The Safe Zone for Cross-Pin Fixation in Anterior Cruciate LigamentReconstruction using Anteromedial Portal Technique

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ABSTRACT

The risk of neurovascular injury is inherent to cross-pin femoral fixation for ACL reconstruction. Therefore, we determined a safe-zone of cross-pin drill angles. Five cadaveric mid-thigh-to-mid-knee specimens underwent ACL reconstruction using the anteromedial portal to drill the femoral tunnel and a cross-pin femoral fixation system. Guide-pins were passed through the femur at -40°°, -20°, 0°, and +20°, with 0° being horizontal, negative angles when the guide-pin started posteriorly, and positive angles when the guide-pin started anteriorly. Distance between guide-pin and peroneal nerve, femoral artery, and saphenous nerve were measured. As the guide-pin was rotated from -40° to +20°, the average distance between the pin and peroneal nerve increased, the average distance between the pin and the femoral artery decreased, and the average distance between the pin and saphenous nerve decreased. The femoral artery was at risk for rupture by the cross-pin at +20°, and the saphenous nerve was at risk at 0° and +20°. Our results indicate that the safe range for cross-pin drilling is between -40° -20°.

INTRODUCTION

Anterior cruciate ligament (ACL) reconstruction remains one of the most common knee surgeries in the United States, with over 100,000 surgeries performed annually [1]. Variation in surgical technique and the desire to improve clinical outcomes have prompted much research. Two areas of ongoing study include femoral tunnel placement and fixation technique.

A more traditional approach to femoral tunnel placement is the transtibial technique, wherein the femoral tunnel is drilled via a previously established tibial tunnel. This technique has been validated in peer-reviewed literature and is the preferred technique for many surgeons [2, 3]. However, evidence has emerged suggesting that the center of the femoral ACL footprint is inaccessible when using the transtibial technique due to spatial restrictions imposed by the tibial tunnel [4]. Some advocate aiming for the center of the ACL footprint in order to ensure anatomic placement of the graft tunnel and avoid tunnel malpositioning, which has been associated with graft failure [5]. Thus, an alternative technique has emerged wherein the femoral tunnel is drilled through an anteromedial (AM) arthroscopic portal [6, 7]. Using this technique, which we refer to hereafter as the AM portal technique, surgeons have achieved positions that are more posterior and lateral on the lateral femoral condyle compared to the transtibial technique [8].

A popular choice for femoral fixation is the Arthrex® TransFix® system (Arthrex, Naples, FL). This technique involves suspending the ACL graft from a cross-pin inserted lateromedially across the distal femur. Cross-pin fixation has been praised for its fixation strength with soft-tissue grafts and good clinical outcomes [9-11]. However, this technique requires an incision near the lateral distal femur and drilling a guide-pin across the distal femur and through the skin on the medial side. This creates additional risk for damaging neurovascular structures that traverse the knee joint; namely, the peroneal nerve laterally, the femoral artery posteriorly, and the saphenous nerve medially [12].

A recent study described a "safe zone" for cross-pin fixation with the Arthrex® TransFix® system using the transtibial technique to drill the femoral tunnel [12]. Since the orientation of the femoral graft tunnel is different in a tunnel drilled via an AM portal, one would expect the orientation of the cross-pin guide pin tunnel to be different as well. Therefore, we performed an anatomic study to determine the safe zone for cross-pin placement using the AM portal technique and the Arthrex® TransFix® system.

MATERIALS AND METHODS

Five right extremities from mid-thigh to mid-leg underwent arthroscopic surgery. Each knee was mounted on a clamp so that the shaft of the femur was parallel to the floor and the leg flexed to 90°. Standard arthroscopic portals were established on either side of the patellar tendon. Once the ACL was identified as intact, it was resected and the attachments preserved. A 9mm femoral tunnel was drilled over the center of the ACL

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footprint. Once the femoral tunnel was drilled, the legs were partially dissected to identify the pertinent neurovascular structures. Next, a TransFix® drill guide was inserted through the AM portal into the graft tunnel. The guide was rotated about the axis of the femoral tunnel until the guide pin sleeve was in the same plane as the femoral shaft (the horizontal plane, parallel to the floor). This position was set at 0°. A 3mm cross-pin drill guide was inserted through the sleeve, then passed through the femur and out through the skin medially. A ruler with 1 mm accuracy was used to measure the shortest distances between the tip of the guide pin and: a) the saphenous nerve; b) the femoral artery; and c) the peroneal nerve. Following this, the guide pin was removed and reset at various angles with respect to the horizontal. The cross-pin was redrilled at various angles above and below the horizontal plane (positive and negative angles, respectively).

RESULTS

As the drill guide was moved anteriorly from -40° to +20°, the average distance between the pin and the peroneal nerve increased. The peroneal nerve was safe at all angles between -40° and +20°. As the guide pin moved more anteriorly from -40° to +20°, the average distance between the guide pin and the femoral artery decreased. The femoral artery was safe between -40° and 0°. However, at +20° the femoral artery was at risk for rupture. As the guide pin moved anteriorly from -40° to -20°, the average distance between the pin and the saphenous nerve decreased. The saphenous nerve was safe between -40° and -20° but was at risk from 0° to +20°.

DISCUSSION

Cross pin fixation with the TransFix® device has become increasingly common for ACL reconstruction with soft tissue grafts. Several studies have shown that cross-pin fixation provides superior biomechanical properties compared to other techniques for soft tissue fixation [10, 13, 14]. Two studies have found that using the TransFix® system significantly reduced tunnel widening compared to fixation with an interference screw [15] or EndoButton® CL [16]. Clinical studies have found fixation with the TransFix device to be as effective as interference screw fixation [11]. However, there are reports of complications with cross-pin fixation, wherein the cross-pin migrated from its tunnel and protruded into the soft tissue [17, 18].

Femoral tunnel placement is another important consideration. Traditionally, the femoral tunnel is placed at the 11:00/1:00 o'clock position. However, there is biomechanical evidence that grafts placed lower on the clock face (i.e. more laterally) provide increased resistance to rotatory stress compared grafts in the 11:00/1:00 o'clock positions, while providing the same resistance to anterior tibial translation [19]. There is also evidence from clinical studies showing that lower femoral tunnels are correlated with less residual pivot shift, more favorable International Knee Documentation Committee evaluation form scores, and more favorable Lysholm scores [5, 20, 21]. It has been demonstrated that surgical technique can affect femoral tunnel placement [4, 22, 23]. In a study using cadaveric knees,

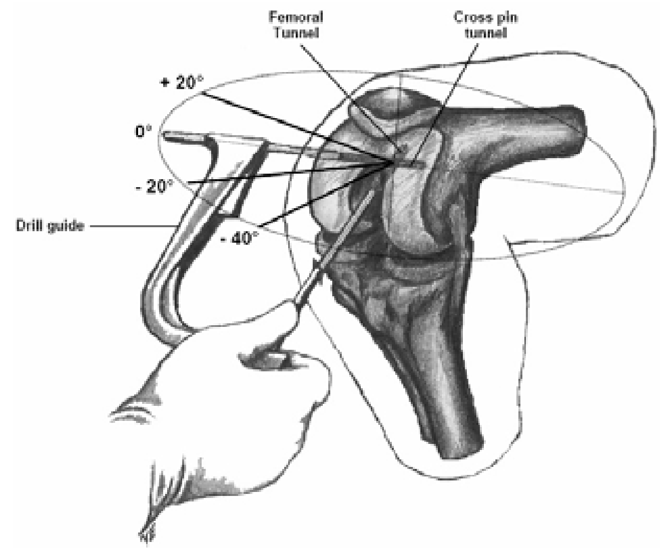

Figure 1 – Passing the guide-pin through the lateral femoral cortex using the AM portal technique. The drill guide was rotated about the axis of the femoral tunnel. The reference point (0°) was defined as the position at which the guide pin sleeve was parallel to the floor, in the same plane as the femoral shaft. Positive angles (+20°) correspond to rotating the guide anteriorly; negative angles (-20° and -40°) correspond to rotating the guide posteriorly.

Arnold et al. were unable to reach the femoral ACL insertion site through a transtibial tunnel [22]. Kaseta et al. showed that the transtibial technique places the femoral tunnel significantly further from center of the anatomic ACL insertion than an independent drilling technique [4]. Golish et al. showed that when drilling transtibially, a more medial tibial tunnel will allow a more lateral femoral tunnel and that drilling through an AM portal allows placement of the femoral tunnel at or more lateral than 10:00 [23]. These and other studies have prompted many surgeons to use the anteromedial portal approach to drill the femoral tunnel.

McKeon et al. recently established a safe zone for cross-pin drilling using the transtibial technique [12]. In their analysis, the distance between pin and femoral artery and the distance between pin and saphenous nerve decreased as the drill guide was repositioned from posterior to anterior (-40° to +40°), while the distance between the pin and peroneal nerve increased. Our results show a similar trend, which suggests that the change in femoral tunnel orientation does not lead to a large change in the safe zone limits. McKeon et al. showed that the cross-pin violated the femoral artery safe zone between 0° and +40° and the saphenous nerve between +20° and +40°. Similarly, our results indicate a violation of the femoral artery safety zone at +20° and the saphenous nerve safety zone from 0° and +20°.

Our results suggest that it is safe to orient the cross-pin drill guide between -40° and -20° when the femoral tunnel has been drilled via an anteromedial portal. If the guide is rotated to 0°, the risk for damaging the femoral artery increases. If the drill guide is rotated beyond 0°, then both the femoral artery and the saphenous nerve are vulnerable to penetration by the guide pin.

There are a number of limitations to our study. The small sample size (n=5) limits the extent to which our data can be generalized to the population seeking ACL reconstruction. Also, since we used cadaveric knees that had been transected at the mid-thigh and mid-leg, it is possible that the soft tissues became distorted relative to their normal positions *in vivo*. In order to minimize this effect, we dissected as little soft tissue as possible to make distance measurements. In the future, it would be beneficial to compare the safe zones of cadaveric knees with both transtibially drilled femoral tunnels and femoral tunnels drilled via an AM portal, using more samples for each group. This would allow one to compare the safe zones of the two techniques while controlling for anatomic variation.

CONCLUSION

In conclusion, we have shown that there is a 40° safe zone, from -40° to 0°, within which a cross-pin guide pin can be placed avoiding the peroneal nerve, the femoral artery, and the saphenous nerve, when keying off of a femoral tunnel drilled via the anteromedial portal.

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