

Radiographic Landmarks for Femoral Tunnel Placement in Medial Patellofemoral Ligament Reconstruction

Philip B. Schöttle,* MD, Arno Schmeling, MD, Nikolaus Rosenstiel, MS,
and Andreas Weiler, MD, PhD

From the Sports Traumatology and Arthroscopy Service, Center for Musculoskeletal Surgery, Charité, Free and Humboldt University of Berlin, Campus Virchow, Berlin, Germany

Background: Reconstruction of the medial patellofemoral ligament has recently become popular for restoring patellofemoral stability. Femoral insertion site anatomy of the medial patellofemoral ligament has been described. This anatomical insertion has been inferred to be the isometric point in medial patellofemoral ligament reconstruction, but data about radiographic landmarks for a postoperative or intraoperative control are missing.

Purpose: To determine the radiographic landmarks for control of postoperative and intraoperative femoral medial patellofemoral ligament insertion.

Study Design: Descriptive laboratory study.

Methods: Eight fresh-frozen human knees were dissected, and the medial patellofemoral ligament was exposed. After identification of the femoral medial patellofemoral ligament insertion site, the insertion center was marked with a lead ball of 2-mm diameter. Straight lateral radiographs were taken, and posterior-anterior as well as proximal-distal position were evaluated.

Results: Six of 8 insertion points were anterior to a line representing an extension of the posterior cortex, 1 point was touching this line, and 1 point was posterior to it. All points were situated distal to the posterior origin of the medial femoral condyle and proximal to the most posterior point of the Blumensaat line.

Conclusion: A reproducible anatomical and radiographic point, 1 mm anterior to the posterior cortex extension line, 2.5 mm distal to the posterior origin of the medial femoral condyle, and proximal to the level of the posterior point of the Blumensaat line on a lateral radiograph with both posterior condyles projected in the same plane, shows the mean femoral medial patellofemoral ligament center.

Clinical Relevance: This radiographic point may be useful both intraoperatively and postoperatively.

Keywords: patellar instability; medial patellofemoral ligament (MPFL); tunnel placement; anatomy; radiographic landmarks

The medial patellofemoral complex consists of the medial patellofemoral ligament (MPFL) and the medial patellotibial ligament. Recent biomechanical studies have proved that the MPFL is the main restraint against lateral patellar displacement^{6,8} and that repair or reconstruction of the MPFL restores normal patellar tracking.^{7,14,17,21} Numerous studies have focused on the MPFL anatomy and its isometry as well as reconstruction techniques with

promising results,[†] but guidelines for the radiographic position have not yet been described.

The importance of correct graft positioning for ligament reconstruction was recognized in 1938 by Palmer,²⁰ and its influence on the clinical outcome is well known in ACL reconstruction.^{1,2} Therefore, radiographic guidelines for proper tunnel placement in ACL reconstruction were given to improve clinical results.^{5,24}

In MPFL reconstruction, an anatomical reconstruction is recommended as well because it is hypothesized that nonanatomical reconstruction or an excess tension is correlated with an increased medial patellofemoral pressure.^{3,10,23}

The purpose of this present study is to determine the proper radiographic landmarks of the anatomical femoral

*Address correspondence to Philip B. Schöttle, MD, Center for Musculoskeletal Surgery, Charité, Campus Virchow-Klinikum, Free and Humboldt-Universität in Berlin, Augustenburger Platz 1, D-13353 Berlin, Germany (e-mail: philip.schoettle@charite.de).

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[†]References 9, 11, 12, 18, 19, 22, 23, 25, 26, 27.

MPFL insertion. This can serve as a postoperative control as well as a guideline for intraoperative tunnel placement.

MATERIALS AND METHODS

Eight frozen human cadaveric knees of unknown age but with intact medial patellofemoral complexes were completely dissected to isolate the MPFL. After identification of the MPFL, the midpoint of the femoral insertion was marked with a 2-mm lead ball (Figure 1A).

Standardized lateral radiographs were taken using an image intensifier (Siremobil Iso-C, Siemens, Erlangen, Germany), with both posterior condyles projected in the same plane (Figure 1B). A ruler was positioned in the radiograph allowing correction for magnification. The anterior-posterior as well as the proximal-distal position were determined in the lateral view only.

For measurement of the femoral MPFL location in relation to defined reference lines, an extension of the posterior femoral cortex was drawn distally (line 1, Figure 2), and the distance between the marked insertion point and this extension was measured (positive value, if the point was anterior to line 1). Then, 2 perpendicular lines to this extension line were drawn (Figure 3): 1 (line 2) intersecting the contact of the posterior femoral condyle with the posterior cortex (point 1) and 1 (line 3) intersecting the posterior point of the Blumensaat line (point 2). The distance between the marked point and line 2 was measured to determine the insertion in the proximal-distal direction (positive value, if the point was distal to line 2). In addition, the distance between line 2 and 3 was measured.

RESULTS

The MPFL itself and its femoral insertion were identified in all cases as described in other anatomical studies.^{15,23,26}

Anterior-posterior Position. The insertion marker was located anterior to the posterior cortical extension line in 6 specimens, on the line in 1 specimen, and posterior to the line in another specimen. The mean location was 1.3 ± 1.7 mm (range, -2 to $+3$ mm) anterior to the posterior cortex line.

Proximal-distal Position. In all 8 specimens, the MPFL marker was midway between line 2 and line 3. The mean location was 2.5 ± 0.8 mm distal to line 2, which was 5.5 mm proximal to line 3. All points were within 5 mm of each other. A 5-mm-diameter circle containing all 8 specimen locations is shown in Figure 4.

DISCUSSION

The MPFL reconstruction is an accepted surgical technique for treatment of chronic patellofemoral instability.^{4,7,9,11,13,18,22}

The goal of this study was to determine the radiographic landmarks for the anatomical femoral location of the MPFL because the anatomical insertion has been inferred to be the isometric point at the femoral attachment.^{3,23,25}

Radiographic landmarks would help evaluate postoperative tunnel placement in cases of persisting pain or instability

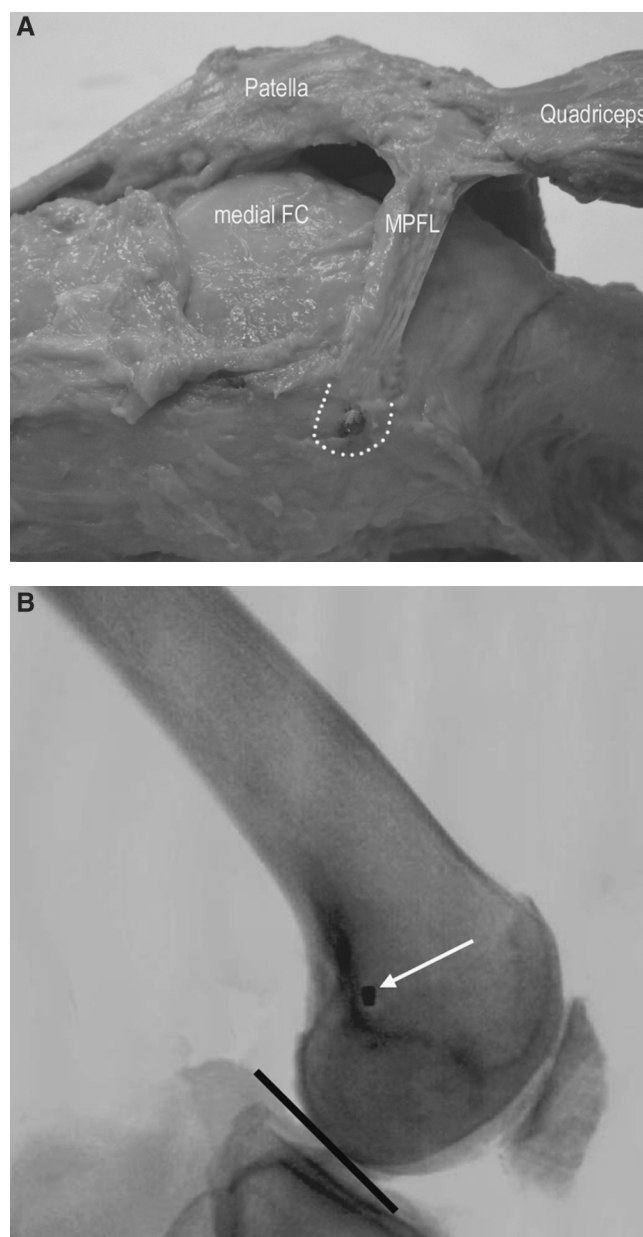


Figure 1. A, gross anatomy of the prepared MPFL with its femoral insertion (area marked with white points) and the lead ball, indicating the femoral insertion center. B, lateral view of the femur with the posterior condylar margin overlapped (black line) and the marked center of the femoral MPFL attachment, using a 2-mm lead ball (white arrow). MPFL, medial patellofemoral ligament; FC, femoral condyle.

because it is hypothesized that a too proximal-positioned or a too anterior- and proximal-positioned femoral attachment can lead to an increase of the medial patellofemoral pressure.^{3,10,23} In addition, intraoperative verification of the proper femoral MPFL insertion by image intensifier would be helpful, as MPFL rupture after patellar dislocation mainly

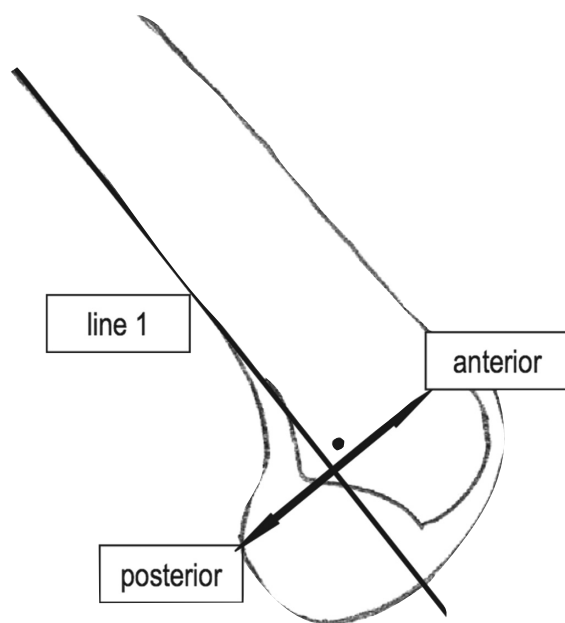


Figure 2. For determination of the anterior-posterior position, the distance between the center of the lead ball (black point) and the extension of the posterior cortex (line 1) was measured.

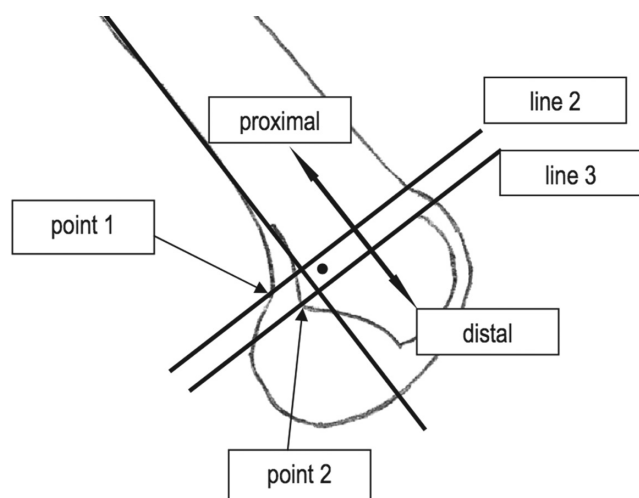


Figure 3. Two perpendiculars to line 1 are drawn, intersecting the contact point of the medial condyle and the posterior cortex (point 1, line 2) and intersecting the most posterior point of the Blumensaat line (point 2, line 3). For determination of the vertical position, the distance between line 2 and the lead ball center is measured as well as the distance between line 2 and line 3.

occurs at the femoral insertion.¹⁶ Furthermore, the medial epicondyle or the adductor tubercle can be difficult to palpate when covered by soft tissue.

These points and the importance of correct graft positioning are known²⁰; however, literature is lacking about radiographic landmarks for the proper femoral insertion point.

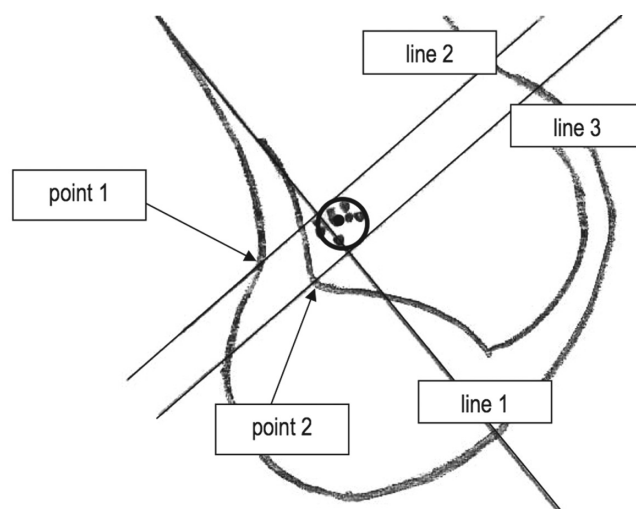


Figure 4. Mean insertion center of the femoral medial patellofemoral ligament attachment of the 8 examined knees. The circle around the dots indicates a femoral drill hole diameter of 5 mm, including all 8 femoral insertion centers.

In the present study, the MPFL was identified in all cases, according to the findings of other anatomical studies,^{12,14,17,23,26} and the femoral attachment of the specimens extended from the adductor tubercle proximally to the medial epicondyle distally, as has been shown before.^{15,23,26}

The mean position of the femoral MPFL insertion centers in the cadaveric knees was 1.3 mm anterior to the posterior cortex extension, 2.5 mm distal to a perpendicular intersecting the origin of the posterior medial femoral condyle, and 3 mm proximal to a perpendicular intersecting the posterior point of the Blumensaat line on a lateral view with the posterior condylar margin overlapped.

One can say that the mean position that was determined is not valid for every knee as the distance of the single points was up to 5 mm in the proximal-distal direction; therefore, one has to respect that it has been shown by Smirk and Morris²³ that a distance of 5 mm or less from the anatomical femoral MPFL insertion does not change the MPFL isometry. Furthermore, it was proved that a circle with a 5-mm diameter around the evaluated mean insertion point included all 8 insertion centers.

This anatomical radiographic study of the femoral MPFL location has shown the mean femoral insertion center of the MPFL lying anterior to a posterior cortex tangent and distal to a perpendicular through the posterior origin of the medial condyle. If the minimum femoral tunnel diameter used for MPFL reconstruction is 5 mm, the guide wire could be placed at this point, covering all insertion centers found in the cadavers used in the present study.

Because it is hypothesized that a nonanatomical placement in MPFL reconstruction at the femoral side leads to non-physiological loading conditions, as a too proximal fixation point would lead to an increased distance to the patella when the knee flexes and vice versa for a too posterior attachment,³ a proper tunnel placement is necessary to restore physiological kinematics and pressure postoperatively.

CONCLUSION

A reproducible anatomical and radiographic point, 1.3 mm anterior to the posterior cortex extension and 2.5 mm distal to the posterior origin of the medial femoral condyle, just proximal to the level of the posterior point of the Blumensaat line on a lateral view with the posterior condylar margin overlapped, determined the radiographic landmarks for the mean femoral MPFL center. These landmarks not only can be used for postoperative control but also to verify the femoral insertion for MPFL reconstruction intraoperatively.

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