A Review Paper

Correct Positioning of the Medial Patellofemoral Ligament: Troubleshooting in the Operating Room

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Abstract

Medial patellofemoral ligament (MPFL) reconstruction is often required after failed nonoperative management of lateral patellar instability. It is important to properly re-create the native ligament to avoid altering patellofemoral biomechanics. Such alterations can cause knee stiffness, anterior knee pain, and patellofemoral chondrosis.

Incorrect femoral location is the most common mistake that affects MPFL graft biomechanics. Authors have described multiple radiographic and anatomical landmarks that assist in determining the appropriate location, and time should be taken to accurately localize this position.

Regardless of the reconstruction technique used, the knee should be taken through its full range of motion, before the MPFL graft is secured, to test the biomechanics and reduce the risk of postoperative complications. If the graft becomes too tight as the knee moves into flexion, the femoral location is too proximal and should be adjusted ("high and tight"). By contrast, if the graft becomes too loose in flexion, then the femoral location is too distal ("low and loose"). These simple rules can be used to intraoperatively troubleshoot the tunnel placement.

The medial patellofemoral ligament (MPFL), which is essential in preventing lateral patellar instability, becomes torn in almost 100% of dislocation events.[1] Therefore, in cases of failed nonoperative management, this important constraint should be reconstructed. Reconstruction is technically challenging, precision is needed to avoid postoperative complications, and a thorough understanding of the native MPFL anatomy is paramount.

As a thickening of the medial patellar retinaculum, the MPFL connects the medial patella to the medial femur. The femoral insertion has been described a few ways. In a cadaveric study, LaPrade and colleagues[2] noted that it inserts 1.9 mm anterior and 3.2 mm distal to the adductor tubercle. Radiographically, the attachment has been described by Schöttle and colleagues[3] and Stephen and colleagues.[4] These techniques are discussed in more detail later.

The MPFL is a static restraint to lateral patellar translation—it acts only as a checkrein. It functions mainly in 0° to 30° of knee flexion because once the patella engages the trochlear groove, the bony articulation guides the patella during the rest of knee flexion.[5] Most authors agree that the native MPFL is mostly isometric, and the re-created ligament should replicate it.[6,7] Using cadaveric specimens, Steensen and colleagues[6] found that, from 0° to 90° of knee flexion, the distance from the inferior patellar attachment to the superior femoral attachment changed only 1.1 mm.

Biomechanical studies have shown that a MPFL graft with excessive tension predisposes to postoperative abnormal patellofemoral contact pressures, which cause anterior knee pain, loss of knee flexion, and patellofemoral chondrosis.[8-10] Furthermore, an overtensioned graft can cause iatrogenic medial patellar subluxation, and an undertensioned graft may still allow for pathologic lateral patellar translation.

Anatomical Bony Insertions

Femoral Insertion

Precise localization of the proper anatomical femoral attachment of the MPFL is a crucial step in reconstruction.[11] Small errors in femoral location have resulted in significant loss of graft isometry, increased patellofemoral contact pressures in cadaveric models,[4,7] and increased rates of failure after both MPFL repair[12] and reconstruction.[13] Several methods for confirming proper femoral location during surgery have been described; these methods help obviate the need for large formal dissection of the medial knee.

In a cadaveric study, Schöttle and colleagues[3]

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described a reproducible radiographic point that precisely identifies the appropriate femoral location for MPFL graft placement. The point is located on a standard true lateral radiograph of the distal femur. First, a line is drawn extending the posterior cortex of the femur distally. Next, 2 lines are drawn perpendicular to the first: one intersecting the posterior point of the Blumensaat line, the other intersecting the transition between the posterior femoral condyle and the posterior femoral cortex[3] (**Figure 1**). Of the 8 MPFL femoral attachment sites in the study, 7 (88%) were at or anterior to the posterior femoral cortex line, and all were between the 2 perpendicular lines. The "Schöttle point" has become the benchmark for intraoperative radiographic confirmation of femoral location and is our preferred method.

Another radiographic method for intraoperatively identifying the anatomical MPFL femoral attachment was described by Stephen and colleagues.[4] They used a cadaveric model to confirm radiographic findings and found that the femoral attachment point, taking the anterior-to-posterior medial femoral condyle distance to be 100%, was identified 40% from the posterior border of the medial femoral condyle, 50% from the distal border, and 60% from the anterior border. This simple "40%–50%–60%" normalizing rule for radiographically defining the femoral attachment point is another helpful intraoperative adjunct for templating the appropriate location for graft placement, but calculation in a sterile operative environment can be difficult.

Both of these techniques depend on a perfect lateral radiograph of the knee, as even minor variations in a radiograph can have a dramatic effect on the appearance of the starting point. Ziegler and colleagues[14] examined the impact of an imperfect lateral radiograph and found that malrotation of as little as 5° resulted in a significantly malpositioned femoral insertion (**Figures 2A-2C**).

Palpation of bony landmarks is another method for preliminarily identifying the appropriate location for femoral pin placement. If done properly, palpation helps obviate the need for corrections when confirming location using isometry or radiography. The center of the femoral attachment of the MPFL can be located in a groove midway between the medial epicondyle and the adductor tubercle.[4] Fujino and colleagues[15] conducted a cadaveric study of 31 knees in an effort to relate osseous landmarks with the femoral attachment of the MPFL. In all knees, the adductor tubercle was a reliable osseous landmark. The anatomical MPFL attachment was 10.6 mm distal to the apex of the adductor tubercle and was consistent between knees.

Although all these options offer the best available and most reproducible methods for establishing an

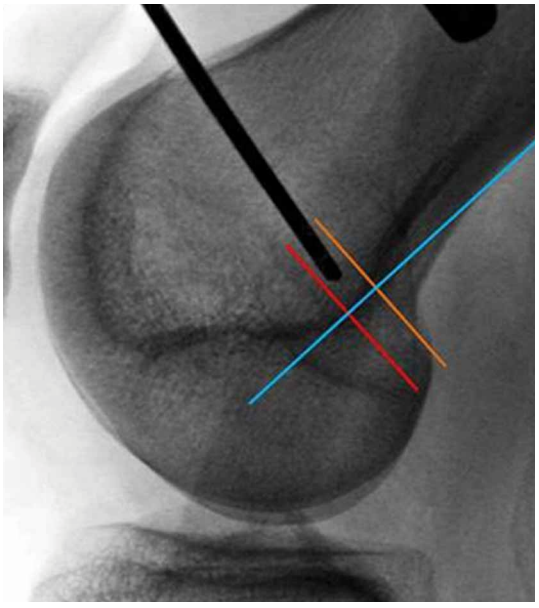

Figure 1. Intraoperative localization of Schöttle point. Blue line is drawn down posterior femoral cortex; orange line marks transition of curve of posterior femoral condyle and is perpendicular to blue line; red line is at posterior aspect of Blumensaat line and is also perpendicular to blue line.
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Take-Home Points

- Use fluoroscopy, isometry, or both to double-check the femoral attachment point. Failure to do so can lead to an overtensioned or undertensioned graft caused by anisometric graft placement.
- To minimize the risk of fracture, avoid drilling transverse tunnels across the patella.
- Do not "pre-tension" the medial patellofemoral ligament graft. There should be little or no tension in the graft when the patella is centered in the groove, regardless of the angle of knee flexion.
- The angle of knee flexion during securing of the graft may be important for inaccurate femoral tunnel placement. Before final fixation of the graft, always range the knee fully to make sure full passive motion will be possible once the graft is secured.
- Understanding the anatomy of the MPFL is key before considering reconstructing: That is, fluoroscopy only suggests a "cloud" to begin assessment of the femoral attachment site and is secondary to anatomic references and check of length changes between the attachment point through range of motion. New studies demonstrate the patellar attachment is broad and extends proximally from the historical patellar attachment site to an equal distance along the distal quadriceps.

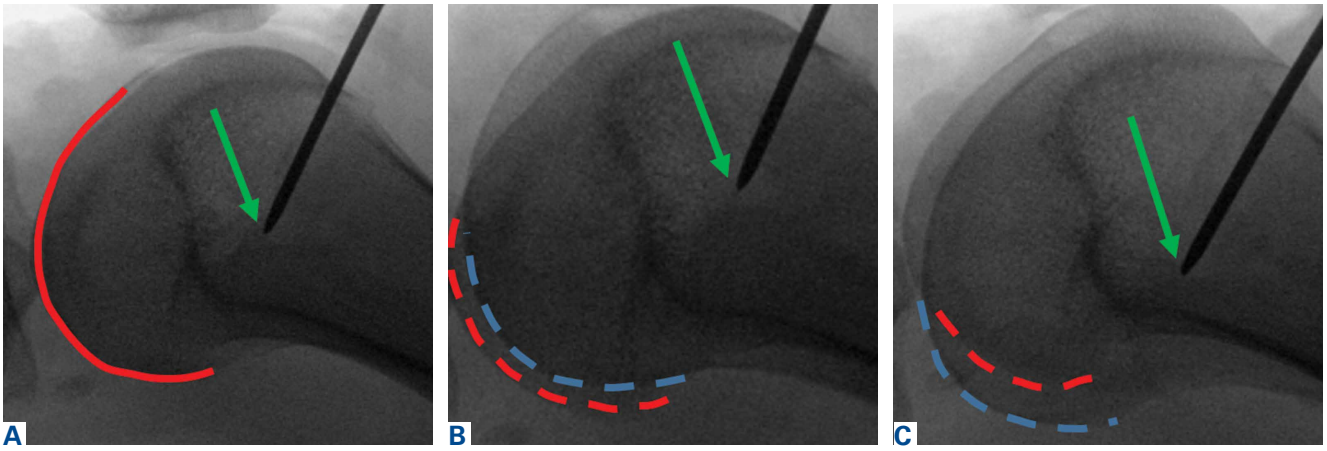

Figure 2. If a radiographic technique is used to locate the femoral medial patellofemoral ligament insertion, it is imperative to obtain a perfect lateral radiograph. (A) A perfect lateral radiograph is confirmed with complete overlap of the posterior femoral condyles (solid red line). (B) If the femur is slightly internally rotated, then 2 condyles contours are now visualized with the medial condyle (dashed red line) appearing posterior to the lateral condyle (dashed blue line). (C) With external femoral rotation, now the lateral condyle (dashed blue line) appears posterior to the medial condyle (dashed red line). Importantly, the location of where the guide pin contacts the femur (green arrow) appears to change substantially based on rotation of the femur even though these are actually all the same location.

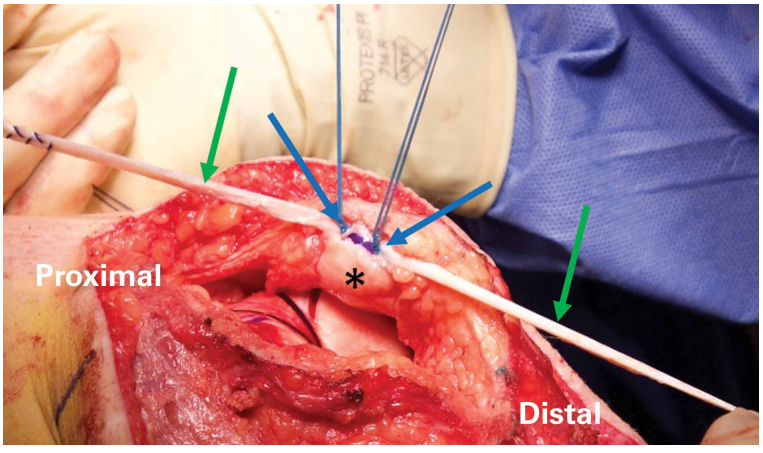

Figure 3. Intraoperative medial patellofemoral ligament (MPFL) reconstruction using suture anchor technique for patellar (*) fixation. Gracilis autograft (green arrows) is laid over the top of 2 suture anchors (blue arrows), then tied in place. Medial patellar cortical bone can be roughened with burr to encourage healing of graft to patella. MPFL reconstruction was combined with other procedures; thus, incision was larger than would be required for MPFL reconstruction only.

anatomical femoral graft insertion site, it is important to note that they are based on cadaveric specimens without recurrent patellar instability. Most knees with chronic patellar instability have associated anatomical abnormalities that are not present in nondysplastic cadaveric specimens, which may alter the relationship of osseous landmarks such as the medial epicondyle and adductor tubercle.[16] In a recent study of 30 patients with chronic lateral patellar instability, Sanchis-Alfonso and colleagues[16] used 3-dimensional computed tomography with these radiographic landmarks and simulated femoral graft attachment sites. They found that the methods of Schöttle and colleagues[3] and Stephen and colleagues[4] did not provide precise anatomical femoral placement. Ziegler and colleagues[14] correlated the anatomical femoral location of the MPFL with the Schöttle point and found the radiographic site to be 4 mm, on average, off the anatomical location. The location of an appropriate anatomical femoral attachment should be confirmed using multiple methods, including palpation of known osseous landmarks, intraoperative fluoroscopy, and, most important, assessment of graft isometry through full range of motion (ROM).

Patellar Insertion

The patellar attachment of the MPFL has received considerably less attention than the femoral attachment.[11] Anatomical studies have shown that the MPFL inserts on the superomedial half to third of the patella, in addition to a portion inserting on the undersurface of the vastus medialis.[17] Recreation of this insertion is more forgiving than the femoral attachment, and thus there are numerous acceptable options for graft configuration and fixation.[4,6,18] Two-tail grafts are thought to cover more of the native footprint.[11] Fixation options include suture anchors, interference screws, transpatellar sutures, suspensory techniques, and bone tunnels; none is superior over the others, according to the literature[19-22] (**Figure 3**). However, caution must be taken with bone tunnels, as full-width transverse tunnels can act as stress risers and may lead to patella fracture.[21] Our preferred technique for the patellar attachment includes 2 short, paral-

lel, oblique drill holes (3 mm in diameter) in the proximal half of the patella. Gracilis autograft is looped through these tunnels, obviating the need for patellar fixation, decreasing implant costs, and reducing the risk of fracture by avoiding full-width transverse tunnels (**Figures 4, 5A-5B**).

Troubleshooting

It is essential to check graft tension through full knee ROM and observe how the graft behaves in order to prevent iatrogenic complications[11] (**Figures 6A, 6B**). Cadaveric studies have shown that the MPFL is mostly isometric between 0° and 100°, and becomes slightly looser in deep knee flexion in which the patella is stabilized by the trochlear groove.[4,6,17] These findings are attributable to the cam shape of the distal femur, which directly impacts the tension of the MPFL as the knee goes from extension into flexion. Fixing the graft

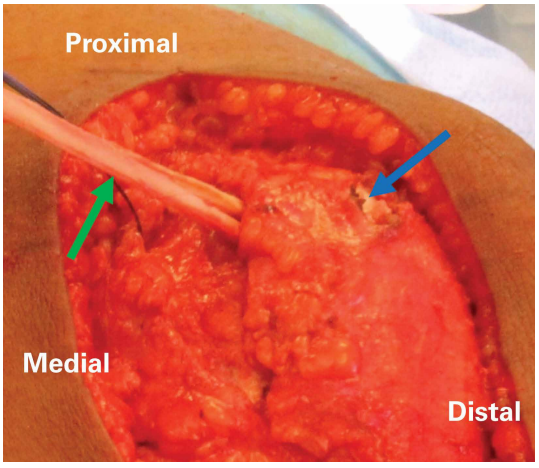

Figure 4. During medial patellofemoral ligament (MPFL) reconstruction, graft (green arrow) is looped through short oblique drill holes over (blue arrow) the top of the patella. MPFL reconstruction was combined with other procedures; thus, the incision was larger than would be required for MPFL reconstruction only.

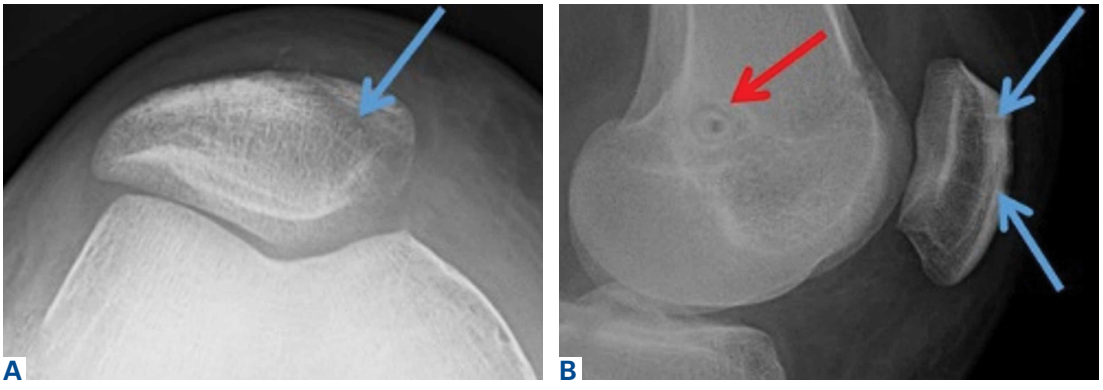

Figure 5. Postoperative (A) sunrise and (B) lateral radiographs show appropriately placed medial patellofemoral ligament tunnels: 2 short oblique patellar tunnels (blue arrows) and femoral tunnel (red arrow) at Schöttle point with secure fixation using bioabsorbable interference screw.

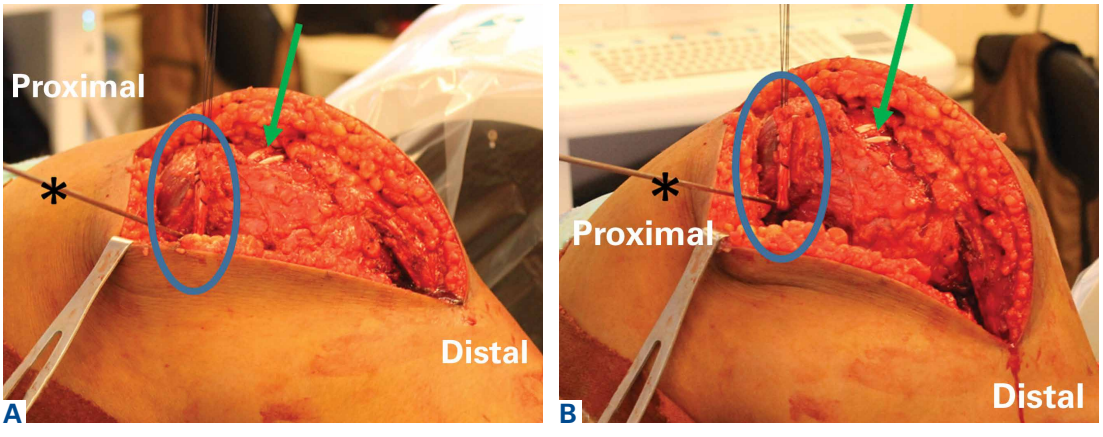

Figure 6. (A, B) During medial patellofemoral ligament (MPFL) reconstruction, isometry is tested after placement of guide wire (*). After graft (blue circle) is looped around femoral guide wire, knee is taken through range of motion to ensure graft tension does not change. Two graft tails (green arrow) are visible before they enter into the patellar tunnels. MPFL reconstruction was combined with other procedures; thus, incision was larger than would be required for MPFL reconstruction only.

on the patella first, which is less crucial in terms of position, offers the ability to loop the ends of the graft around a passing pin to assess the planned femoral fixation site. If the graft becomes tighter with knee flexion, the femoral attachment is too proximal.[23] This error is referred to as "high and tight," meaning that a high or proximal femoral attachment produces a graft that is too tight with knee flexion. This is the worst mistake to make. If graft tension increases with increasing knee flexion, the result is loss of knee flexion or graft failure, increased contact forces resulting in patella femoral chondrosis, and possibly medial subluxation.[10,11,24] Conversely, a distally misplaced femoral attachment yields a graft that is looser in flexion, or "low and loose." These helpful phrases describe graft behavior as the knee is brought from extension into flexion, and as such are troubleshooting aids in the operating room.[23]

If the graft is secured in high degrees of knee flexion, and the femoral location is not anatomical, a different phenomenon occurs when the knee is brought back into extension. For proximal femoral tunnels, the graft loosens in knee extension and may lead to continued lateral patellar instability. On the other hand, a distal femoral tunnel may result in iatrogenic medial patellar subluxation as the graft becomes too tight in extension.

Correct Amount of Graft Tension

Overtightening the MPFL during fixation is an easy but avoidable mistake. Unlike the anterior cruciate ligament, the MPFL should not be secured while applying maximum tension. Stephen and colleagues[7] and Beck and colleagues[8] found that tension of only 2 N (~0.5 lb) is needed to accurately re-create the biomechanics of the native graft.

The amount of tension may inadvertently be increased by an interference screw, which tends to pull the graft into the femoral tunnel during insertion. Attention should be given to watching and palpating the graft as the screw is inserted, especially during the last few turns. Turning the screw half a turn backwards after full insertion can release this increased tension and help avoid overtensioning.

Correct Amount of Knee Flexion

This is probably the least studied aspect of MPFL reconstruction. Recommendations range from 0° to 90° of knee flexion during fixation.[7,25-30] Most recommendations are surgeon preference, or are based on a sound rationale that lacks supporting research. Tensioning in full extension has been advocated for assessing for the appropriate amount of lateral patellar translation.[27] Authors who endorse deeper knee flexion (60°-90°) think that, because the patella engages a deeper trochlear groove in increased flexion, the bony articulation can be used to establish graft length.[30,31]

Our cadaveric study showed that lower degrees of knee flexion are safest for minimizing the effect of a malpositioned femoral tunnel.[26] If femoral tunnel location is not exactly anatomical, any errors are magnified (with even worse graft mechanics) the deeper in flexion the graft is fixed. Once the patella engages the trochlear groove, at about 30° of knee flexion, this can assist in establishing correct graft length. Therefore, we recommend fixation of the graft in 30° to 45° of knee flexion. Our study results also showed that, if femoral tunnel location is anatomical, the graft will be mostly isometric through knee ROM, and, therefore, amount of initial knee flexion does not affect graft behavior.

Regardless of knee flexion chosen, it is imperative to take the knee through full ROM after fixation to ensure the graft does not excessively loosen or tighten in flexion or extension.

Conclusion

MPFL reconstruction is fraught with errors and technical nuances that may be underappreciated. Accurately locating the femoral insertion is crucial to a biomechanically sound graft, and this location should be scrutinized during surgery with accurate radiographs or bony landmarks and verified with knee ROM. Although there is no clear gold standard for fixation and graft options, the graft should be secured while pulling very little tension (2 N) and with the knee in 30° to 45° of flexion to minimize the effect of any inaccuracies in femoral location. Overall, most patients do well after MPFL reconstruction, and attention to surgical technical detail helps maximize the chances of a satisfactory outcome.

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