A COMPARISON OF FOUR COMMON RADIOGRAPHIC VIEWS IN THE ASSESSMENT OF POSTOPERATIVE ACL RECONSTRUCTION FEMORAL TUNNEL ORIENTATION USING THE CLOCK FACE METHOD

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Objective: The purpose of this study was to assess the differences in apparent ACL femoral footprint location between four commonly used radiographic views, and to determine which view most consistently places the native ACL femoral origin at a previously described target clock-face position in the femoral intercondylar notch.
Methods: Using six cadaveric knees, the position of each femoral ACL footprint center was marked with a 2.0 mm Kirschner wire, and images were taken using four common radiographic views: 1) AP in extension, 2) PA Tunnel View with the knee in 20 degrees of flexion, 3) Rosenberg View, and 4) AP Axial Intercondylar View with the knee in 60 degrees of flexion. Four surgeons estimated the clock positions of the wires on each radiographic image on two different occasions, and the distance in minutes between each estimate and the described target clock-face position of two-o'clock for a left knee and ten-o'clock for a right knee was recorded. Radiographic views were compared using linear mixed models to account for the correlation of repeated assessments within specimen and within surgeon. Additionally, to assess rates of clinical accuracy of the radiographic views, clock values within a "half hour" of the target clock-face position were labeled as "accurate", those more than a "half hour" away from the target as "inaccurate", and accuracy rates were compared using the chi-square test of homogeneity.
Results: The distance between depicted clock position of the ACL femoral origin and the target clock position was lowest in the Axial Intercondylar view, which was significantly different from both the Tunnel view with the knee in 20 degrees of flexion and the AP view in extension (p less than 0.0001). The distance off target in the Rosenberg view was in between those of the Axial Intercondylar view and the other two views, and was not significantly different from any other view. When further evaluating for clinical accuracy, our results indicated differences in the accuracy rates of the four radiographic views (p less than 0.0001) with AP Extension accuracy of 8%, Tunnel View 38%, Rosenberg 58%, and Axial Intercondylar 92%. For the four views evaluated in this study, accuracy increased as the offset of the central ray from the long axis of the femur decreased.
Conclusion: Of the four radiographic views assessed in this study for postoperative evaluation of femoral tunnel orientation using the clock face method, the AP view of the knee in full extension possesses the largest potential for misrepresentation of the femoral tunnel orientation. The AP axial intercondylar radiographic view with the knee in 60 degrees of flexion yields the least potential for misrepresentation of the femoral tunnel orientation.

Introduction: ACL Reconstructive surgery is a common orthopedic procedure. Accurate femoral tunnel placement during reconstruction is critical to the overall success of the procedure. Several studies have identified misplacement of the femoral tunnel as a common factor leading to ACL revision surgery[1, 2]. When drilling the femoral tunnel, the

knee is placed into flexion to facilitate visualization of the ACL femoral footprint, which is the desired location for placement of the femoral tunnel. The orientation of the footprint has been described as a position on a clock-face, and surgeons take care to drill the femoral tunnel at this target clock-face position in order to ensure proper tunnel location.

The clock position of the femoral tunnel is commonly evaluated on postoperative radiographs in order to assess femoral tunnel orientation. This might be done when planning revision surgery, when assessing postoperative patients with continued laxity, or when surgeons wish to critically evaluate tunnel position as a matter of perfecting their reconstruction technique. However, the ideal radiographic view for postoperative evaluation of femoral tunnel placement remains to be determined. Standard radiographs of the knee do not replicate or take into consideration the flexed position of the knee at the time of surgical tunnel placement and thus may not allow for accurate determination of femoral tunnel orientation[3]. The goal of this study was to reveal which radiographic view results in the most accurate assessment of femoral tunnel placement.

Methods: Six fresh frozen cadaveric knee specimens were stripped of skin, subcutaneous fat, and muscle, leaving the femur, tibia, and ligamentous attachments in place. The native ACL was identified and sharply resected from its femoral and tibial insertions. The center of the femoral ACL footprint was identified with the knee in maximum flexion, a single 2.0mm Kirschner wire inserted in the center of the footprint via an anteromedial portal trajectory, and the wire cut shear at the bone surface. Thus, the Kirschner wire represented the path of an ACL femoral tunnel placed in the center of the ACL femoral footprint.

Radiographs were then obtained for each specimen using four different radiographic positions/techniques: 1) AP in Extension, 2) PA Tunnel View with the knee in 20 degrees of flexion, 3) Rosenberg View, and 4) AP Axial Intercondylar View with the knee in 60 degrees of flexion. These radiographic methods were performed as described in Merrill's Atlas of Radiological Positions and Radiological Procedures, 10th Edition, with the exception of the Tunnel view, which was performed with the knee in 20 degrees of flexion as is commonly done in the NMCSD radiology department, rather than with the knee in 70 degrees of flexion as described in the text. Appropriate knee angle measurements were verified by use of a goniometer[4], and images were saved for future analysis.

The position of the femoral ACL footprint center, as represented by the Kirschner wire, was assessed using a clock-face method as proposed by the scientific committee of ESSKA[5]. In the particular technique employed in this study, the 3-o'clock and 9-o'clock positions were defined by a line drawn between both intercondylar walls at the points of interface with the articular cartilage. Images were randomized and assessments performed in a blinded fashion on two separate occasions by four surgeons. Clock positions of the wires on the radiographic images were recorded and their distances away from the described target clock position of 2 o'clock for a left knee and 10 o'clock for a right knee were determined and recorded as minute values.

Statistical Methods: Minute value distances of the wires from the described target values for each radiographic view were compared using linear mixed models to account for the correlation of repeated assessments within specimen and surgeon. Additionally, to assess

rates of clinical accuracy of the radiographic views, clock values within a “half hour” of the target clock-face position were labeled as “accurate”, and those more than a “half hour” away from the target as “inaccurate”. Accuracy rates were compared using the chi-square test of homogeneity.

Results: Six Cadaveric Specimens with mean age 79 (Range 56-98) were utilized for this study. The distance between depicted clock position of the ACL femoral origin and the target clock position differed between the AP Axial Intercondylar view, which was lowest, and both the AP Extension and PA Tunnel views (p<.0001). The distance from target of the Rosenberg view fell between the values for the Axial Intercondylar view and the other two views, and was not found to be significantly different from any other view. The adjusted mean (95% confidence interval) of the four types of radiographs are shown in Table 1.

Table 1. The mean and 95% C.I. of the distance in minutes between ACL femoral tunnel orientation and target clock position of 2-o’clock for left knees and 10-o’clock for right knees, as determined by using the clock face method in four commonly used radiographs.

	AP Extension	PA Tunnel 20	Rosenberg View	AP Axial Intercondylar 60
Mean (95% C.I.) of Distance from Target	49.7 (39.5-59.9)	41.9 (31.7-52.0)	32.2 (22.1-42.4)	20.9 (10.8-31.1)

When further evaluating for clinical accuracy, our results indicated differences in the accuracy rates of the four radiographic views (p<.0001) with AP Extension accuracy of 8%, Tunnel View 38%, Rosenberg 58%, and Axial Intercondylar 92% (shown in Table 2).

Table 2. The accuracy of four commonly used radiographs in depicting the ACL femoral origin at a described target clock position. Radiographic views depicting differences greater than 30 minutes between observed femoral tunnel orientation and target clock positions were considered inaccurate, while those depicting differences of less than or equal to 30 minutes were considered accurate

	% of accurate assessments (Less than or equal to 30 minutes from target)
AP Extension	8%
PA Tunnel 20	38%
Rosenberg View	58%
AP Axial Intercondylar 60	92%

Conclusion: Our study demonstrates that when evaluating postoperative radiographs after ACL reconstruction for femoral tunnel orientation using the described clock face method, the Axial Intercondylar radiographic view yields the closest approximation as well as the highest accuracy rate. Our data further suggest that the use of AP radiographs of the knee in extension should be avoided when using the clock face method to evaluate ACL femoral tunnel placement after ACL reconstruction.

Discussion: This study is elegant in its simplicity, but has obvious limitations. First, greater specimen numbers and more objective, precisely quantifiable measurements of tunnel

position would improve further studies, perhaps by revealing a statistically significant difference between the Axial Intercondylar and Rosenberg views. Second, our study used the center of the ACL femoral origin for the location of the femoral tunnel, which is specific to single bundle ACL reconstructions. For practitioners who favor the origin of the anteromedial bundle for placement of a single bundle, or for those who favor double bundle repair, the study would need to be repeated with K-wires placed in the appropriate locations for those types of repairs. Siebold *et al.* have reported that during arthroscopy, when the femoral shaft was elevated 12^{o} from horizontal with the knee in 102^{o} of flexion, both the anteromedial and posterolateral bundles aligned at the 1-o'clock position (+/- 30 min.) for left knees and the 11-o'clock position (+/- 30 min.) for right knees. Further studies might determine which radiographic view most consistently places the origins of both ACL femoral bundles at a single clock position, and describe the mean and standard deviation of that clock position for practitioners who wish to evaluate tunnel orientation following double bundle ACL repair. Lastly, based on the described radiographic techniques, accuracy of the views appeared to increase as the angle between the central ray of the radiograph and the long axis of the femur decreased. Thus, the AP Extension view with the central ray perpendicular to the femur was least accurate, and the AP Axial Intercondylar view with the knee in 60 degrees of flexion and the central ray 30 degrees off of the long axis of the femur was the most accurate. This raises the question of whether or not the Tunnel view, if performed as described in Merrill's Atlas, would be more accurate than the Axial Intercondylar view. The common method employed at NMCSD and in this study, places the knee in 20 degrees of flexion and the central ray offset from the femoral axis by 70 degrees; close to perpendicular. If performed as described in the text, with the knee in 70 degrees of flexion and with the central ray only 20 degrees offset from the femoral axis, the results of this study might have been very different.

References

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