

Use of transtibial aimer via the accessory anteromedial portal to identify the center of the ACL footprint

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Abstract

Purpose To assess the ability of a transtibial aimer with a 7-mm off-set in a standardized position to reach the center of the ACL footprint on the femur through the AM portal. **Methods** Nineteen cadaveric knees were dissected, and the perimeter of the femoral ACL footprint was marked. The aimer was placed just superior to the medial joint line close to the medial condyle through the AM portal. The guide was rested upon the posterior cortex and placed in three different positions: (A) at zero degrees in frontal plane and 60° in axial plane, (B) at 45° in frontal and 45° in axial, and (C) at the center of the ACL insertion site under direct visualization. A digital camera was used to take pictures on the axial plane, and *Image J* software was used for angle measurement. Aluminum beads were used to mark the three positions indicated by the aimer, and CT

scans were performed. The distances from the true center of the ACL to each point were determined.

Results Position A resulted in femoral tunnel placement furthest from the center of the ACL footprint (8.6 mm). Position B was at a distance of 3.2 mm, and position C was the most accurate, with an average distance of 2.0 mm. The angles required by Position C varied with an average of 54° ± 11° in the frontal plane and an average of 44° ± 6° in the axial plane.

Conclusion The 7-mm transtibial aimer was unable to reach the center of ACL footprint at a fixed orientation.

Keywords Anterior cruciate ligament · ACL · Anatomical reconstruction · Transtibial aimer · ACL footprint

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Introduction

Some orthopaedic surgeons still perform both anatomical single and double-bundle ACL reconstruction using an anatomical femoral aimer with different off-sets to reach the center of the footprint [6, 11]. An understanding of the anatomy of the anterior cruciate ligament (ACL), particularly its anatomical footprint on the lateral femoral condyle, is important in anatomic ACL reconstruction [20, 25]. For single-bundle ACL reconstruction, correct anatomic position of the femoral tunnel is important as incorrect positioning of the femoral tunnel has been shown to lead to poor clinical results [13]. Most of the femoral tunnels placed using a transtibial technique tend to be placed deep and high in the notch, away from the center of the ACL footprint [1, 8, 23]. Use of a transtibial technique constrains the surgeon's freedom in choosing the position for the center of the ACL footprint leading some surgeons to use

the anteromedial (AM) portal technique [12, 14, 16]. However, the AM portal technique also has some disadvantages [4]. The significance of correct positioning of the ACL graft in the sagittal plane has long been recognized; however, the importance of positioning in the frontal plane has been underestimated. Recently, several studies have shown the biomechanical advantages of recreating the obliquity of the native ACL in the frontal plane [3, 17, 21, 24]. The tunnel is placed in the center of the ACL footprint in order to replicate equal parts of both the anteromedial and posterolateral (PL) bundles of the ACL [5].

This study evaluated if an aimer with 7-mm offset, widely used for transtibial technique, could reach the center of ACL footprint through the accessory medial portal to place the femoral tunnel in the anatomic position. If the aimer can be reliably used in a fixed orientation to locate the center of the ACL footprint, it would greatly aid in performing anatomic tunnel positioning.

Materials and methods

Nineteen human cadaveric knees were used for this study. Six were right knees, thirteen left with thirteen male and six female specimens. Knees were excluded if they displayed osteophytes in the intercondylar notch or signs of osteoarthritic changes greater than Outerbridge III, as evaluated on gross observation and CT scan. The cadaveric knees were previously dissected, and the perimeter of the femoral ACL footprint was marked using a 1.5-mm drill bit. The knees were fixed in 110° of flexion using clamps to protect the articular cartilage and assure a sufficient femoral tunnel length [2, 9, 19, 26]. The condyles were aligned to the posterior aspect of the tibial plateau, and a 6-mm spacer was used to reproduce the articular space usually filled by the menisci [26]. The aimer was placed just superior to the medial joint line close to the medial femoral condyle, simulating an AM portal approach [7, 16, 18]. A 12-mm-diameter spacer was used for the aimer to maintain a safe distance (6 mm) from the cartilage and to avoid damaging the medial femoral condyle [22].

An aluminum wire was attached to the posterior margin of the tibial plateau as a reference to measure the angle in the axial plane. A femoral 7-mm offset guide [Acufex, Smith and Nephew, Andover, MA, USA] was rested upon the posterior cortex and placed in three different positions: (a) at zero degrees in frontal plane and 60° in axial plane, (b) at 45° in frontal plane and 45° in axial plane, and (c) at the estimated center of the ACL insertion site under direct visualization (Fig. 1). A digital camera, perpendicular to tibial axis, was used to take pictures on the axial plane, and Image J software [Image J, National Institutes of Health, USA] was used to measure all angles. Two examiners

independently performed the measurements twice. The three selected positions were marked with aluminum beads of different sizes. Then CT scans [GE Light Speed 4—Slice Scanner 625 × 625 mm, standard filters] were taken of each knee (Fig. 2). A 3-D model of each knee was reconstructed using MIMICS software [Mimics 12.3, Materialise, Belgium] to verify the positions and to virtually remove the medial femoral condyle to better visualize the lateral femoral condyle and ACL footprint (Fig. 3). The center of ACL insertion was calculated using software [Geomagic Studio 11, North Carolina, USA] (Fig. 4). Initially, the study started with 20 specimens, but when measuring the distance using the software, one knee was excluded because it was too osteoporotic and the boundaries of the ACL footprint were not readily visible.

Statistical analysis

For data analysis, measurements were divided into three groups based on the position used (position A, position B, and position C). The distance between each position was marked, and the center of the ACL footprint was calculated. The frontal and axial angles for position C were also calculated. Non-parametric tests (Friedman Test, Wilcoxon signed ranks test) were used to compare the distance (mm) to the center of the ACL footprint between groups A, B, and C. The Spearman's correlation was calculated to determine whether there was a correlation between the axial angle and frontal angle used in position C. The alpha level for statistical significance was set at $P < 0.05$ and 0.017 (0.05/3) for the Wilcoxon signed ranks test (SPSS, version 17.0, SPSS Inc, Chicago, IL, USA).

Results

Position A (0°/60°) resulted in femoral tunnel placement furthest from the center of the ACL footprint (8.6 ± 1.8 mm). Position B (45°/45°) was closer than Position A, but still had an average distance of 3.2 ± 1.5 mm away from the center of the footprint. Position C (direct visualization) was the most accurate, with an average distance from ACL center of 2.0 ± 0.9 mm. The angles required by Position C varied with an angle of in the frontal plane $54^\circ \pm 11^\circ$ and $44^\circ \pm 6^\circ$ in the axial plane. There was a statistically significant difference (P -value < 0.001) between all groups, as well as between all pairs (P -value < 0.001). The Spearman's correlation was $r = -0.13$ ($P = 0.58$) showing that there was no significant correlation between frontal and axial plane positioning on direct visualization (Position C). Intra-tester and inter-tester reliability

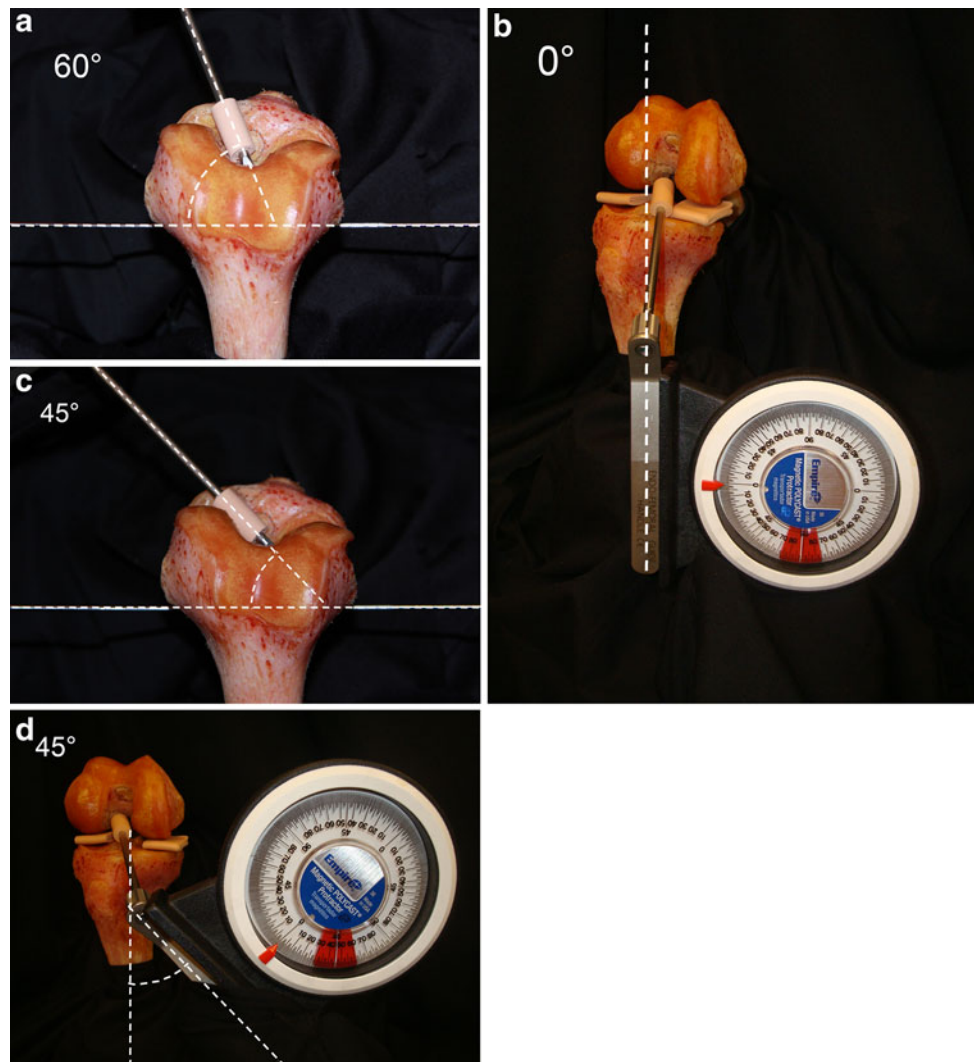


Fig. 1 Aimer positions **a** position A-60° in axial plane, **b** position A-0° in frontal plane, **c** position B-45° in axial plane, and **d** position B-45° in frontal plane

correlations for A, B, and C were all between 0.980 [95% CI 0.948–0.992] and 0.998 [95% CI 0.995–0.999].

Discussion

The most important finding of this study is that the transtibial aimer with 7-mm offset cannot reach the center of the ACL footprint at a fixed orientation. Thus, it is not possible to give a specific procedure for using the aimer through the AM portal to find the center of the ACL footprint. This is supported by the data that show the range for angle in both axial and frontal plane required to reach the ACL center by direct visualization was very large.

Few studies have been performed to determine whether the femoral tunnel can be positioned at the center of the

ACL footprint with a transtibial aimer [5]. For anatomical ACL, it is best to visualize the proximal stump of the ACL [20]; however, in chronic cases the ACL attachment can have disappeared and bony landmarks can be difficult to find in the notch area by arthroscopy, so the use of a guide could aid the surgeon in performing anatomic ACL reconstruction if the technique could be standardized. Arnold et al. demonstrated that it is impossible to reach the center of the ACL footprint using the aimer through the transtibial tunnel and only in some knees could the anterior border (or most superior part in 90° of knee flexion) of the native femoral ACL insertion site be reached [1]. They concluded that the use of an aiming device through the transtibial tunnel leads to a non-anatomical position of the graft on the femoral side, and it was suggested that an anteromedial portal can be used to reach a more anatomical femoral tunnel position.



Fig. 2 CT scan showing **a** axial, **b** sagittal, and **c** coronal views. Aluminum bead is indicated by the *arrow*

In this study, a widely known guide for the transtibial technique was used to attempt to reach the center of ACL footprint using an accessory AM portal approach [20]. Having an accessory AM portal as the viewing portal has the advantage of a better visualization of lateral wall of the intercondylar notch and consequently of the ACL footprint and a notchplasty is not necessary to view the lateral wall of the notch [7, 16, 18, 20]. Anatomical ACL reconstruction can be performed freehand but considerable experience, and a good knowledge of the anatomy is required [6, 10, 15], which led to this study to explore whether a

common device can be reliably used to determine the center of the ACL footprint on the femur.

In this study, the accessory anteromedial portal approach was simulated and two fixed positions (A and B) were chosen that could be easily reproduced in a clinical situation to evaluate whether the aimer could be used to find the center of the footprint. Position A was chosen from gross observation because it was seen that in many knees that the position closest to the ACL footprint was with the aimer perpendicular to the tibial axis (0° on frontal plane) and approximately 60° in the axial plane. Position B is also easily reproducible because the angle for the aimer was 45° in both the axial and frontal planes. With this position, the aimer was either inside the ACL footprint or at the least on the anterosuperior boundaries of the ACL footprint. The results showed that both positions at fixed angles did not reach the center of the ACL footprint in all cases. The point chosen by position A had a distance of 8.6 ± 1.8 mm from the center of the ACL footprint, and for position B the distance was 3.2 ± 1.5 mm. It was observed that the distance from the position A was large and many times even outside of the ACL footprint in the posterosuperior part of the lateral notch. For position B, in three knees, it was impossible to place the aimer in the 45° position on the axial plane because the medial condyle was too large, but it was attempted to stay as close as possible to the 45° angle (48° , 49° , 51°). It was observed that the point found by position B was close to that of position C, it was always inside the ACL footprint and in few cases close to the superior limit of the boundaries of the attachment with knee flexed at 90° . While position B was closer to the ACL footprint center than position A, it was more dependent on the morphology of each knee and in this position the aimer seemed to be at risk of damaging the cartilage of the medial condyle. This is something to avoid, especially when the diameter of the reamer is too large or when the intercondylar notch is narrow [22].

Position C (direct visualization) was the closest to the actual center of the footprint, and found by estimating the center ACL from the outline of the ACL insertion marked by 1.5-mm drill holes. The software calculated the actual center of the outlined geometry and then the distance to the center to the point determined by position C. This distance was 2.0 ± 0.9 mm. The measured angle on axial and frontal plane for position C was found to have mean of 44° for the axial and 54° for the frontal direction. However, because the range for the angle in both planes was very large (32° – 68° for the frontal plane and 36° – 59° for the axial plane), these data are not very useful in determining a specific aimer position for locating the center of the insertion site.

A limitation of this study is that fresh frozen human knees were not used, but nineteen human cadaveric knee bones with a standardized articular space. Even though the knees

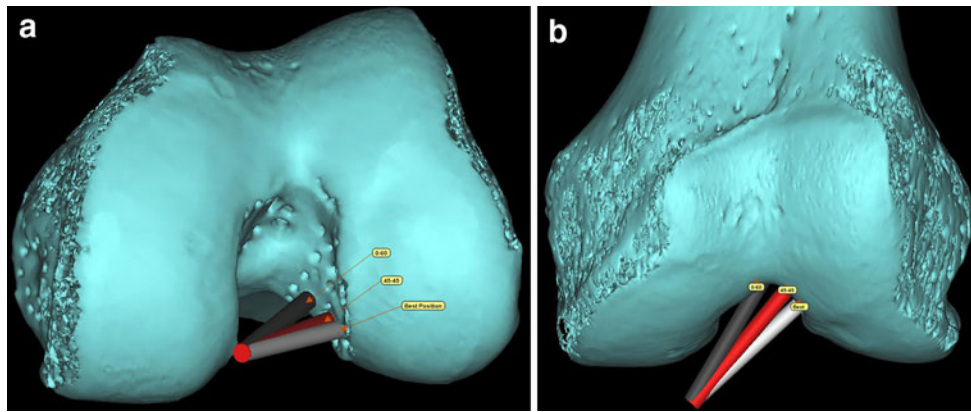
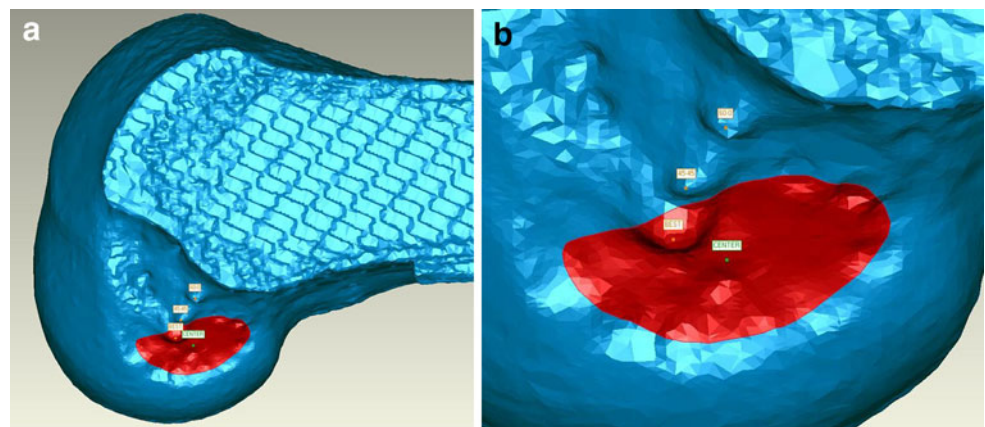


Fig. 3 The three different positions in **a** the frontal view and in the **b** axial view: *black cylinder* 0°–60° (Position A), *red cylinder* 45°–45° (Position B), and *grey cylinder* under direct visualization (Position C)

Fig. 4 Femur with medial condyle cut showing ACL footprint shown in red with Positions A, B, C and calculated footprint center in **a** standard view and **b** enlarged view



had all the soft tissue removed, including skin, subcutaneous, fat pad, and menisci, the ACL footprint could still be located using the intact ACL, which was not removed until after marking the borders of the insertion sites. The nineteen specimens allowed the use of very reliable landmarks, such as the posterior line for measuring the exact angle in the axial plane, which it is not possible arthroscopically in vivo with intact specimens with soft tissue. This may overestimate the ability to reach the femoral ACL insertion site with the aimer under direct visualization.

Conclusion

As hypothesized, this study found that the 7-mm offset aimer is unable to reach the center of the ACL footprint on the femur at a fixed angle. The angle under direct visualization had a large variation among specimens, making it impossible to give a specific orientation for the use of this transtibial aimer for anatomical ACL reconstruction through the accessory medial portal.

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