What is the “Perfect” Lateral Radiograph? Effects of Fluoroscopic Beam Directionality and Condylar Alignment on the Perceived Location of the Medial Patellofemoral Ligament

Ameen Z Khalil, Joseph Featherall, Allan Kenneth Metz, Justin J Ernat, Stephen K Aoki

INTRODUCTION:

Medial patellofemoral ligament (MPFL) reconstruction has become one of the more common surgical interventions used to address recurrent patellar instability. The procedure's success is heavily dependent on proper identification of the native MPFL femoral insertion site. Aberrant placement can lead to overtightening or residual laxity. Schöttle's point is an established radiographic landmark that provides an efficient technique to approximate the femoral location of the MPFL insertion. This technique is founded on the use of a "perfect" lateral radiograph, which has been described as aligning the medial and lateral posterior femoral condyles. However, discrepancies in condylar size are exceptionally variable, making it difficult to align both the proximal and distal aspects of the posterior condyles. Deciding which aspects of the femoral condyles to align is ultimately left to surgeon preference (Figure 1). This unclear process is further observed with C-arm beam directionality, which can be placed in either direction relative to the knee, and is oftentimes positioned interchangeably based on operating theater layout. The purpose of this study was to quantify the effects of these variations in fluoroscopic beam directionality and condylar alignment on the perceived location of the MPFL insertion site.

METHODS:

Sixteen cadaveric knees were included. The medial aspect of the knees were dissected, and the femoral insertion of the native MPFL was identified and fixed with a radiopaque metal marker. Following a calibration shot, fluoroscopic lateral images were taken in the medial-to-lateral direction, first with posterior proximal condyles aligned, then with posterior distal condyles aligned. This process was repeated with the beam shooting in the lateral-to-medial direction. Once all images were obtained, the different variations were superimposed and aligned, and the discrepancy in marker location, if any, was measured and quantified in the X- and Y- planes, with the X-axis representing proximal-distal displacement, and the Y-axis representing anterior-posterior displacement. Two-tailed t-tests were performed on the obtained variations and compared.

RESULTS:

When shooting fluoroscopy in the medial-to-lateral direction aligning the proximal versus distal aspects of the posterior condyles shifted the perceived location of MPFL insertion site by a mean of 1.65±1.03mm When comparing the same differences in alignment, but shooting in the lateral-to-medial direction, the mean difference was greater, at 2.91±2.12mm, with significant trend in displacement distally along the femur. When comparing both shots with the posterior proximal condyles aligned, the mean difference between the medial-to-lateral and lateral-to-medial beams was significant (2.98±1.55mm), with lateral-to-medial beam consistently displacing the perceived MPFL insertion site posteriorly along the femur. This trend was even more pronounced when comparing shots with the posterior distal condyles aligned (3.94±1.18mm).

DISCUSSION AND CONCLUSION:

When taking a "perfect" lateral radiograph, changes in fluoroscopy beam directionality were shown to have significant role on the perceived location of the MPFL insertion site. The view with the smallest discrepancy from our standardized "perfect" lateral was shot in the medial-to-lateral direction, with the proximal aspects of the posterior condyles aligned. That said, regardless of any specific condylar alignment, shooting fluoroscopy in the lateral-to-medial direction led to consistent and appreciable posterior displacements of the perceived MPFL insertion site. Although these differences seem minute, displacing the MPFL insertion site by as little as 5 mm during reconstruction has been shown to alter the biomechanical axis of the ligament, risking failure and further complication. As such, extra caution should be given to consistently shoot in the medial-to-lateral direction, and align the posterior condyles in a manner that optimizes consistency and replicability of native anatomy.

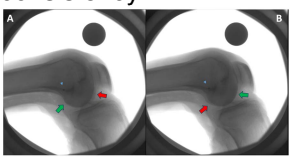

Figure 1A-C: Common Iterations in Condylar Alignment when taking a "Perfect" Lateral on Fluoroscopy. The MPFL insertion site is fixed with a radiopaque marker, highlighted by the small blue arrows. (A) Prioritized alignment of the proximal aspects of the posterior condyles (green arrow), leading to condylar misaligned overlap of the distal aspects of the posterior condyles (red arrow). (B) Prioritized alignment of the distal aspects of the posterior condyles (green arrow), with subsequent misalignment of the proximal aspects of the posterior condyles (red arrow).

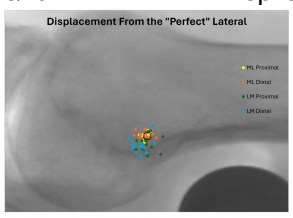

Figure 2: Displacement from "Perfect" Lateral Colibretial representation of displacements seen relative to the marked, true insertion of the MPFL (black ring). Medial-to-lateral (ML) variations were consistently closer to the desired point than lateral-to-medial (LM).

Comparison	p-value ΔX (Proximal-Distal Axis)	p-value ΔY (Anterior-Posterior Axis)
ML Proximal vs ML Distal	0.372	0.421
LM Proximal vs LM Distal	**0.005***	0.665
ML Proximal vs LM Proximal	0.560	**<0.001***
ML Distal vs LM Distal	0.0652	**<0.001***

Table 2: Table of p-values for Statistical Significance: Results of 2-tailed students' t-tests comparing the X and Y plane displacements between associated variations of beam directionality (ML=medial-to-lateral; LM=lateral-to-medial) and condylar alignment. *p-value indicates statistical significance, with values less than 0.05 suggesting a significant difference.

Comparison	Average Absolute Difference (mm)	SD Absolute Difference (±mm)	Avg. ΔX (mm)	SD ΔX (±mm)	Avg. ΔY (mm)	SD ΔY (±mm)
ML Proximal vs ML Distal	1.651	1.029	0.428	1.860	-0.113	0.546
ML Proximal vs LM Proximal	2.975	1.546	-0.258	1.730	2.220	1.873
ML Distal vs LM Distal	3.940	1.180	1.260	2.533	2.548	1.707
LM Proximal vs LM Distal	2.908	2.121	1.946	2.372	0.215	1.950

Table 1: Comparative Distances between Alignment Variations. X-axis represents the proximal-distal plane along the femur, with positive values signifying a proximal shift, and negative values, distal. The Y-axis represents the anterior/posterior plane, with positive values indicating anterior shift, and negative values indicating posterior shift. The Euclidean distance provides an overall magnitude of change irrespective of direction.