Technical Note

Small (3.2-mm), Short, Oblique Patellar Tunnels for Patellar Fixation in MPFL Reconstruction

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Abstract: Multiple techniques exist for patellar graft fixation during medial patellofemoral ligament (MPFL) reconstruction, each with their respective advantages and disadvantages. In recent studies, the use of 2 small (3.2-mm), short, oblique patellar tunnels with looped graft has been shown to be effective for patellar fixation during MPFL reconstruction. This technique does not appear to be associated with the same risk of patellar fracture as the use of larger (4.5-mm) transpatellar tunnels. A recent retrospective study also reported decreased risk of recurrent patellar instability and decreased cost compared with the use of suture anchors for patellar fixation, which is currently the most common modality. Given these promising findings relative to existing techniques for patellar fixation, further description of the senior author's technique for using these small (3.2-mm), short, oblique patellar tunnels is provided. This technique is safe, efficacious, and cost-conscious and should be considered a viable option for patellar fixation during MPFL reconstruction.

Reconstruction of the medial patellofemoral ligament (MPFL), the main static stabilizer of the knee during early flexion, is the primary surgical intervention for recurrent patellar instability.[1] Current reconstruction techniques, which differ in their modality of patellar graft fixation, include the use of suture anchors, interference screws, and transpatellar bone tunnels.[2] To date, no single technique has been shown to have superior clinical outcomes. Suture anchor fixation and transpatellar bone tunnel techniques have both yielded good to excellent clinical outcomes with low rates of recurrent dislocation; however, each technique has its own advantages and disadvantages.[3,4]

The use of 4.5-mm transverse patellar tunnels with looped graft for patellar fixation has been identified in the literature as increasing the risk of patellar fracture compared with the use of suture anchors, possibly owing to the introduction of stress risers in the patella.[5,6] The lower risk of patellar fracture has led to the increased use of suture anchor fixation for this purpose relative to transpatellar bone tunnels, despite the increased material cost associated with this technique.[7] A recent retrospective study comparing the use of small (3.2-mm), short, oblique patellar tunnels and suture anchors for patellar fixation found that using the smaller tunnels is not associated with an increased risk for patellar fracture, and actually led to a decreased rate of recurrent patellar instability events.[8] In this Technical Note, we describe the senior author's method of using small (3.2-mm), short, oblique patellar tunnels for patellar fixation in MPFL reconstruction (Video 1).

Surgical Technique

Preoperative Assessment

A full summary on the evaluation of patellar instability is outside the scope of this Technical Note, but history taking should detail the instability events themselves and help the surgeon to identify the frequency and chronicity of such events.[9] Detailed history, physical exam, and radiographic evaluation are vital to identify the presence of primary anatomic risk factors of patellar instability, including trochlear dysplasia, coronal malalignment manifested as genu valgum or elevated tibial tubercle-trochlear groove (TT-TG) distance, femoral anteversion, and patella alta.[1] We acquire a standard 3-view

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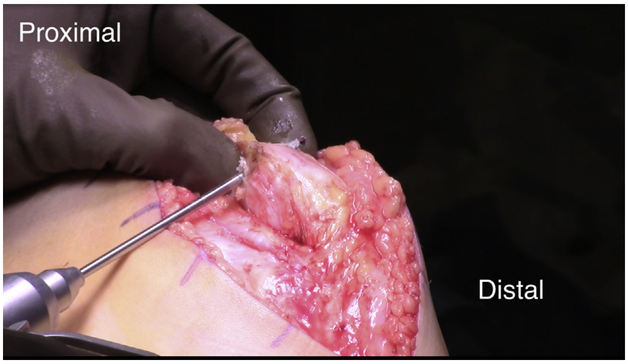

Fig 1. Left knee: A 3.2-mm drill bit is used to create the first of 2 short, oblique patellar tunnels. The tunnel is created in the upper third of the medial border of the patella, just anterior to the articular surface. The drill is advanced until it emerges through the anterior cortex of patellar bone approximately one-third of the diameter across the patella. A Beath pin is placed in this first tunnel before creating the second patellar tunnel to serve as a guide for the desired drill trajectory.

radiographic series, including a standing flexion posteroanterior, lateral, and 45° flexed axial Merchant view of the knee as part of our initial imaging workup. We routinely acquire additional advanced imaging, usually consisting of magnetic resonance imaging for further evaluation of the patient's anatomy. In our practice, computed tomography (CT) scan is typically reserved for cases with more atypical bony anatomy, such as severe dysplasia or femoral anteversion. Identifying and addressing additional anatomic features that predispose patients to instability events with a combination of surgical interventions helps to ensure the best outcome.[1]

Surgical Setup and Preoperative Examination

The patient is positioned supine on the operating room table, and examination is performed under anesthesia, which allows for a more objective assessment of patellar maltracking and instability that may otherwise be confounded by the patient's symptoms or guarding. Because of the routine performance of a diagnostic or therapeutic knee arthroscopy before MPFL reconstruction, a lateral arthroscopic stress post (Allen Medical Systems, Acton, MA) is placed proximal to the knee at the level of the tourniquet if one is used.

Surgical Approach

Before the knee is approached in an open manner for MPFL reconstruction, a standard diagnostic knee arthroscopy is performed.[10] Knee arthroscopy allows the surgeon to directly visualize patellar maltracking and instability, as well as to address any intra-articular pathology or loose bodies. For the MPFL reconstruction, the knee may be approached using 1 long anteromedial incision or through 3 smaller incisions to allow for graft harvest, creation of the patellar tunnels, and femoral graft fixation. If a medial parapatellar approach is performed, the incision is started proximally from the superior aspect of the patella, continued through the medial arthroscopic portal, and ended distally at the insertion of the pes anserinus. If the preoperative plan identifies the need for a concomitant tibial tubercle osteotomy, the incision may be extended further distally to accommodate this procedure. Skin flaps are then raised to allow for appropriate visualization of the surgical area.

Attention is next turned to ipsilateral hamstring autograft harvest. Dissection is carried down to the sartorial fascia, and the pes anserinus is located by direct palpation of the tendon's insertions. An incision is made in the sartorial fascia just proximal to the tendons, carried anteriorly to the medial edge of the tibial tubercle, and turned distally, and the pes insertion is reflected off the tibia so that the tendons can be viewed from the undersurface. Although a semitendinosus autograft or hamstring allograft may be used based on surgeon preference, we favor the use of a gracilis graft because of the 3.2-mm size of the oblique tunnels used for patellar fixation. The larger size of the semitendinosus graft typically requires larger bone tunnels in the patella, which potentially increase the risk of patellar fracture. The free, distal end of the gracilis tendon is whip-stitched with #1 absorbable Vicryl suture (Johnson & Johnson, New Brunswick, NJ). While applying longitudinal traction to the distal gracilis tendon stump with the suture end, a closed tendon harvester is slid proximally around the tendon to release the tendon from its proximal origin. The tendon is taken to the back table, where it is placed under tension for measurement and further preparation. We have found that an average-sized male needs 25 cm of graft length and an average-sized female needs 23 cm to account for the tendon being looped through the two oblique patellar tunnels. Muscle and excess tissue are then sharply removed from the graft, and the proximal end of the graft is also whip-stitched in a "crossing" manner with #1 Vicryl suture. Any redundant tissue at

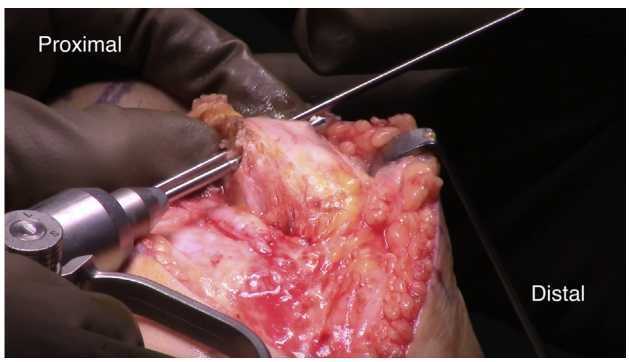

Fig 2. Left knee: A 3.2-mm drill bit is used create the second of 2 short, oblique patellar tunnels. The second tunnel is created 1 cm distal to the first patellar tunnel.

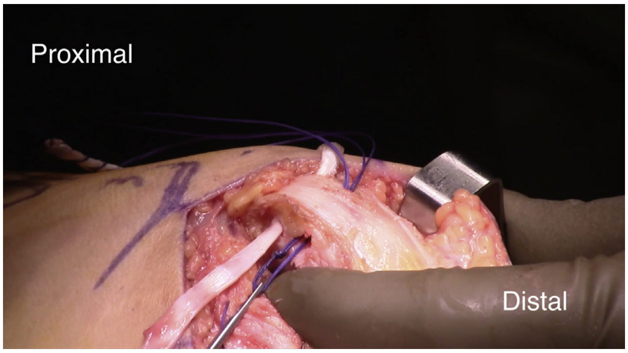

Fig 3. Left knee: The whip-stitched end of the prepared graft is placed in a Beath pin to facilitate graft passage through the tunnels. Here, the Beath pin is being used to pull the leading edge of the graft through the distal patellar tunnel in a lateral to medial direction.

the ends of the graft are trimmed to facilitate passage through the bony tunnels.

After graft harvest is completed, the medial patellar arthrotomy is performed to allow visualization of the medial aspect of the patella along the proximal two-thirds of the medial border. This allows for direct visualization of the starting points for drill placement. Using a 3.2-mm drill bit, the first of these holes is drilled in the upper third of the medial border of the patella just anterior to the articular surface (Fig 1). The drill is started perpendicularly to the anterior surface of the patella, before the surgeon's hand is dropped toward the floor as the drill is advanced, to create as steep an angle as possible while maintaining a bony bridge. The drill bit may naturally engage with the far medial corner of the articular cartilage; however, this area is outside of the major weightbearing zone. The drill is advanced until it emerges through the anterior cortex of patellar bone approximately one-third of the diameter across the patella. To create smooth edges of the ends of the bone tunnel, the drill bit is then advanced back through the tunnel in the opposite direction. We recommend placing

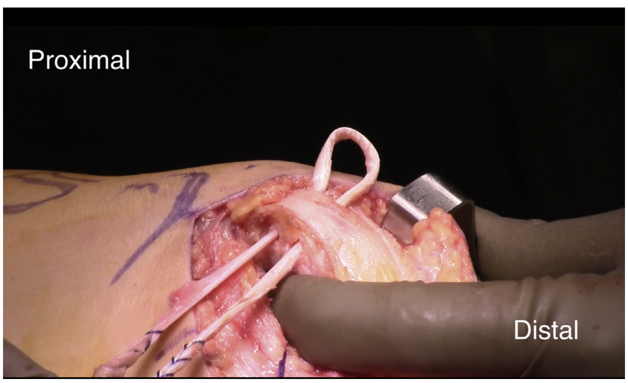

Fig 4. Left knee: The graft has been looped through both patellar tunnels, and the whip-stitched ends are brought medially before passage between layers 2 and 3 of the medial knee.

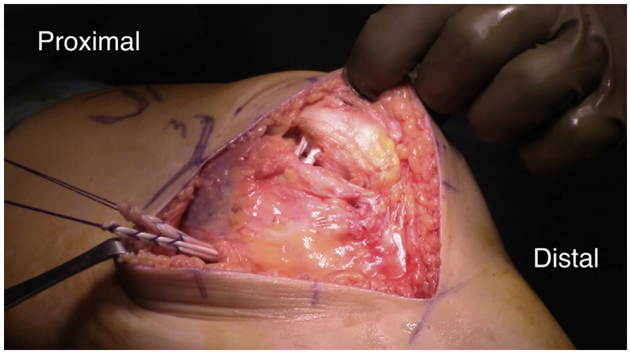

Fig 5. Left knee: Both whip-stitched ends of the graft are placed within the looped end of a suture shuttle and passed through layers 2 and 3 of the medial knee in a lateral to medial direction.

a Beath pin in this first tunnel before creating the second patellar tunnel to serve as a guide for the desired drill trajectory. The second patellar tunnel is then drilled 1 cm distal to the first patellar tunnel in a similar manner (Fig 2). The 2 tunnels thereby restore the MPFL anatomy to the proximal half of the patella. Once the tunnels have been created, a path for the graft through the medial tissues is created using tonsil forceps passed between layers 2 and 3 of the medial knee. A looped passing suture is placed to facilitate shuttling the graft.

To pass the graft through the patella tunnels, the whip-stitch from of the proximal end (smaller end of the tendon) of the prepared graft is placed in a Beath pin eyelet. The Beath pin is used to pull the leading end of the graft through the proximal patellar tunnel in a medial to lateral direction. The Beath pin is then again used to pull the leading edge of the graft through the distal patellar tunnel in a lateral to medial direction (Figs 3 and 4); thus the graft has been looped through both holes. No further patellar fixation is used. If the diameter of the graft is large relative to the 3.2-mm size of the patellar tunnels, mineral oil may be used for lubrication. Both whip-stitched ends of the graft are then placed within the looped end of a suture shuttle and passed through layers 2 and 3 of the medial knee in a lateral to medial direction (Fig 5).

Next, fluoroscopy is used to capture perfect lateral radiographs of the knee to identify the Schottle point and

Table 1. Small (3.2 mm), Short, Oblique Patellar Tunnels: Advantages and Disadvantages

Advantages
- No risk of anchor pull-out, decreasing possible mechanism of recurrent instability
- Enhanced tendon-to-bone healing by providing a larger area of graft-to-bone contact
- Less expensive than suture anchor fixation
Disadvantages
- Theoretical risk of violating articular surface
- Longer tendon graft required compared with suture anchor technique

Table 2. Suture Anchors: Advantages and Disadvantages

Advantages	
	- Allows use of a shorter graft versus tunnels with looped graft
	- Easier to perform through 3 small incisions, versus patellar tunnels with looped graft
Disadvantages	
	- Risk of suture anchor pull-out, leading to recurrent instability
	- Greater cost than tunnels with looped graft
	- Weaker biomechanically than large transpatellar tunnels with interference screws

determine anatomic placement of the graft at its femoral attachment.[11] To determine this radiographic landmark, the technique described by Schöttle et al.[11] is used, in which an imaginary line is extended distally from the posterior femoral cortex. Two intersecting, perpendicular lines are then drawn from the posterior aspect of Blumensaat's line and the transition of the curve of the posterior femoral condyles, respectively. The Schottle point can then be located 2 mm anterior to the extended posterior femoral cortical line, between the two intersecting, perpendicular lines. A 3/32" Beath pin is then placed at this point, with care being taken not to drive it too far distally or posteriorly when advancing it into the femur. The graft may then be wrapped around the Beath pin to allow for assessment of isometry throughout the entirety of knee range of motion in the manner described by Burrus et al.[12] If the graft overtightens as the knee is brought into flexion, the point identified on the femur is too proximal ("high and tight"). Similarly, the point identified is too distal if the graft loses tension while the knee is flexed ("low and loose").[12]

While the knee is taken throughout full range of motion, patellar translation and stability are also assessed. Once the correct femoral attachment is identified, the Beath pin is advanced farther across the distal femur. It is then overdrilled with a reamer to create a tunnel for graft fixation. The reamer size used is the same diameter as the interference screw, typically 7 mm. The length of the femoral tunnel needed can be determined by referencing the graft length against the depth measurements on the cannulated reamer before reaming. At this point, too much graft length will abut the far femoral cortex. This can be drilled through with the reamer if necessary, but ideally is avoided to prevent the creation of a stress riser. Before graft passage, a nitinol guidewire is placed into the femoral tunnel to facilitate eventual interference screw placement. The strands of suture at each of the tendon ends should be knotted together so that they may be easily distinguished on the other side of the knee during graft tensioning. The suture ends of the graft are then passed through the femoral tunnel using a Beath pin. With the knee held in 30° to 45° of flexion on a radiolucent triangle (Innovative Medical Products, Plainville, CT), a 7 by 23-mm Milagro Advance interference screw (Johnson & Johnson) is placed within the reamed tunnel. The graft is secured in place under ∼0.5 pounds (2 N) of force at 30° to 45° of flexion, or just enough flexion to ensure the patella is centered in the trochlea.

After fixation, the knee is again taken through full range of motion to reassess patellar tracking and stability. If the lateral retinaculum is found to be too tight, a Z-lengthening of the lateral retinaculum may be performed to restore proper graft tension and patellar tilt.[13] After thorough irrigation of the surgical area with normal saline, the medial parapatellar arthrotomy is closed with no. 1 suture. Layered closure is performed before the skin is closed using 3.0, running, absorbable suture. A sterile, soft dressing is applied over the surgical incision, and the operative lower extremity is placed in a hinged knee brace.

Postoperative Rehabilitation

Our postoperative rehabilitation protocol varies depending on any osseous procedures being performed in addition to MPFL reconstruction. However, all rehabilitation protocols emphasize using cryotherapy, proprioceptive exercises, and physical therapy, with a focus on strengthening the vastus medialis and vastus medialis obliquus muscles. Early range of motion is also allowed to decrease stiffness and the formation of scar tissue.

If patients undergo MPFL reconstruction alone, they initially wear an unlocked long, hinged knee brace to allow range of motion from 0° to 90° of knee flexion after surgery. If no concomitant tibial tubercle osteotomy is performed, weightbearing is restricted by 50% for the first 2 weeks after surgery, and then patients are able to resume full weightbearing. The brace is unlocked for full flexion from weeks 2 to 4 and then removed. If tibial tubercle osteotomy is performed, weightbearing is restricted by 50% for 6 weeks postoperatively. In these patients, range of motion is progressed in the hinged knee brace from 0° to 70° for the first 2 weeks, to 0° to 90° for weeks 3 and 4, and then full flexion until 6 weeks, when the brace is removed.

Further progression in gait training, quad strengthening and range of motion takes place with the assistance of a physical therapist, and patients are progressed toward using a stationary bike, elliptical, and leg press machine,

Table 3. Large (4.5 mm), Transpatellar Tunnels: Advantages and Disadvantages

Advantages	
	- No risk of anchor pull-out, decreasing possible mechanism of recurrent instability
	- Enhanced tendon-to-bone healing by providing a larger area of graft-to-bone contact
	- Less expensive than suture anchor fixation
Disadvantages	
	- Greater risk of patellar fracture compared with smaller (3.2 mm) tunnels and suture anchors
	- Theoretical risk of violating articular surface
	- Longer tendon graft required compared with suture anchor technique

followed by a walk-jog progression. Advanced plyometric exercises, and motions involving deceleration, cutting, and changing directions quickly are restricted until patients are without symptoms, demonstrate normal gait, and have the ability to control alignment and stability in a single limb stance during dynamic activities. Patients then undergo a sport-specific, return to play progression. All restrictions are lifted once the patient demonstrates appropriate quality of movement with required sport-specific activities. This is typically between 3 and 4 months postoperatively for isolated MPFL reconstructions and between 5 and 6 months when additional osteotomies have been performed.

Discussion

Multiple techniques have been described with good clinical outcome for patellar graft fixation during MPFL reconstruction, including the use of suture anchors, interference screws, and transpatellar bone tunnels.[2] The technique selected may reflect surgeon preference or be dependent on each technique's respective advantages and disadvantages (Tables 1-3). The primary disadvantage associated with the use of larger (4.5-mm), transverse patellar tunnels is the relatively rare, but included serious complications of postoperative patellar fracture.[5,6] Schipouwer et al.[5] found a patellar fracture incidence of 3.6% and a 14.1% major complication rate using two 4.5-mm patellar tunnels in a case series that included 192 knees in 171 patients. Another large case series by Parikh et al.,[6] which included 179 knees, found a fracture incidence of 3.35%. This increased risk for patellar fracture has led to suture anchors becoming the most common modality of patellar fixation.[7] Using suture anchors also allows for MPFL reconstruction to occur with a shorter graft versus using a looped graft through bone tunnels.[7] Suture anchors, however, come with additional material cost and are associated with lower mean failure loads and stiffness compared with transpatellar bone tunnels and interference screw fixation in some studies.[7]

A recent retrospective cohort study by Deasey et al. including 384 knees in 354 patients undergoing MPFL reconstruction presented outcomes with the use of smaller (3.2-mm), short, oblique patellar tunnels for graft fixation.[8] Importantly, they found that the use of smaller tunnels was not associated with an increased incidence of patellar fracture compared with the use of suture anchors. Additionally, they reported only one instance of patellar fracture out of a cohort of 215 knees (incidence 0.46%), which is lower than the historical rates presented in similarly sized studies by Schipouwer et al.[5] and Parikh et al.[6,8] Deasey et al.[8] also showed that the use of these small (3.2-mm), short, oblique tunnels led to a statistically significant decrease in the risk of recurrent patellar instability events compared with suture anchors. The authors hypothesized that the increased risk of recurrent instability may be due to anchor pull-out, which is a risk not found with the use of osseous tunnels and a looped graft. Other advantages of small, oblique patellar tunnels with looped graft possibly include enhanced graft-to-bone healing by providing a larger area of graft to bone contact and increased cost effectiveness relative to the suture anchor fixation technique.[8]

In conclusion, the use of small (3.2-mm), short, oblique patellar tunnels with looped graft is safe, efficacious, and cost-conscious and should be considered a viable option for patellar fixation during MPFL reconstruction.

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