the extensor mechanism behind quadriceps tendon ruptures and patellar fractures.[3,4]

Patellar tendon ruptures occur from tensile overload of the extensor mechanism in the setting of long-standing chronic tendon degeneration.[3] Chronic inflammatory changes can contribute to an increased risk of tendon rupture as seen in patients with diabetes, hemodialysis, chronic renal disease, fluoroquinolone antibiotic use, chronic corticosteroid use, rheumatoid arthritis, and systemic lupus erythematosus, as well as several other chronic medical conditions.[3] Because of severe functional debilitation associated with these injuries, surgical intervention is warranted in nearly all cases of patellar tendon rupture.

Chronic patellar tendon injuries are defined as tears greater than 2 weeks old and are typically more complex to manage than acute tears.[5] As the duration from injury progresses, the tear edges retract, tendon quality degenerates, and surrounding supportive tissues scar and atrophy.[1,3,4] These factors often preclude primary repair in a large percentage of chronic patellar ruptures. Consequently, reconstruction techniques have been developed that use a variety of graft options, including autografts, allografts, xenografts, and synthetic materials.[4]

Despite these challenges, numerous studies have reported reliable postoperative improvement in pain and functional outcomes after reconstruction of chronic patellar tendon ruptures with an Achilles allograft.[6-8] Many techniques augmenting Achilles allograft to improve the biomechanical strength of the reconstruction have also been described, including

From the Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, Illinois, U.S.A. (W.C., J.C.); and Midwest Orthopaedics at Rush, Chicago, Illinois, U.S.A. (L.M.F., B.K., S.P.D., S.G., J.C.).

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Address correspondence to Jorge Chahla, M.D., Ph.D., Department of Orthopaedic Surgery, Rush University Medical Center, 1611 W Harrison St, Ste 300, Chicago, IL 60612, U.S.A. E-mail: Jorge.chahla@rushortho.com

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suprapatellar cerclage wire, Achilles tendon with bone plugs secured with an interference screw, and ipsilateral hamstring autograft.[4,9-11] Recently, the use of a double-row suture anchor configuration has been explored as a technique to provide improved strength while providing tendon-to-bone compression at the anatomic footprint.[12]

The purpose of this Technical Note is to describe our step-by-step surgical technique of chronic patellar tendon rupture repair using a double-row suture fixation construct with Achilles allograft augmentation.

Preoperative Evaluation and Planning

Preoperative evaluation begins with a high index of suspicion. Most patients presenting with a complete patellar tendon rupture will describe acute pain and a tearing sensation, followed by the inability to bear weight and a large effusion.[13] On physical examination, a palpable infrapatellar gap with relative proximal migration of the patella is commonly appreciated.[14] In addition, a lack of active knee extension or an inability to maintain a straight leg extended against gravity further suggests disruption of the extensor mechanism.[13]

Standard anteroposterior and lateral radiographic views of the knee are obtained as the initial imaging workup. These plain films can assess any osseous injury, such as patellar or tibial tubercle (TT) avulsion fractures.[13] The lateral view is then used to calculate the Caton-Deschamps Index, which measures the distance between the distal aspect of the patellar articular surface and the anterosuperior border of the tibia. This length is then divided by the length of the articular surface of the patella[15] (Fig 1). An index of 1.2 or greater confirms patella alta and can suggest disruption of the patellar tendon.[15]

Magnetic resonance imaging (MRI) is not necessary for preoperative planning in the setting of a palpable gap and gross functional deficits. However, in the setting of clinical uncertainty, MRI is useful because it is the most sensitive imaging modality by which to confirm disruption of the tendon.[16] MRI may also be helpful in detecting concomitant intra-articular pathology if suspected.[17] In addition, in the chronic setting, MRI is particularly useful to determine the length of the gap between the tendon edges and help guide whether primary repair will be sufficient or whether augmentation is required.

Our technique is indicated for patients who present with chronic disruption of the extensor mechanism and are found to have either an avulsion of the patellar tendon from the TT or a distal patellar tendon rupture close to its native attachment. It is challenging to accurately assess the location of patellar tendon disruption without an MRI scan; therefore, it is often

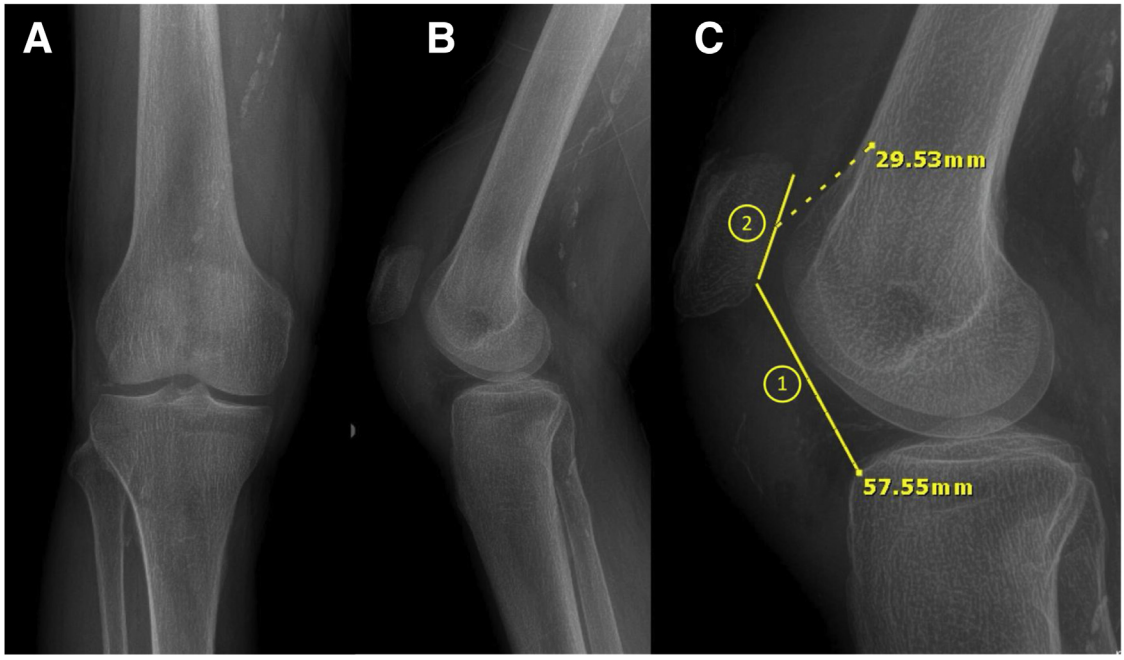

Fig 1. Preoperative radiographs of a right knee. (A) Standard anteroposterior radiograph. (B) Standard lateral radiograph. (C) Lateral radiograph showing measurement of the Caton-Deschamps Index (CDI). A line is drawn from the distal aspect of the patellar articular surface to the anterosuperior border of the tibia (1); another line is drawn across the entire articular surface of the patella (2). The CDI is calculated as the line 1 measurement divided by the line 2 measurement. In this case, the CDI is 1.95, which is greater than the threshold of 1.2, confirming patella alta.

Table 1. Pearls and Pitfalls

Pearls
Concomitant repair of retinacular tears during patellar tendon repair is crucial to avoid postoperative patellar instability and ensure the overall success of the construct.
The surgeon should use a rongeur or burr and debride the patellar tendon insertion site at the tibial tuberosity to prepare a site of healthy bleeding bone for optimal tendon-to-bone healing.
Using the same angle while creating the drill holes and performing anchor insertion is important to optimize placement and purchase of the anchors, especially when placing the FiberTak soft suture anchors.
The graft should be measured prior to cutting to ensure adequate coverage over the entirety of the native patellar tendon.
The described technique can be used in cases of patellar tendon avulsion from the tibial tubercle or cases of distal patellar tendon rupture in the chronic setting.
Pitfalls
Care must be taken to insert the proximal row of anchors prior to tendon reduction; otherwise, the tendon will cover the ideal area for anchor placement.
Our technique should not be used for more proximal tears or tears with significant tissue loss because this technique relies on the ability to reduce adequate tendon tissue to the tibial tubercle footprint.
After securing each anchor and performing tendon reduction, the surgeon should leave the free suture ends intact for later use in the final construct.

necessary to carefully evaluate the degree and location of tendon injury intraoperatively.

Technique

Patient Positioning and Anesthesia

After the induction of general anesthesia, the injured knee is examined. The patient is positioned supine with all bony prominences well padded. A padded thigh-high tourniquet is placed onto the operative leg. Appropriate perioperative antibiotics are administered prior to surgical incision, followed by an appropriate paralytic agent to allow for complete muscular relaxation, which can improve tendon mobilization during repair.

Surgical Technique

The surgical technique is demonstrated in Video 1, and surgical pearls and pitfalls are summarized in Table 1. The advantages and disadvantages of this technique are outlined in Table 2. A standard anterior midline knee incision is used, extending from the distal pole of the patella inferiorly to the distal end of the TT. Sharp dissection is carried down to the paratenon, which is often disrupted. The patellar tendon is then identified, and flaps are made to fully visualize the extent of the patellar tendon tear. In a full-thickness tear, it is common for the tendon to be significantly retracted proximally. There is also usually a notable hematoma and early scar tissue formation expressed at the rupture site owing to the traumatic nature of this injury. Evacuation of the hematoma is necessary to adequately visualize the anatomy (Fig 2). The surrounding retinaculum, which is commonly injured, is then carefully dissected both medially and laterally. Next, 2 self-retaining retractors (Modular Soft Tissue Retractor Set; Arthrex, Naples, FL) are placed proximally and distally to provide adequate exposure.

Attention is then turned to the TT. A rongeur and burr are used to debride the patellar insertion site at the TT in preparation for the proximal row of anchors. It is important to create a site of healthy bleeding cancellous bone to optimize tendon-to-bone healing. A 4.0-mm drill (Arthrex) is first used to create a socket into the center of the TT. Then, a 4.5-mm Corkscrew tap (Arthrex) is used, followed by placement of a 4.75-mm PEEK (polyether ether ketone) Corkscrew anchor (PEEK Corkscrew FT Suture Anchor; Arthrex) double loaded with 1.3-mm SutureTape (Arthrex).

Prior to reduction of the tendon, 2 additional double-loaded 2.6-mm Knotless FiberTak soft anchors (Arthrex) are placed 1 cm medially and 1 cm laterally and proximal to the initial Corkscrew suture anchor placed in the center of the TT (Fig 3). These 2 knotless anchors comprise the proximal row of the double-row construct (Fig 3).

The distal aspect of the patellar tendon is reduced back to its anatomic position and secured with a running Krackow stitch using the 2 limbs of the SutureTape from the center Corkscrew anchor. This effectively reduces the tendon back to its anatomic position prior to securing the repair and compressing the tendon to its footprint with the double-row fixation (Fig 4).

Next, attention is turned to the proximal row of the 2 previously placed 2.6-mm knotless FiberTak anchors. The internal locking strand from each knotless anchor is brought over the top of the tendon toward the opposite anchor and looped through the suture anchor's locking loop and is then tensioned such that a knotless suture—staple configuration compresses the tendon back down to its footprint.

Finally, the distal row of the construct is created, using a 4.75-mm PEEK SwiveLock Anchor (Arthrex), placed approximately 3 cm inferior to the initial TT suture anchor. The pilot hole for the anchor is drilled and appropriately tapped. The 2 free suture limbs from the proximal row of FiberTak anchors are then pulled over the top of the tendon distally, loaded through the eyelet of the distal 4.75-mm PEEK SwiveLock Anchor, and tensioned as the anchor is secured within bone. The 2 free ends of suture from the SwiveLock anchor are secured back through the distal aspect of the patellar tendon and tied using standard knots (Fig 5).

In the setting of suboptimal native tendon tissue quality, an Achilles tendon allograft is used to augment the repair. The graft is measured and cut appropriately

Table 2. Advantages and Disadvantages

Advantages
A theoretically biomechanically stronger construct is provided compared with a single-row construct.
Strong tendon-to-bone compression is provided with an increased footprint bed to maximize the potential for tendon-to-bone healing.
Familiar suture anchor technology is used.
No prominent suture knots are required.
The use of transosseous bone tunnels, which increase the risk of patellar fracture or articular penetration, is avoided.
The need for autograft and increased risk of donor-site morbidity are avoided.
The construct strength allows early mobilization and active motion, thus preventing muscle atrophy and knee stiffness postoperatively.
Disadvantages
The overall operative time is increased compared with single-row repair constructs.
This construct is more technically demanding than single-row repair constructs.
There is an increased overall cost associated with the need for additional suture anchors and allograft tissue.

to provide coverage over the entirety of the native patellar tendon. Suture limbs from the initial TT Corkscrew anchor are whipstitched through the allograft in a Krackow fashion both medially and laterally around the edges of the graft (Fig 6).

Once the allograft is secured over the repair, the knee is gently flexed to ensure adequate strength of the construct. No. 2 synthetic nonabsorbable sutures are used to repair the medial and lateral retinacular gutters. Concomitant repair of the disrupted retinaculum during patellar tendon repair is crucial to protect the repair and optimize repair strength. The wound is then copiously irrigated, and 1 g of vancomycin powder is distributed over the repair construct. The deep tissues are closed in a layered fashion, and the skin is closed in a standard fashion using a running absorbable suture, followed by application of a sterile occlusive dressing over the incision. A standard hinged brace is applied and locked in full extension.

Postoperative Protocol

Patients are made weight bearing as tolerated in a knee brace locked in full extension at all times using crutches for 2 weeks postoperatively. They are allowed to remove the brace only during therapy sessions. Patients should have active and passive knee flexion between 0° and 30° by 2 weeks, between 0° and 60° by 4 weeks, and between 0° and 90° by 6 weeks. By 6 weeks postoperatively, the brace is unlocked for ambulation and patients are gradually weaned from its use over a couple of weeks. During this time, patients will begin to regain their normal range of motion and start to advance quadriceps strengthening exercises. By 6 months, patients are expected to be able to bear weight without assistive devices or braces and to show a normal gait pattern with full range of motion. A running and jogging regimen may be initiated once quadriceps strength normalizes.

Discussion

Chronic patellar tendon injuries remain a challenging surgical dilemma for orthopaedic surgeons.[18] Delayed surgical intervention results in increased tendon adhesions and degeneration, potentially affecting the ability to achieve healing of the repair.[3] From a rehabilitation standpoint, tendon retraction and fibrous adhesions also put patients with chronic patellar tendon injuries at an increased risk of postoperative rerupture as compared with patients with acute repair.[19] Belhaj et al.[19] reported significantly lower postoperative Knee Society Score (KSS) knee and function scores for patients undergoing chronic patellar tendon repair with hamstring allograft as compared with the cohort undergoing acute repair with a similar postoperative protocol. These unfavorable outcomes indicate that patients with chronic injury patterns may need a specialized treatment plan that is distinctly different from that of their counterparts with acute injuries.[3,19]

Despite a wide range of surgical options for chronic injuries, there exists no consensus on the best management strategy. Some of the most common surgical options include Achilles tendon allograft augmentation, semitendinosus autograft augmentation, transosseous flexible suture frame, knotless suture anchor tape, and end-to-end suture repair with cerclage augmentation.[20-23] However, these techniques are not without drawbacks. Cerclage supplementation requires a second operation for wire removal, autograft augmentation increases the risk of donor-site morbidity, and allograft reconstruction is associated with an increased risk of failure.[12] All of these options put patients at further risk of potential complications.

There are also a variety of fixation methods used in conjunction with the aforementioned techniques; however, suture anchors are becoming the most popular fixation method to secure tendon to bone in the repair setting.[13] Traditional methods of passing sutures through transosseous drill holes created in the patella have drawbacks that suture anchors avoid.[24] For instance, transosseous drill holes through the patella can disrupt the articular surface, injure the quadriceps tendon, or increase the risk of postoperative patellar fracture.[24] Obliquely oriented transosseous tunnels may also result in patellar tilt and lead to abnormal forces through the extensor mechanism, whereas the need for patellar debridement may shorten the already injured patella.[24] In addition, transosseous drill holes require a larger incision and may be associated with increased postoperative pain.[25] Suture anchors, on the other hand, are low profile, may provide a more accurate placement, and avoid the risk of injury to the

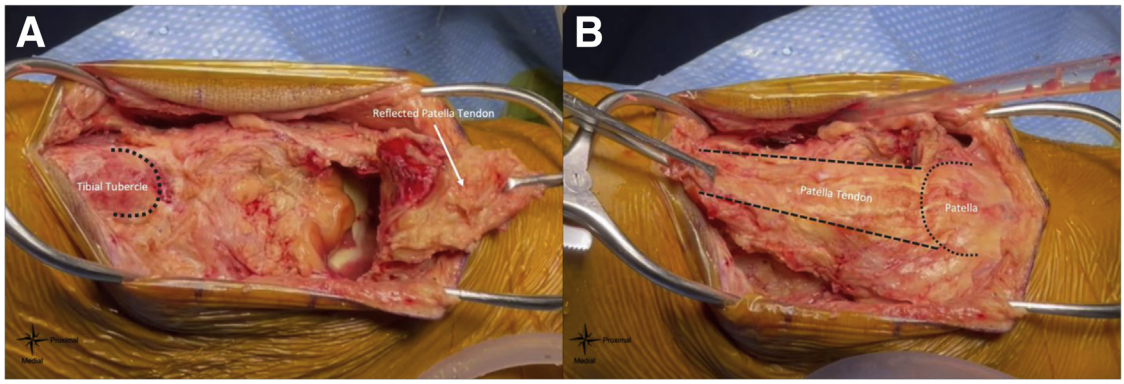

Fig 2. Intraoperative photograph of a right knee with a distal patellar tendon tear off of the tibial tubercle. (A) The tendon edge is reflected proximally with the tibial tubercle footprint marked. (B) The distal edge of the tendon is reduced back down to the tibial tubercle.

cartilage or soft tissues.[24] A recent biomechanical study comparing knotless suture anchor tape with transosseous suture found no differences in mean load to failure between the 2 constructs, suggesting the clinical feasibility of using suture anchor constructs.[23]

As a result, suture anchor fixation in a single-row construct for patellar tendon repair has been previously reported.[25] However, there is concern over the strength of a single-row construct in isolation, which has led to some authors recommending augmentation

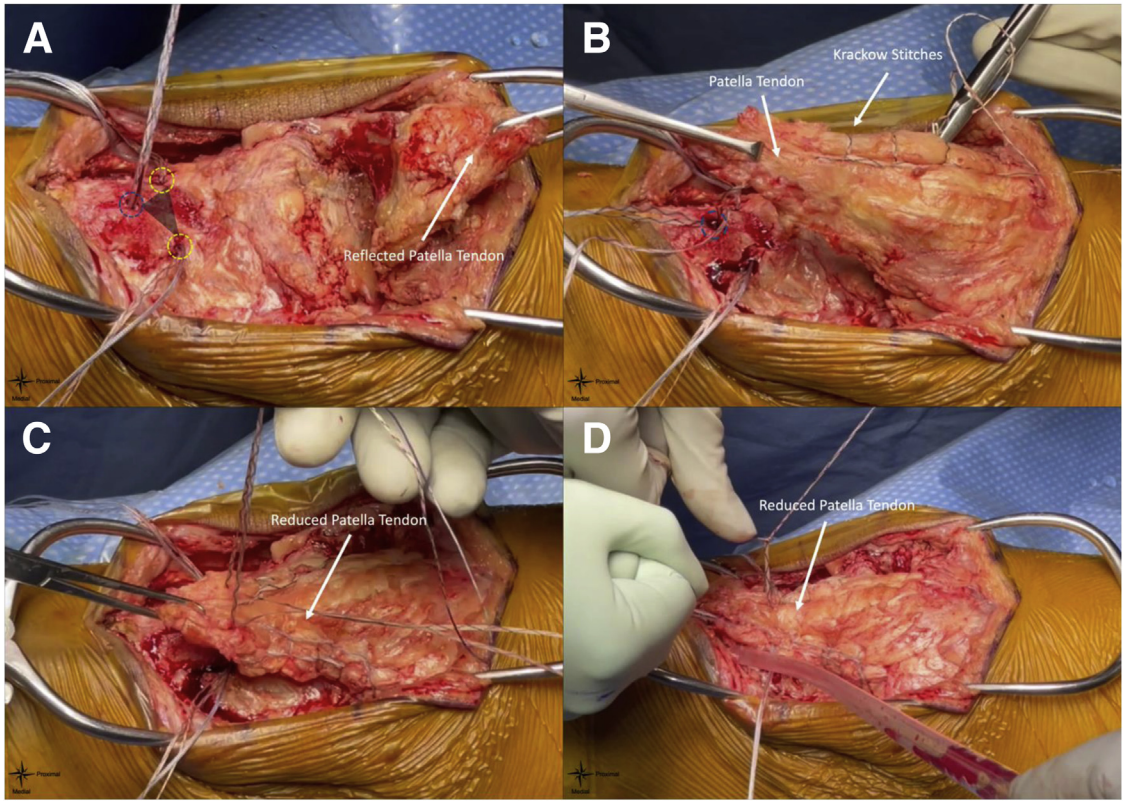

Fig 3. Intraoperative photographs showing placement of the described suture anchor construct into the tibial tubercle footprint of a right knee as the patient is positioned supine. (A) Placement of 3 anchors in an inverted triangle formation, with a 4.75-mm PEEK Corkscrew anchor double loaded with 1.3-mm SutureTape placed centrally in the footprint and two 2.6-mm knotless FiberTak soft anchors placed medial and lateral and slightly proximal to the initial suture anchor to comprise the proximal row. (B) Passage of both limbs of the SutureTape from the center anchor at the apex of the triangle through the tendon proximal to distal and then back with an interlocking Krackow stitch. (C) Final view after passage of Krackow stitches. (D) Tying of knots between medially and laterally passed sutures. Yellow circles represents 2.6-mm knotless FiberTak soft anchors; blue circles represents 4.75-mm PEEK Corkscrew anchor; gray triangle represents the inverted triangle formed by the 3 anchors placed into the tibial tubercle footprint.

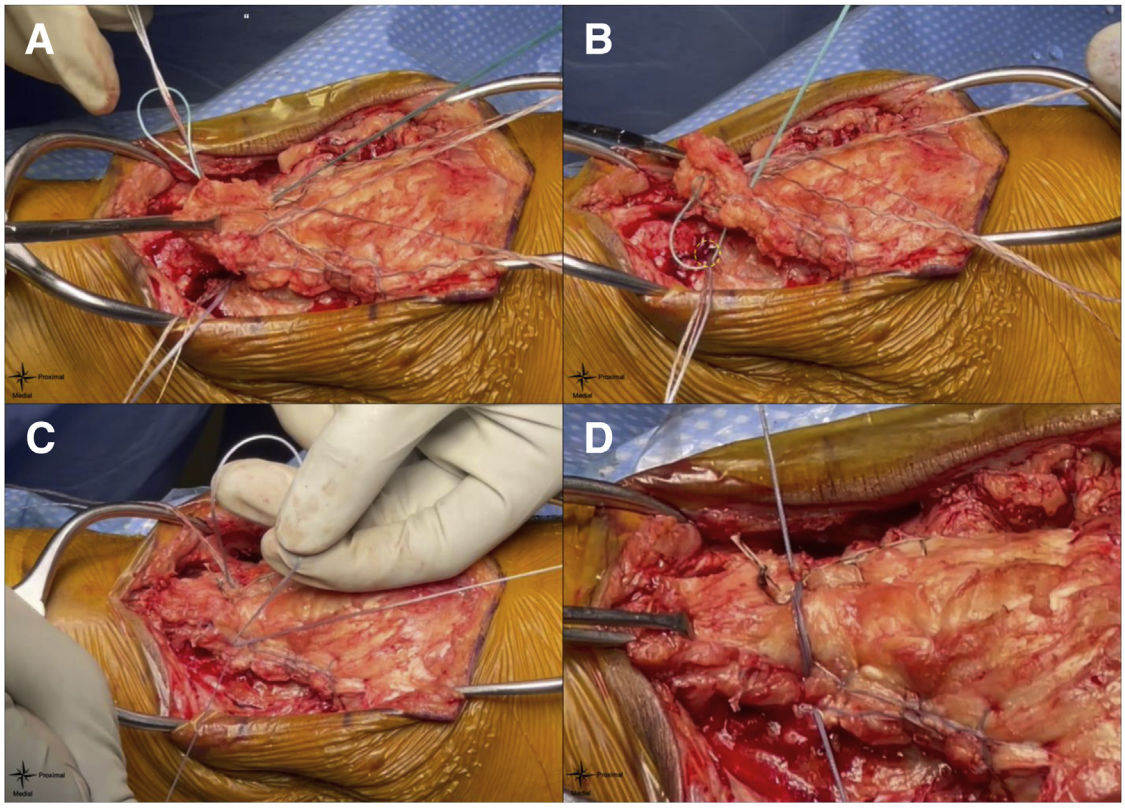

Fig 4. Intraoperative photographs showing proximal-row fixation using 2 knotless anchors to create a suture anchor compression staple over the right knee patellar tendon as the patient is positioned supine. (A-C) The internal locking strand from each anchor is brought over the tendon and threaded through the locking loop of the opposing suture anchor to create a self-tensioning and locking suture—staple construct. (D) The final compression staple construct securing the tendon to its footprint is shown. The free ends of suture remaining are left attached for later use to secure the distal footprint.

of the repair with cerclage.[26] Consequently, researchers have begun to explore the use of double-row suture anchor fixation, primarily in rotator cuff tendon repair surgery. A recent biomechanical study in human specimens found that double-row rotator cuff repair techniques increased tendon footprint contact significantly.[27] Further studies have shown that this technique promotes compression of the tendon to bone, encouraging early revascularization at the tendon-bone interface.[28] These biomechanical benefits also translate into superior clinical results. Millett et al.[29] performed a systematic review and

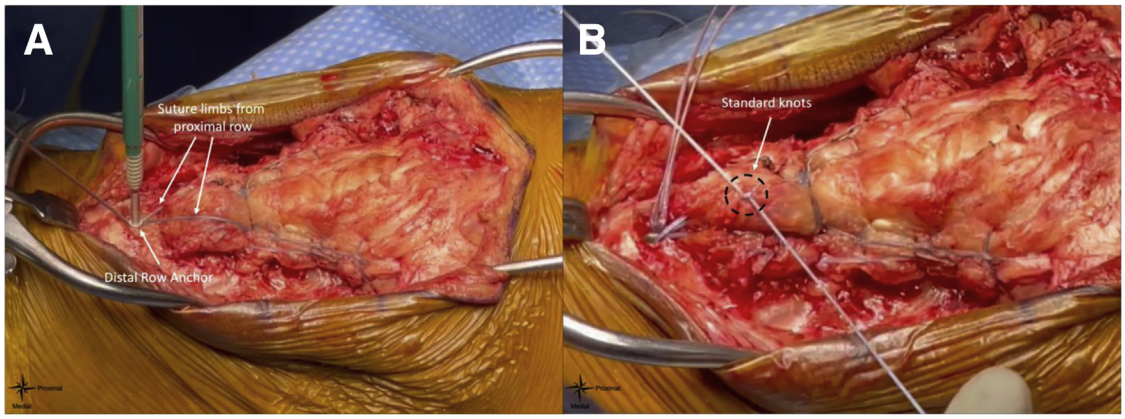

Fig 5. Placement of the second-row suture anchor on the distal aspect of the right tibial tubercle as the patient is positioned supine. (A) One limb of each knotless 2.6-mm FiberTak suture anchor from the proximal row is loaded through the eyelet of the 4.75-mm SwiveLock distal-row anchor. (B) The sutures are secured and tied down under tension using standard knots.

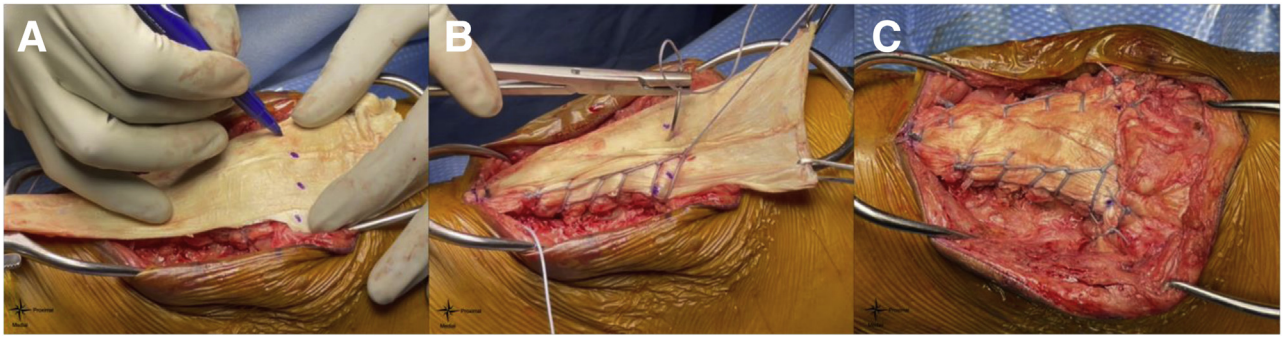

Fig 6. Placement of Achilles tendon allograft to augment the right patellar tendon repair construct as the patient is positioned supine. (A) The proximal aspect of the allograft is measured and marked to ensure complete coverage over the native tendon. (B) The medial aspect of the allograft is whipstitched using a suture limb from the tibial tubercle Corkscrew anchor. (C) Final view of the repair construct with the Achilles allograft secured into place.

meta-analysis comparing single-row versus double-row rotator cuff repair and found a significantly decreased retear rate in the double-row group compared with the single-row group. Similar results were confirmed by Rossi et al.,[30] who reported that double-row repair resulted in superior functional outcomes and fewer retears than single-row repairs while also having the benefit of more adequate restoration of the anatomic footprint.

Until recently, no studies had reported the use of a double-row technique in the context of patellar tendon repair. In 2020, Rose et al.[12] published a technique article describing the use of a double-row suture anchor construct in primary repair of an acute distal patellar tendon avulsion injury. By enhancing the biomechanical strength of our fixation with a double-row construct, we are able to perform a primary repair of a chronic injury while avoiding the need for a reconstruction and its associated disadvantages. The use of a double-row suture anchor fixation also provides strong tendon-to-bone compression to maximize the chance of healing and avoid the potential downsides of transosseous drill holes. Finally, augmentation with Achilles allograft ensures optimal strength of the entire construct, minimizes the risk of rerupture, and enhances healing. Ultimately, the strength of this repair permits early mobilization postoperatively to help avoid quadriceps atrophy and knee stiffness. Further clinical studies are warranted to compare this double-row fixation technique using augmentation with other previously reported techniques.

It is important to mention that our technique is not without limitations. The current procedure is technically more demanding to execute than a single-row suture anchor construct, especially for surgeons who do not routinely perform double-row fixation during other procedures such as arthroscopic rotator cuff repair. The combination of this technique with Achilles allograft also increases the overall operative time and has the potential to expose the patient to complications, such as increased blood loss or infection. Moreover, there is an increased overall cost for performing this procedure owing to the need for additional suture anchors, materials, and allograft tissue.

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