Technical Note

Preoperative Positioning and Socket-Anchor Technique for Arthroscopic Medial Patellofemoral Ligament Reconstruction Using Allograft Tendon

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Abstract: Accurate positioning of the femoral insertion of the medial patellofemoral ligament (MPFL) is the main difficulty in MPFL reconstruction. This article describes an all-arthroscopic MPFL reconstruction procedure. Preoperative 3-dimensional computed tomography assists in MPFL patellar and femoral insertion positioning, with arthroscopic reconfirmation of femoral insertion positioning through a subcutaneous tunnel during surgery. In the socket-anchor technique for patellar insertion fixation, a 10-mm-deep bone tunnel (socket) is created along a previously located guide pin at the MPFL patellar insertion; then, an absorbable suture anchor is inserted into the end of the socket to fix the tendon graft. This technique provides the advantages of being minimally invasive, yielding accurate positioning, ensuring a sufficient tendon-bone interface healing area of the graft, and having no need for intraoperative fluoroscopy.

Lateral patellar dislocation (LPD) is the most common knee pathology in young girls, the incidence rates of which range from 2.3 to 42 per 100,000 depending on the population studied.[1] The medial patellofemoral ligament (MPFL) is the primary stabilizer of the patella between full knee extension and 30° of flexion, providing 50% to 60% resistance to prevent it from moving outward.[2] In surgically proven cases, MPFL injury occurs in 94% to 100% of LPDs, and it has been identified in 84% to 100% of cases in previous magnetic resonance imaging studies.[3]

MPFL reconstruction was first described in 1992, using a synthetic graft attached from the medial femoral condyle passed through transverse bone tunnels to the patella.[4] To date, a multitude of techniques for MPFL reconstruction have been described in the literature, and MPFL reconstruction has become one of the main surgical methods for treating LPD.[5,6] The main reason for complications or failure after MPFL reconstruction is inaccurate femoral tunnel positioning.[7] The commonly used MPFL femoral insertion positioning methods mainly consist of the Schöttle method,[8] Stephen method,[9] and adductor tubercle (AT)—assisted positioning method.[10] Increasing evidence has shown that the relation between the AT and the MPFL femoral insertion is relatively stable, and thus, it has become a bony landmark for femoral insertion positioning.[11] Most of the current MPFL reconstruction techniques involve open surgery and require fluoroscopy. We describe all-inside arthroscopic MPFL reconstruction using preoperative positioning and a socket-anchor technique for patellar insertion fixation, which offers safe, rigid fixation; is easy to perform; and is expected to achieve satisfactory outcomes.

Surgical Technique

Preoperative Positioning

Two steel balls are fixed with tape on the skin of the patient's knee joint, one near the AT and one on the medial edge of the patella, and 3-dimensional computed tomography examination is performed. By use of imaging on a picture archiving and communication system, the positional relations between the 2

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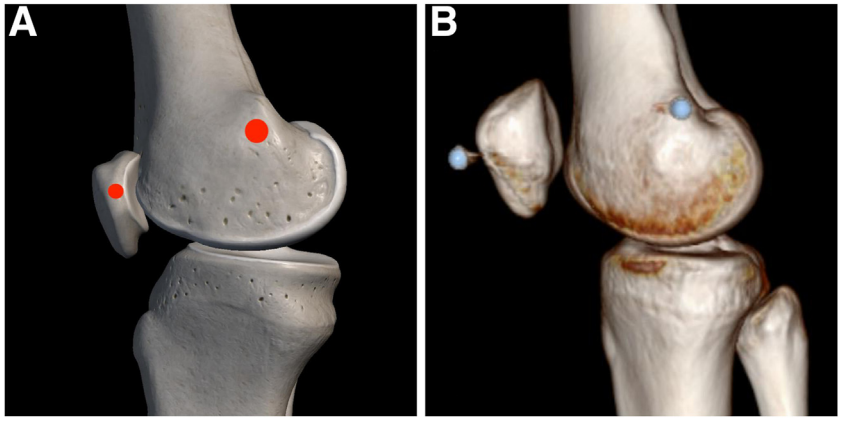

Fig 1. Preoperative positioning of medial patellofemoral ligament (MPFL) insertions (sagittal view of left knee joint). (A) MPFL patellar and femoral insertion points (red dots). (B) Preoperative steel balls on body surface to locate patellar and femoral insertion points for MPFL on 3-dimensional computed tomography.

steel balls, as well as their connecting line, and the femoral insertion point (midpoint between the medial femoral condyle and the AT) and patellar insertion point (upper third of the medial edge of the patella) of the MPFL are measured. Then, the predetermined MPFL point is marked on the patient's skin based on the measurement data (Fig 1, Video 1).

Patient Positioning and Marking of Surgical Portals

After satisfactory subarachnoid space block anesthesia, the patient is placed in the supine position with a tourniquet placed on the proximal thigh. Body surface markers are drawn, and 4 arthroscopic portals are marked: anteromedial (AM) portal, anterolateral (AL) portal, preoperative positioning patellar incision (PI) portal, and preoperative positioning femoral (F) portal (Fig 2).

Graft Preparation

An anterior tibialis tendon allograft is prepared on the back table. Both ends of the graft (about 3 cm) are sutured in a running configuration. The folded form of the tendon (about 5.0 or 6.0 mm in diameter, 17-20 cm in length) is tested and then stored by wrapping it with a wet tampon impregnated with vancomycin (Fig 3).

Patellar Insertion Creation by Socket-Anchor Technique

A 1-cm incision is made in the upper third of the medial edge of the patella (PI portal). Soft-tissue dissection is then taken down to bone, which is exposed subperiosteally. A 2.3-mm Kirschner wire, as a guide pin, is drilled into the patella by approximately 25 mm, parallel to the patellar surface. A 10-mm-deep bone tunnel (socket) is prepared by use of a 5.0-mm cannulated drill system, and a 3.0-mm bioabsorbable suture anchor (Gryphon; Johnson & Johnson) is inserted into the end of the socket after a blind tunnel is drilled. The end of the suture is pulled to confirm that the anchor is well fixed (Fig 4).

Femoral Tunnel Creation

With the knee flexed, a 2.3-mm guide pin is advanced in a proximal and anterior direction through the femur to the contralateral cortex at the preoperative positioning F portal, and a 5-mm skin incision is made. A large clamp is used to create a subcutaneous tunnel from the AM portal and PI portal to the F portal (Fig 5A). The suture tape on the anchor is tightened to the guide pin, and flexion and extension of the knee joint are applied to test the isometric properties of the MPFL femoral insertion point (Fig 5B). While viewing from the PI portal, the surgeon uses a shaver to perform debridement of subcutaneous soft tissue (Fig 5C). A radiofrequency device is used for coagulation of soft tissues, and the adductor magnus tendon is identified as the MPFL femoral insertion, which is located at its extension line (Fig 6A). Then, the arthroscope is placed in the F portal for confirmation of the AT (as femoral insertion) and surrounding structures and readjustment of the guide pin location if needed (Fig 6B). The guide pin is overdrilled using a 5.0-mm cannulated reamer to create a bone tunnel penetrating the femur (Fig 6C). In skeletally immature patients, the distal femoral drill tunnel should be angled 15° to 20° distally and anteriorly to minimize the risk of damage to the physis and the joint.[11] A 1.6-mm passing pin with a looped thread (traction suture) is inserted into the femoral tunnel and penetrates the femur and skin on the opposite side (Fig 5D). The looped thread is fixed on the surgical drape with a clamp for later use.

Patellar Insertion Fixation

One end of the 2 strands of suture in the anchor is sutured to the midpoint of the graft to tie it tightly (Fig 7A). With the other end of the suture acting as a guidewire, the graft is pulled into the socket and then knotted to the bone surface (Fig 7B). The traction suture is pulled out by a clamp from the PI portal via the subcutaneous channel, and the other ends of the graft are led into the femoral tunnel by pulling the traction suture (Fig 7 C and D).

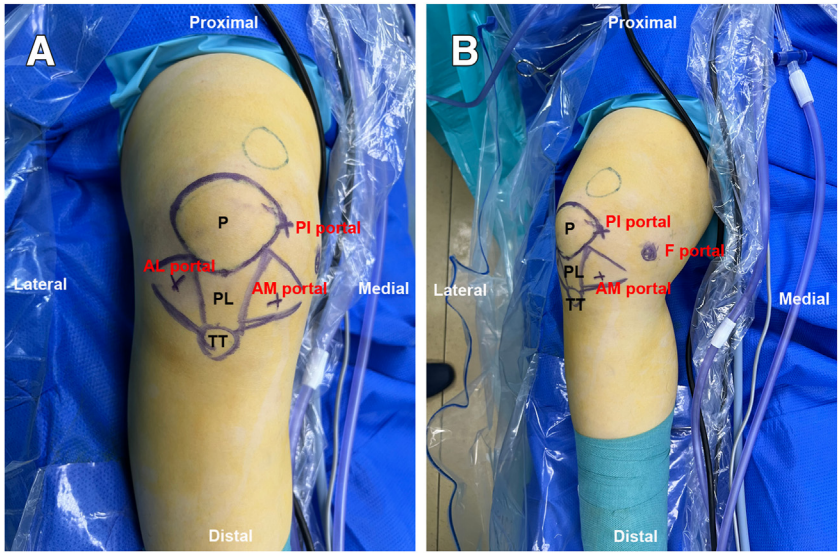

Fig 2. Portals and body surface markers drawn on right knee. (A) Front view of knee. (B) Medial view of knee. (AL, anterolateral; AM, anteromedial; F, femoral; P, patella; PI, patellar incision; PL, patellar ligament; TT, tibial tubercle.)

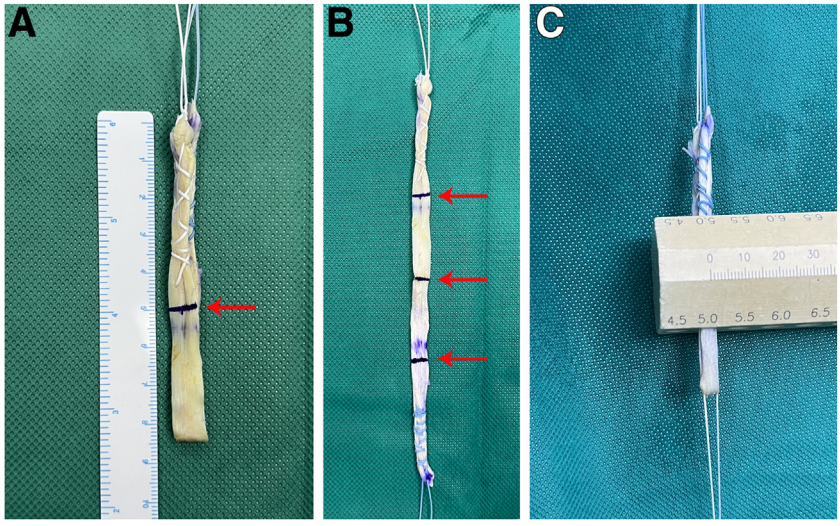

Fig 3. Graft preparation using anterior tibialis tendon allograft. (A, B) The allograft is harvested with a length of 17 to 20 cm (8.5 cm when folded in this case), and both ends of the tendon are whipstitched with No. 1-0 Vicryl suture (Ethicon). The graft is marked with lines 50 mm from both ends and in the middle (arrows). (C) The recommended graft diameter is 5.0 or 6.0 mm when folded into 2 strands (5.0 mm in this case).

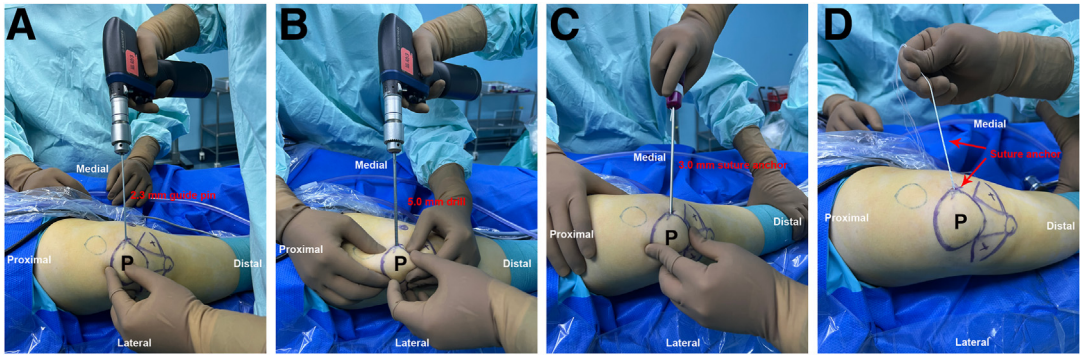

Fig 4. Patellar tunnel creation and suture anchor insertion (right knee). (A) A guide pin is inserted into the upper third of the medial edge of the patella (P). (B) A 10-mm-deep bone tunnel (socket) is prepared by a 5.0-mm cannulated drill system. (C, D) A suture anchor is inserted into the end of the socket.

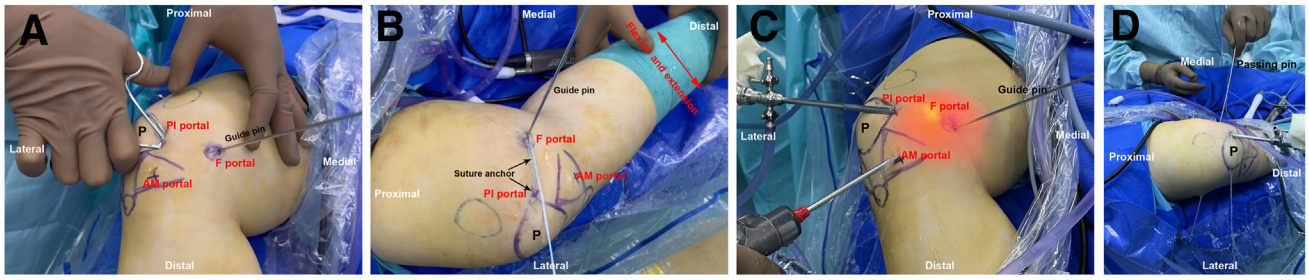

Fig 5. Creation of subcutaneous channels and isometric testing (right knee). (A) Creation of subcutaneous channels from patellar incision (PI) portal and anteromedial (AM) portal to femoral (F) portal. (B) Flexion and extension of knee joint to test isometric properties of femoral insertion point of medial patellofemoral ligament. (C) Use of shaver for debridement of subcutaneous soft tissue. (D) Insertion of passing pin with looped thread (traction suture) into femoral tunnel, penetrating femur and skin on opposite side. (P, patella.)

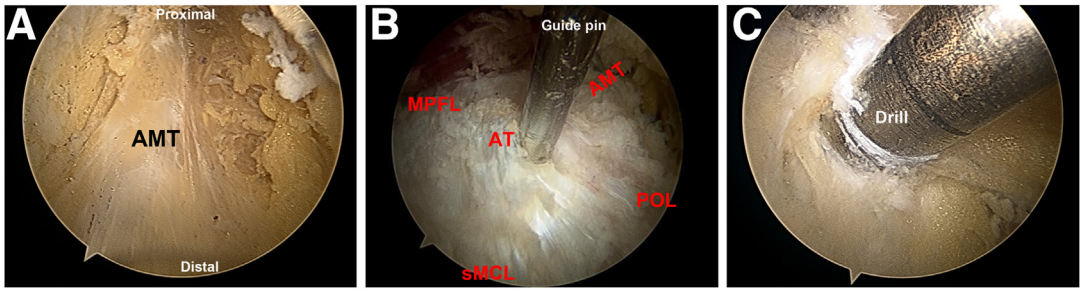

Fig 6. Femoral tunnel creation (viewed from anteromedial [AM] portal). (A) Identification of adductor magnus tendon after debridement. (B) Confirmation of medial patellofemoral ligament (MPFL) femoral insertion. (C) Creation of bone tunnel penetrating femur using 5.0-mm cannulated reamer. (AMT, adductor magnus tendon; AT, adductor tubercle; POL, posterior oblique ligament; sMCL, superficial medial collateral ligament.)

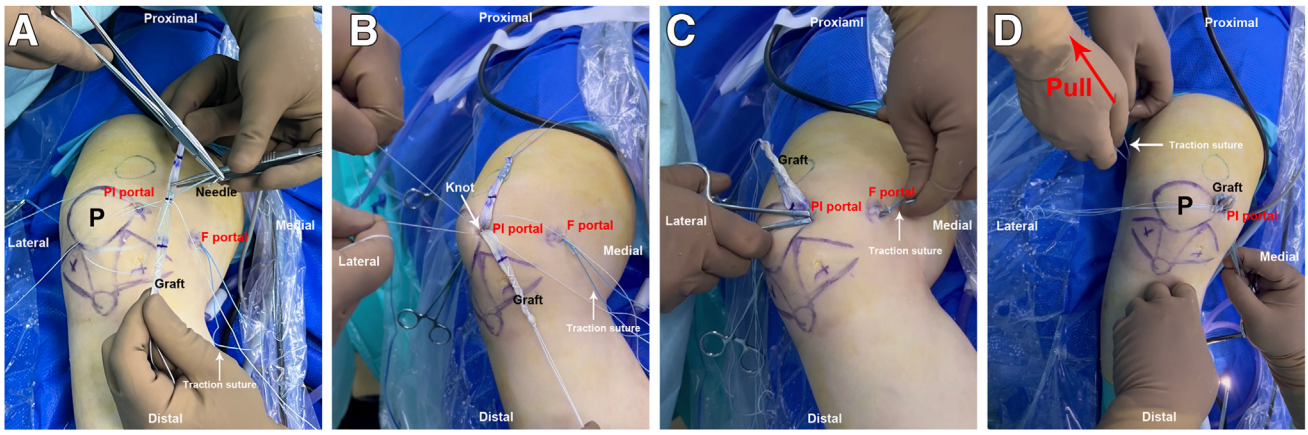

Fig 7. Graft patellar insertion fixation and introduction into joint (right knee). (A) The graft is stitched to the suture of the anchor. (B) The graft is pulled into the patellar socket and tied to the anchor. (C) The traction suture is pulled out by a clamp from the patellar incision (PI) portal via a subcutaneous channel. (D) The other ends of the graft are led into the femoral tunnel by pulling the traction suture. (F, femoral; P, patella.)

Femoral Insertion Fixation

The standard AL and AM portals are created, and the patellofemoral joint is evaluated by placing the arthroscope in the AL portal; it is confirmed that the patella is not in the trochlear groove and is displaced laterally (Fig 8A). The knee is placed in 30° of flexion, and manual tension is applied to the graft to restore the alignment relation between the patella and the trochlear groove while the MPFL tension is adjusted by pulling the traction suture (Figs 8 B and 9 A). With the guidance of a 1.5-mm guide pin inserted into the femoral tunnel, a 5.0-mm bioabsorbable interference screw (Smith & Nephew) is inserted to secure the graft (Figs 8 C and D and 9 B).

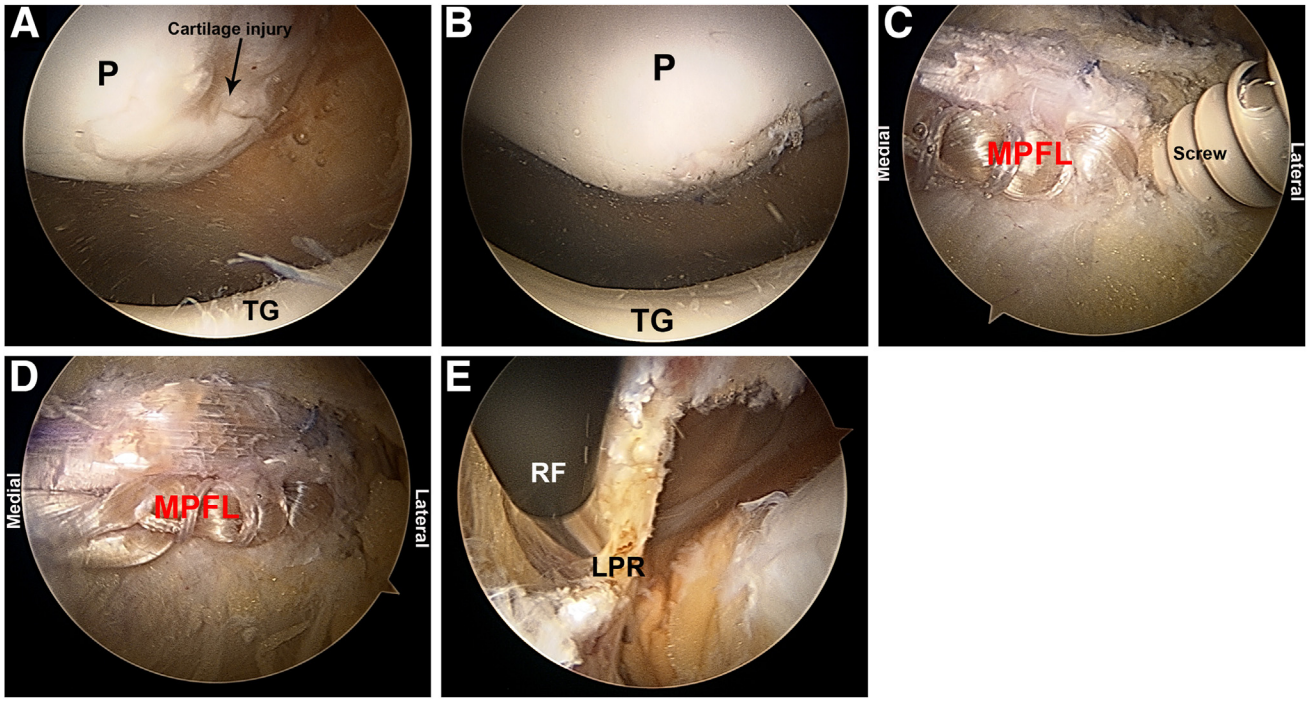

Fig 8. Graft femoral insertion fixation and lateral patellar retinaculum (LPR) release under arthroscopy. (A) Malalignment between patella (P) and trochlear groove (TG). The patella (P) in lateral subluxation with the medial facet cartilage shows a small osteochondral lesion (viewed from anteromedial portal). (B) Reduction of patellofemoral joint surface. (C) The graft is secured in the femoral tunnel with a 5.0-mm bioabsorbable interference screw. (D) Overview of reconstructed medial patellofemoral ligament (MPFL) from femoral portal. (E) LPR release using radiofrequency device (RF).

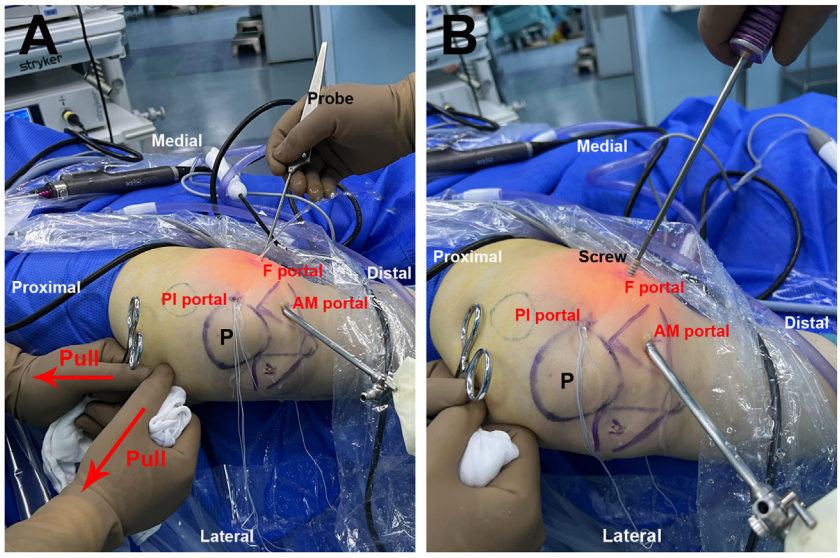

Fig 9. Graft femoral insertion fixation (right knee). (A) The threads at the ends of the 2 tendon grafts are pulled with both hands, and the graft tension is adjusted manually. (B) The graft is secured in the femoral tunnel with a 5.0-mm bioabsorbable interference screw. (AM, anteromedial; F, femoral; P, patella; PI, patellar incision.)

A cannula is used to bluntly separate the lateral subcutaneous tissue, and a needle is inserted into the patellofemoral space for positioning. The radiofrequency device is applied for lateral patellar retinaculum release until the patella can be manually lateralized about 10 mm (Fig 8E).[12] A step-by-step summary of this technique is provided in Table 1.

Discussion

The native MPFL is the medial stabilizer of the patella, which consists of 2 functional bundles. Therefore, double-bundle MPFL reconstruction operations are performed to mimic the native MPFL. Wang et al.[13] reported that there was no significant difference in redislocation rates during postoperative follow-up of

Table 1. Pearls and Pitfalls of Key Surgical Steps

Key Surgical Step	Pearls	Pitfalls
Preoperative positioning	The positional relations between the 2 steel balls, as well as their connecting line, and the MPFL insertions are measured via an imaging system, and the portals are accurately marked on the skin.	Inaccurate pre-positioning will result in loss of efficacy of the reconstructed MPFL.
Patellar insertion creation by socket-anchor technique	The guide pin is drilled into the patella parallel to the patellar surface. A 10-mm-deep bone tunnel (socket) is prepared by a 5.0- or 6.0-mm cannulated drill system. A bioabsorbable suture anchor is inserted into the end of the socket without restriction of direction.	To prevent patellar fracture, the guide pin insertion and pateller socket creation should not be too deep. If the suture anchor is not rigidly fixed, it may drop out during surgery.
Femoral tunnel creation	After femoral guide pin insertion, a large clamp is used to create a cutaneous tunnel from the AM portal and PI portal to the F portal. Once the AMT is identified, the surgeon should gently dissect around it, freeing all interdigitations of the tendon down to its insertion, as distal as possible, because this better approximates the anatomic femoral insertion point of the MPFL. In skeletally immature patients, the distal femoral drill tunnel should be angled 15° to 20° distally and anteriorly to minimize the risk of damage to the physis and the joint.	During the operation, isometric testing and reconfirmation of the femoral insertion under arthroscopy need to be performed. If the pre-inserted guide pin is inaccurate, it needs to be removed and re-inserted. If the femoral drilling direction is wrong, the neurovascular bundle behind the knee joint may be damaged.
Patellar insertion fixation	The midpoint of the graft is sutured to the anchor and pulled into the socket and then knotted and tightly fixed.	If the diameter of the socket is not designed to be smaller than the graft, it will be difficult to pull in the graft and secure the knot into the socket.
Femoral insertion fixation	The surgeon use a clamp to expand the subcutaneous tunnel and pull the traction suture to introduce the graft into the femoral tunnel.	The surgeon should ensure that the graft is between the first and second medial retinacular layers, like the native MPFL, and that the graft is not under the skin or is intracapsular.
	Manual tension is applied on the graft while the interference screw is being inserted.	The reconstructed MPFL will be loose if insufficient tension is exerted when fixing the femoral insertion.
	LPR release is performed under arthroscopy using a radiofrequency device.	Using tissue scissors for LPR release without arthroscopic monitoring may lead to excessive release.

AM, anteromedial; AMT, adductor magnus tendon; F, femoral; LPR, lateral patellar retinaculum; MPFL, medial patellofemoral ligament; PI, patellar incision.

patients who underwent double- versus single-bundle MPFL reconstruction. However, there is a study reporting that the risk of iatrogenic patellar fracture increases by opening 2 tunnels in the patella during double-bundle MPFL reconstruction.[14] We prefer to perform single-bundle MPFL reconstruction.

On review of the multitude of techniques for MPFL reconstruction described in the literature, 1 common technique involves drilling patellar bone sockets or tunnels to pass and fix the graft. Although this technique has been shown to successfully reduce the patellar redislocation rate, there is potential risk of intraoperative and postoperative patellar fracture.[15] "Non—bone socket" techniques that involve fixing graft tissue to the cortical surface of the patella with sutures or suture anchors have been described to achieve good outcomes. Although these techniques may have a theoretical advantage of reduced risk of patellar fracture, concerns of poor tendon-bone interface (TBI) healing have arisen.[16,17] An attribute of our technique is the use of a 2.3-mm Kirschner wire as a guide pin without drilling through the lateral patellar cortex; a 5.0- or 6.0-mm cannulated reamer is then used to drill a 10-mm-deep bone tunnel (socket), and a suture anchor is inserted into the blind end of the socket. Suture anchor fixation can provide adequate strength and

Table 2. Advantages and Disadvantages

Advantages
Accurate femoral tunnel creation owing to preoperative 3D CT positioning, isometric testing, and arthroscopic positioning during surgery
All-arthroscopic procedure with minimal invasiveness, faster rehabilitation, and less operative scar formation
No need to sacrifice patient's tissue
Better tendon-bone interface healing at patellar insertion
No need for intraoperative fluoroscopy
Disadvantages
Possible longer operative time than open technique
Possible risk of tunnel fracture and tunnel malpositioning
Technical proficiency and knowledge of anatomy required for arthroscopic positioning

CT, computed tomography; 3D, 3-dimensional.

avoids the risk of patellar fracture caused by a transpatellar tunnel.[18] Besides, the freshened bone surface and 10-mm-deep socket are beneficial for TBI healing.

The key point of MPFL reconstruction is the positioning of the femoral insertion. Many studies have accurately described the anatomic position of the MPFL, searching to define the positional relation between the femoral insertion and specific bony landmarks to facilitate the operator's positioning.[19,20] The AT has become an important anatomic landmark because it is easily identifiable on the body surface and it has a relatively constant positional relation with the MPFL femoral insertion. A recent study has found that the MPFL femoral insertion is located approximately 10 mm distal to the AT.[21] Given the limited operating space in intraoperative fluoroscopy, it is often difficult to obtain standard lateral radiographs and determine the exact location of the femoral insertion from 2-dimensional images. Therefore, we use 3-dimensional computed tomography positioning preoperatively and isometric testing and arthroscopic positioning during surgery to help achieve accurate femoral tunnel creation without the need for intraoperative fluoroscopy.

In conclusion, our technique combines the advantages of rigid anchor fixation and a socket providing a sufficient TBI healing area with accurate femoral insertion positioning. Moreover, this is an all-arthroscopic procedure and is able to reduce surgical incisions, wound scar formation, and harm to the patient from intraoperative fluoroscopy, as well as to enhance recovery after surgery. Pearls and pitfalls of performing this surgical procedure are listed in Table 2.

Disclosures

All authors (Z.D., Z.H., W.F., S.Y., W.Z.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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