Technical Note

Proximal Patellar Tendon Repair: Internal Brace Technique With Unicortical Buttons and Suture Tape

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Abstract: Patellar tendon ruptures may be considerably limiting, especially in younger and highly active patients. These injuries ultimately result in a complete inability to maintain extension of the knee, thereby placing strict impediment on physical activity. As a result, a durable repair construct via surgery is necessary to allow patients to return to their pre-injury activity level. Because of the inherent difficulty in maintaining patellar tendon position after repair, and to avoid failure of the tendon healing to the patella, we recommend using an internal brace construct. The construct uses bone tunnels in the patella and also cortical buttons on the tibia with suture tape whipstitched through the tendon. We feel that this provides an enhanced fixation construct. The purpose of this Technical Note is to describe our preferred method for proximal patellar tendon repair via an internal brace construct with unicortical buttons and suture tape.

Patellar tendon ruptures constitute the third most common injury to the extensor mechanism of the knee occurring mostly in patients younger than 40 years.[1] This entity can be very disabling in the young and active population, resulting in an inability to actively maintain extension. Furthermore, if the tendon fails to heal properly (length or tension), the knee range of motion can be significantly altered.[2]

Conditions such as previous patellar tendonitis and repetitive microtrauma have been associated with a higher risk of patellar tendon rupture.[3] Other predisposing causes are systemic diseases such as rheumatoid arthritis or lupus erythematosus,[4-7] prior bone tendon bone harvest,[8] or previous repeated steroid injections at the patellar tendon.[9] Usually, the mechanism of rupture is a low-velocity, indirect, minor traumatic episode with the knee in flexion and a concomitant extensor mechanism contraction.[9]

Performing a successful repair of the patellar tendon might be challenging because of the high mechanical loads and poor blood supply of this tissue.[10] Given these various factors that may lead to ultimate failure, the optimal technique for patellar tendon repair remains unclear. In case of repair via transosseous sutures, the main mode of failure is gap formation at the repair site due to repetitive loading or a single event.[11] In a recent cadaveric study, patellar tendon repair with suture anchors yielded significantly less gap formation during cyclic loading and resisted significantly higher ultimate failure loads compared with transosseous sutures.[12]

The purpose of this Technical Note is to describe our preferred method of proximal patellar tendon repair via an internal brace construct with unicortical buttons and suture tape.

Objective Diagnosis

Typically, patellar tendon ruptures are unilateral and seen in highly active patients younger than 40 years.[13] In cases of these ruptures, the patient should note a traumatic injury involving knee flexion in combination with quadriceps contraction. However, to accurately diagnose a patellar tendon rupture, a thorough assessment encompassing history, as well as physical examination and imaging, is necessary.[13,14] Given the significant pain and swelling associated with these injuries as well as the patient's apprehension, it is usually difficult to complete a thorough physical

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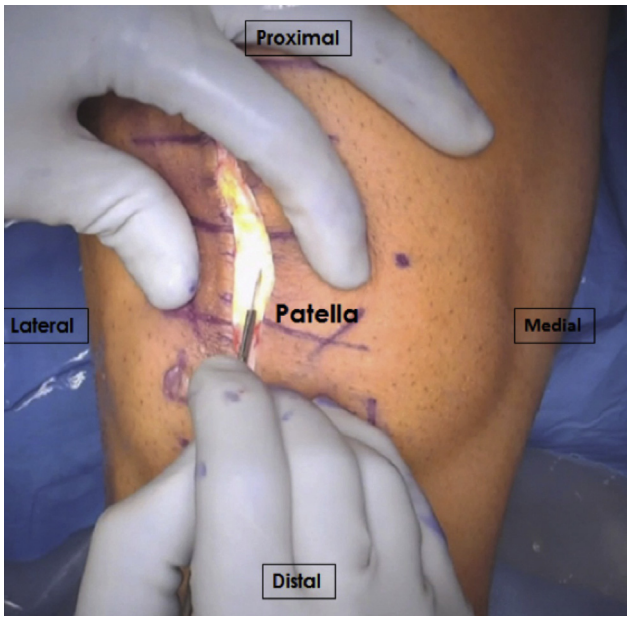

Fig 1. Patellar tendon repair performed in a right knee. After a well-padded thigh tourniquet is placed on the upper thigh of the operative leg and the surgical leg is prepped and draped in a sterile fashion, a midline incision centered on the patella is performed 4 cm above the patella and extended distally to the tibial tubercle. This will allow for complete exposure of the patellar tendon and its edges. Of note, care must be taken to avoid damage to the patellar tendon and to the medial and lateral retinaculum.

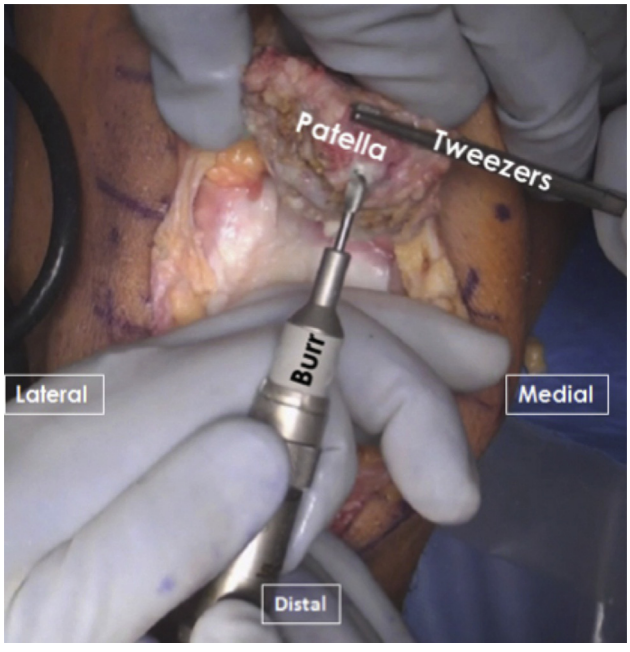

Fig 2. Patellar tendon repair using an internal brace technique with unicortical buttons and suture tape in a right knee. After the patellar tendon is exposed, the distal patella pole is cleared of all scar tissue using a combination of a curette, rasp, and burr to expose the bony surface. All previous hardware from prior surgery is removed at this point of the procedure with care taken to avoid patellar fracture or over-resection.

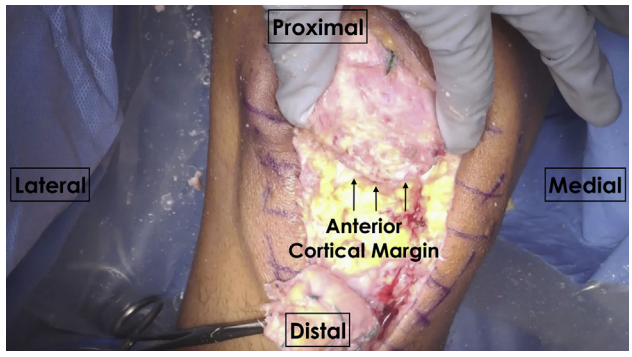

Fig 3. To perform the patellar tendon repair in a right knee using an internal brace technique, the distal pole of the patella should be prepared using a combination of curette, rasp, and burr. A bleeding surface is created, which will improve the reattachment of the tendon to the patella. It should be noted that the repair site on the patella is at the anterior cortical margin and drill tunnels and bony preparation should be completed at this area.

examination.[14,15] Furthermore, the patient will likely be unable to stand up. However, if an examination is possible, the knee joint will be visibly swollen with marked tenderness at the anterior aspect. The patient will also exhibit palpable infrapatellar tendinous defects and an inability to complete straight leg

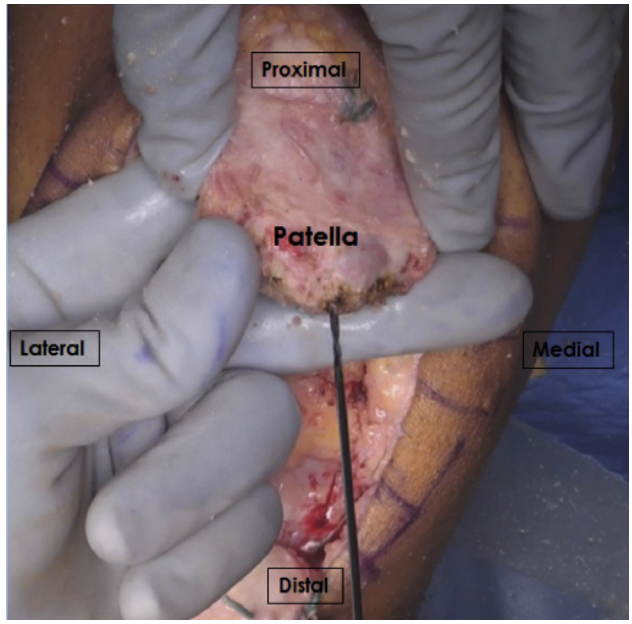

Fig 4. Tunnel preparation in the patella of a right knee. To reattach the patellar tendon to the distal pole of the patella, 3 tunnels are performed. A 2.5-mm drill is used to perform the first tunnel, which should be parallel to the longitudinal axis of the patella at the midline. The tunnel should be located directly centered at the transverse distance of the patella and at the anterior cortical margin to avoid damage to the cartilage and potential fracture. The first tunnel will be used as reference for placement of the medial and lateral tunnels, which should be parallel to this first tunnel.

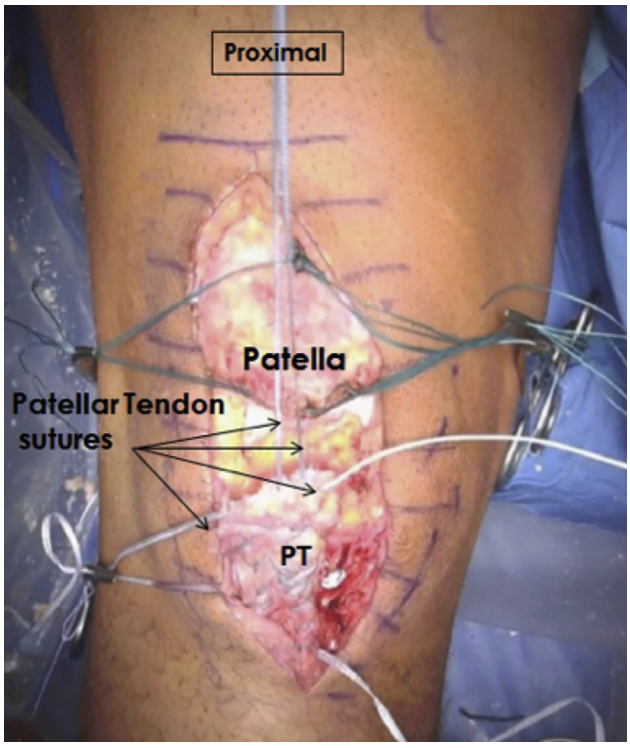

Fig 5. After the distal pole of the right patella is cleared of all scar tissue and a bleeding surface is achieved, 3 high-strength FiberTape sutures (Arthrex, Naples, FL) are used to whipstitch the tendon, first medially and laterally while leaving the ends out distally for fixation and augmentation, and then, the last suture is placed in the midline of the tendon. (PT, patellar tendon.)

raises.[14,15] Given the high degree of swelling and apprehension, acute ruptures of this tendon are initially misdiagnosed in a considerable percentage of cases, reported as high as 38%.[14] Therefore, to minimize this possibility, imaging should be undertaken.

For confirmation of a patellar tendon rupture, anteroposterior and lateral radiographs of the knee in a supine position should be taken. In particular, lateral radiographs should be performed through the use of a horizontal beam while the knee is in flexion, if tolerated. To quantify the extent of the injury, the Insall-Salvati ratio should be employed, in which the length of the patellar tendon is divided by the length of the patella. A ratio of 1 is considered "normal," whereas a ratio of <0.8 is categorized as patella baja and >1.2 as patella alta.[16,17] Fazal et al.[18] showed that all patients with a patellar tendon rupture exhibited an Insall-Salvati ratio greater than 1.2, whereas all patients in the control group were between 0.8 and 1.2.

Surgical Technique

Preoperative Setup

When performing this technique, detailed planning, preparation of the operative suite, and surgical setup are crucial. We recommend having a C-arm in the operative suite to evaluate patella position and avoid patella baja. After the induction of general anesthesia, the patient is placed in the supine position on the operating table (Video 1). A thorough physical examination is performed involving both knees to confirm the diagnosis on the symptomatic side as well as to verify the patellar height on the normal side. A high thigh tourniquet is subsequently placed around the proximal aspect of the operative leg to establish a bloodless field.

Surgical Approach

A midline incision centered on the patella is performed 4 cm above the patella, extending distally to the tibial tubercle (Fig 1). A sharp dissection is then performed into the subcutaneous tissue and sharply through the retinaculum. After this, the prepatellar bursa is excised for access to the tendon and bone. The medial and lateral sides of the tendon must be visualized to ensure the optimal position of the suture tape. In chronic cases, there is usually scar tissue in the injury zone between the patellar tendon and the distal pole of the patella. In acute cases, there is usually a significant amount of hematoma, as well as scar tissue and

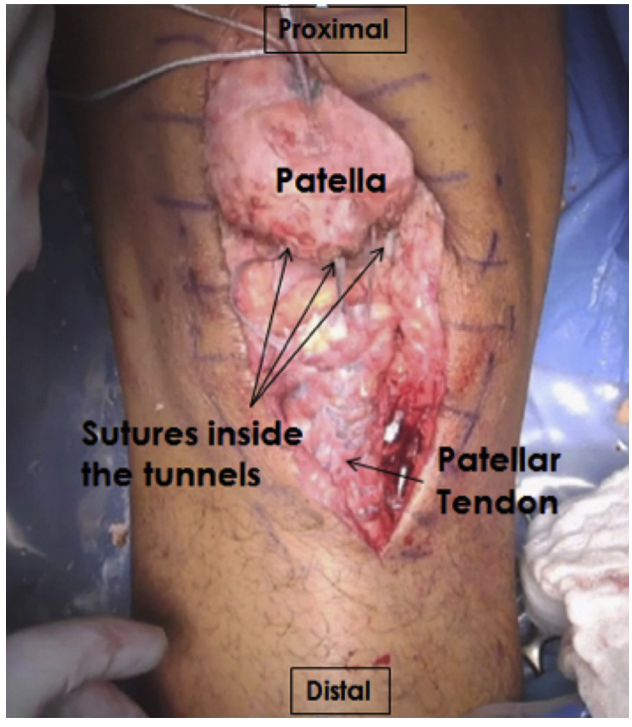

Fig 6. Once the tunnels are complete and the right patellar tendon is whipstitched, the sutures located at the proximal end of the tendon are passed through the tunnels with suture passers. Ultimately, the middle tunnel should contain 2 suture ends. Of note, it is important to ensure that all the bone spikes are removed from the tunnel entrance to avoid damage to the sutures during knee range of motion.

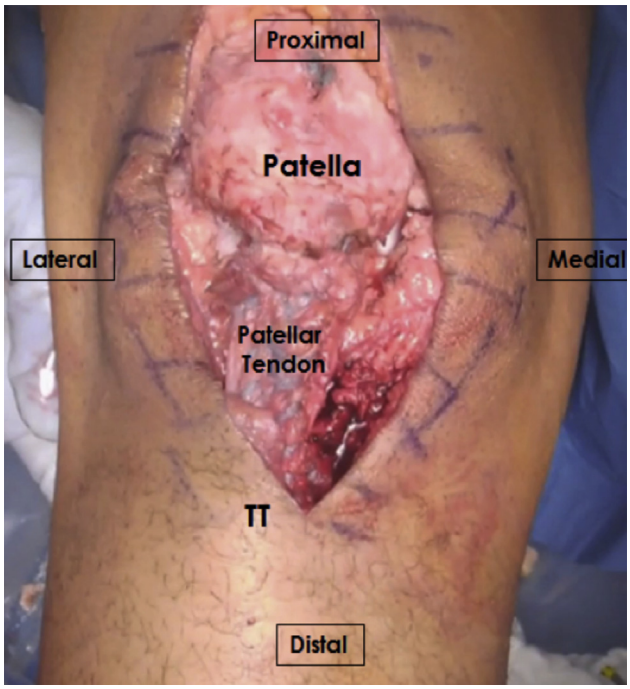

Fig 7. Final view of a right patellar tendon repair through the internal brace technique with unicortical buttons and suture tape. After the suture ends are tied to one another at the proximal pole of the patella, the knee should be guided through a range of motion examination to evaluate the repair integrity and rule out any possible overtensioning. Moreover, the patellar height must be evaluated at this point to confirm optimal positioning of the patella. (TT, tibial tubercle.)

retinacular rupture, both medially and laterally. This is evacuated with suction and bulb irrigation.

Preparation of Patella Bone Bed and Tendon

With traction on the patellar tendon, all adhesions and scarring are removed to allow for full mobilization. The proximal ruptured end of the patellar tendon is cleared of all scar tissue with a sharp 15-blade. It is important to expose normal tendon tissue to facilitate healing. However, this should be performed with caution given that excessive removal may lead to patella baja. The distal patella pole is cleared of all soft tissue as well as scar tissue with a rongeur for full exposure of the bony surface. This bony surface is then prepared with a combination of a curette, rasp, and burr (Fig 2). It should be noted that the repair site on the patella is at the anterior cortical margin; therefore bony preparation and drill tunnels should be performed at this site (Fig 3).

Once the bony surface has been prepared, the bone tunnels are drilled in the patella in a distal-proximal direction. A drill guide for a 2.5-mm drill is used to protect the soft tissue and 3 tunnels—central, medial, and lateral—are drilled parallel to the longitudinal axis of the patella (Fig 4). The drill tunnels should begin just posterior to the distal patella cortex and exit just deep to the quadriceps tendon superiorly. A suture passer is placed in the tunnels to facilitate suture passage later on in the technique. Once these tunnels are finalized, the suture passers are left in place. To minimize the risk of fractures and convergence of the tunnels, it is important to maintain a sufficient bony bridge between the tunnels. A small longitudinal slit in the quadriceps tendon is then performed to make it easier to retrieve the sutures, and then this will be the window in which the sutures are tied at the superior pole of the patella.

Suture Passage and Securement

Using 3 high-strength FiberTape sutures (Arthrex, Naples, FL), the tendon is whipstitched. Starting with a FiberTape suture medially and one laterally, the tendon is whipstitched on each end, leaving out the distal ends of the FiberTape for fixation and augmentation via the internal brace technique (Fig 5). After this, one high-strength FiberTape suture (Arthrex) is used to whipstitch the central portion of the patellar tendon.

Distal Fixation at the Tibia

A 3.7-mm spade tip drill (Arthrex) is used to make 2 drill tunnels for 2 pectoralis major button insertions (Arthrex) at the most proximal insertion of the tibial tubercle on the medial and lateral edges right at the exit of the FiberTape whipstitch. FiberTape suture (Arthrex) ends from the medial and lateral sides are passed through 2 pectoralis major buttons (Arthrex). A small right angle is used to clear space under the cortex to allow for button flipping. The pectoralis major buttons are inserted and flipped on each side of the tibial tubercle with one limb of the FiberTape suture from the respective side inserted. A tension-slide technique is then used to tension the FiberTape through the button, and then tie the suture limbs. The use of these pectoralis major buttons (Arthrex) allows for durable distal fixation of the patellar tendon at the tibia. Once a secure fixation has been reached, the knots are buried in the soft tissue with a free needle after the knots are fully secured.

With the ends of all FiberTape sutures located at the proximal end of the tendon, the 2 limbs of the central suture are then passed through the central tunnel (Fig 6), whereas one limb is brought medially and the other laterally through the tunnels. Therefore, there are 4 suture ends from the patellar tendon passed through 3 tunnels in the patella. The sutures are passed through the tunnels with suture passers. Each suture can then be tied to another suture from another tunnel through 6-squared surgical knots, thereby forming a tight repair construct (Fig 7). The patella is maintained in an anatomic position, whereas the knots are tied through the quadriceps slit, and a knot pusher may be used to facilitate secure knot tying.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Perform a complete preoperative examination with the patient under anesthesia to evaluate the extent of patellar instability	Failure to identify any possible concomitant injuries
Meticulous bony preparation with the aid of shavers and curettes is advocated to enhance healing potential of the repair	Failure of substantial debridement at the distal patella may impair healing potential
Remove any scar tissue at the proximal end of the tendon to enhance healing potential	Improper removal of scar tissue at the proximal end of the tendon may impair healing
Enough spacing between the bone tunnels must be performed to reduce risk of fracture and/or convergence	Insufficient spacing between tunnels may result in fracture and/or convergence
A suture passer should be used to facilitate suture passage through the tunnels	Oversecurement of the patella as well as excessive debridement of the patellar tendon may lead to patella baja
Use locking sutures that can hold in the patella tendon tissue. Identification of both sides of the patellar tendon leads to optimal positioning	Failure to identify both sides of the tendon along with any tendon degeneration may result in procedure failure
Once the repair is complete, verify knee range of motion to guide postoperative rehabilitation	Bone spikes at the tunnel entrance may compromise the suture during flexion exercises and lead to procedure failure
Consider taking a radiograph to ensure that the patella is not fixed in patella baja with the other limb as a reference for patellar position	

Repair Verification and Closure

If the repair exhibits overtensioning or any difficulty involving tendon approximation up to the patella, the knee may be extended for tension relief off of the repair. To ensure the proper location of the patella after repair, the knee should be guided through a range of motion examination to evaluate the repair integrity and rule out any possible overtensioning. The surgeon must be aware that additional surgery may be required if the patella is not in the desirable position with the knee in slight flexion. Lastly, verification is needed to assure that the patella is not fixed in a patella baja position. For this step, fluoroscopy may be used with the contralateral limb and Blumensaat's line serving as reference points. Knee range of motion should be assessed to determine the safe range of motion during physical therapy as well as to ensure that the knee is not stiff. There should be no pull-off of the tendon through a near full range of motion.

Finally, the tourniquet is released and hemostasis is re-established. Thorough irrigation is performed and the patella is sutured to the capsule. After this, subcutaneous sutures are placed and the skin is closed. The pearls and pitfalls as well as the advantages and disadvantages of this technique are reviewed in Tables 1 and 2, respectively.

Postoperative Rehabilitation

After surgery, the patient uses a knee immobilizer and maintains non–weight-bearing status for 6 weeks. Formal rehabilitation begins immediately postoperatively and focuses on restoration of patellofemoral range of motion, quadriceps activation, edema control, and pain management. Passive range of motion is initiated on the first day postoperatively and is gradually progressed to full range of motion as tolerated, with the goal of attaining at least 90° of knee flexion by 2 weeks postoperatively. During the first 6 weeks, the patient's primary exercises are patella and patellar tendon mobilizations, active and passive knee range of motion, and quadriceps activation exercises. At 6 weeks, patients are permitted to gradually wean off crutches and begin spinning on a stationary bike with no resistance. The patient is cleared to be off crutches once he or she can fully ambulate without a limp and show adequate muscular control of his or her quadriceps.

Once they are full weight bearing, patients begin closed chain strengthening exercises with training periodization focused on developing muscular endurance first, followed by strength and power. Strengthening exercises with weight-bearing status begin at 8 weeks postoperatively, with limited leg press to 70° of knee flexion allowed at 10 weeks. Patients may begin running exercises at 6 months with initiation of speed and agility drills at this time. A gradual return to play progression is initiated at 7 months postoperatively

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Evaluation of the patellar cartilaginous surface and patellar tendon integrity	This technique is not recommended for unviable tendons
The patellar height can be measured and changed before the final fixation	Tunnels in the patella increase the risk of patellar fracture and may compromise bone integrity
The internal brace concept provides complementary strength to the fixation of the patellar tendon	Cannot be used for distal ruptures of the patellar tendon (however, these are not common)
Allows for maintenance of reduction while the tendon heals and spreads out tension	Locking sutures can worsen the patellar tendon integrity
	Greater cost associated with pectoralis button reconstruction than the standard technique

after completion of a functional sports examination. Return to sports or activity is allowed when normal strength, stability, and knee range of motion comparable with the contralateral side have been achieved (usually 6-9 months postoperatively).

Discussion

Patellar tendon ruptures are rare injuries with an incidence rate of 6.8 of 1,000,000 per year, with 78% of all injuries occurring in male patients at a mean age of 49 years.[19] Such ruptures require immediate repair to re-establish knee extensor continuity and allow early motion due to evidence showing a prolonged time interval between trauma and surgery to be a major factor for positive treatment outcome.[14,15,20-22] Although they exhibit a peak incidence in the seventh to eighth decades of life with a sharp decline thereafter,[19] patellar ruptures occur in younger patients typically as a result of low velocity, indirect, minor traumatic episode with the knee in flexion with a concomitant extensor contraction.[9] This pathology is particularly disabling in the young and active population, resulting in an inability to actively maintain extension. This results in a significant alteration in knee range of motion.[2] In the older population, multiple factors contribute to degenerative changes that ultimately result in rupture.[4-9,23,24]

High mechanical loads and poor tissue blood supply at the patellar lead to a particularly challenging repair.[10] A balance must be struck between the repair strength and increased strand number and suture caliber, both of which increase the risk of wound complications.[25] Exact causes and optimal repair techniques for each tendon rupture subtype remain largely unclear. A cadaveric biomechanical study in the context of hamstring tendon rupture repair, which tested 3 suture materials and techniques, concluded that the Fiberwire-Baseball combination was most durable, whereas the Fiberwire-Kessler combination showed the lowest elongation after cyclic loading.[26] This study exemplifies the need for further research in tendon rupture repair efficacy.[11]

An additional factor, aside from suture material and technique, is the repair attachment technique. Standard repair calls for transpatellar suture attachment via osseous tunnels. Two separate biomechanical studies evaluated the standard transosseous sutures compared with suture anchors, which have been successfully applied since their introduction by Goble[27] in 1985.[12,28] Both studies concluded that suture anchors were superior to transosseous sutures in terms of gap formation resistance and mean load to failure.[12,28] Additional reported suture anchor advantages include reduced operation time, easily accessible implantation site, and earlier functional rehabilitation.[29-31]

In this Technical Note, we have described our preferred method for patellar tendon repair via an internal brace construct with unicortical buttons and suture tape. On the basis of previous findings,[32] we hypothesize that the pectoralis button fixation in comparison with other techniques allows for a substantial improvement in the strength of the repair construct for the patellar tendon, which has significant forces across it. Furthermore, it helps spread out the tension, thereby also distributing tension on the posterior aspect of the anterior tibial cortex. Lastly, this fixation method also allows for avoidance of possible protrusion of knots, which may be encountered in suture anchor repair techniques. Randomized controlled clinical trials comparing the internal brace construct with unicortical button and suture tape with other techniques widely used for patellar tendon repair are needed to fully assess the efficacy of our described technique.

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