Anterior Cruciate Ligament Femoral Tunnel Length: Cadaveric Analysis Comparing Anteromedial Portal Versus Outside-In Technique

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Purpose: The purpose was to measure anterior cruciate ligament (ACL) femoral tunnel lengths comparing anteromedial (AM) portal and outside-in techniques. Methods: ACL femoral guide pins were drilled into 12 cadaveric knees through the AM portal technique and then the outside-in technique in each specimen. Pin intraosseous distance was measured in millimeters by a MicroScribe 3-dimensional digitizer (Immersion, San Jose, CA). Results: With the AM portal technique, the mean ACL femoral tunnel distance was 30.5 mm. With the outside-in technique, the mean ACL femoral tunnel distance was 34.1 mm. The difference was statistically significant (P = .04). Conclusions: Our results show that the outside-in technique for creating the ACL femoral tunnel results in a longer mean tunnel length than the AM portal technique for creating the ACL femoral tunnel. The outside-in technique best prevents excessively short tunnels. Clinical Relevance: Our results have clinical relevance for surgeons who desire to perform independent, rather than transtibial, drilling of the ACL femoral tunnel and desire adequate length of tendon graft within the femoral bone tunnel.

Historically, arthroscopic anterior cruciate ligament (ACL) reconstruction evolved from a 2-incision technique using outside-in femoral tunnel drilling (over-the-top guide) to an arthroscopic transtibial technique.1,2 Currently, interest in anatomic (single- and double-bundle) ACL technique has led to reconsideration of proper femoral tunnel positioning, as well as an understanding that independent drilling of tibial and femoral tunnels in ACL reconstruction may be more anatomic than the transtibial technique for femoral ACL tunnel creation, because the transtibial technique risks compromise of tunnel position because of transtibial constraint.3,4

As a result of the desire to perform independent drilling during creation of the ACL femoral tunnel, there has been an interest in an anteromedial (AM) portal technique for femoral tunnel creation.4-9 On the other hand, other authors have continued to favor an outside-in (2-incision) femoral tunnel technique,10,11 and outside-in drilling may gain a new following as a result of new outside-in drilling techniques11-13 with retractable retrograde cutting bits (FlipCutter; Arthrex, Naples, FL) that require only a portal-sized stab wound rather than a lateral incision and dissection.

A reported risk of the AM portal technique for ACL femoral tunnel creation is short tunnel length.3,5 This concern is of clinical relevance because short tunnels can result in reduced length of tendon graft within the femoral bone tunnel.14

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The purpose of this study is to measure ACL femoral tunnel length comparing AM portal and outside-in techniques. Our hypothesis was that the outside-in technique will result in a longer ACL femoral tunnel intraosseous distance than the AM portal technique.

METHODS

In 12 paired cadaveric knees, the ACL was debrided by use of arthroscopic anterolateral portal visualization and an AM portal arthroscopic shaver. Bony notchplasty was not performed.

We then performed the AM portal technique for the ACL femoral socket as has been previously described. A 6-mm-offset endoscopic aimer (the diameter is arbitrary but this diameter is often used in our clinical experience) was placed via a low, medial AM portal at the 10-o’clock position (left knee) or 2-o’clock position (right knee) as defined on a clock face on the lateral wall of the femoral intercondylar notch with the knee at 90° of flexion. Then, a 2.4-mm-diameter Beath pin was seated at the mark, the knee was moved into a position of maximum hyperflexion, and the pin was drilled out the anterolateral, distal femur (from a low and medial portal position established to attempt maximum femoral tunnel length) (Fig 2). We used a Beath pin to shuttle a Nitinol wire to mark the AM portal technique’s femoral intraosseous tunnel during subsequent outside-in drilling. It is important to use a wire rather than a suture, because wire is more robust and less likely to tangle with the guide pin during the step next described.

With the wire still in place, the arthroscope was moved to an AM portal viewing position, the tip of a 110° over-the-top femoral outside-in ACL aimer (Fig 1) was placed precisely at the intra-articular footprint centrum, and a 3.5-mm outside-in minimally invasive drilling pin was introduced through a stab incision at the distal midlateral femoral metaphyseal flare, 4 cm proximal to the lateral epicondyle, and drilled to create an outside-in femoral tunnel. The 110° angle of the guide is arbitrary but an angle used often in our clinical experience (Fig 3).

A high-strength suture was passed to mark the outside-in technique’s femoral intraosseous distance before dissection and measurement as described later.

The distal femur was then stripped of soft tissue, and a bioengineer used a 3-dimensional digitizer (MicroScribe G2; Immersion, San Jose, CA) to identify and record guide pin intra- and extra-articular exit points from the femur (Rhinoceros software, version 3.0 SR3; Robert McNeel & Associates, Seattle, WA) (Fig 4). The interosseous distance was calculated by use of SolidWorks Office Premium measurement software, version SP2.1 (Dassault Systèmes SolidWorks, Concord, MA). A linear regression anal-
ysis was conducted to determine whether there was a correlation between donor height versus tunnel length and donor weight versus tunnel length. For linear regression analysis, all distance results (AM portal and outside in) were combined to add statistical power to the analysis.

Statistical Methods

It was estimated that 6 cadaveric pairs (12 samples) would be adequate to achieve a statistical power of 0.80. Significant differences were shown for the primary outcome measure on a post hoc basis, eliminating the need for further testing. Paired t tests were performed by use of SigmaStat software, version 3.10.0 (Systat Software, Point Richmond, CA).

RESULTS

With the AM portal technique, the mean ACL femoral interosseous distance was 30.5 mm (range, 18.4 to 38 mm; SD, 4.9). With the outside-in technique, the mean ACL femoral interosseous distance was 34.1 mm (range, 25.0 to 41.2 mm; SD, 5.3). The difference was statistically significant (P = .04). The results are summarized in Table 1.

Demographic data (donor age, gender, height, and weight) are summarized in Table 2. Femoral interosseous distance directly correlates with donor height and donor weight. The slope of the regression line for donor height versus tunnel length was 0.958 mm/in and was statistically significant (P = .002); the scatter plot and regression line are shown in Fig 5A. The slope of the regression line for donor weight versus tunnel length was 0.065 mm/lb and was statistically significant (P = .004); the scatter plot and regression line are shown in Fig 5B.

DISCUSSION

Our results show that the outside-in ACL femoral tunnel technique’s mean intraosseous distance is statistically significantly greater than that of the AM portal technique.
The mean outside-in tunnel length was 34.1 mm, and in no case was a tunnel less than 25 mm long. Short tunnel length is an issue for surgeons desiring to avoid the risk of inadequate graft tissue within a tunnel. This is particularly clinically relevant for suspensory fixation using a button and suture loop, because the loop of the device leaves less length of graft within the tunnel. The minimum length of graft within the tunnel has not been reported in humans. A clinical demonstration of the surgeon’s (J.H.L.) current method using the outside-in technique for creating the ACL femoral socket and achieving suspensory fixation using a button and suture loop appears in Video 1 (available at www.arthroscopyjournal.org).

The surgeon’s subjective observation was that outside-in drilling with 90° of knee flexion seemed both less difficult and safer than AM portal drilling in knee hyperflexion, consistent with the pitfalls and risks of the AM portal technique that have previously been described.9,15

Giron et al.16 found no differences in the accuracy of tunnel positioning using outside-in, transtibial,
and AM portal techniques for creating the femoral tunnel. Tunnel length was not reported. Similarly, we subjectively observed accurate positioning at the intra-articular ACL femoral footprint centrum with both outside-in and AM portal techniques.

The mean tunnel length with the AM portal technique was 30.5 mm. Previous authors have measured ACL femoral tunnel intraosseous distance using the AM portal technique. An investigation of ACL posterolateral (PL) bundle found a femoral tunnel length of 36.9 mm using the AM portal technique in 2008.5 This distance is longer than our finding, and a limitation of our study is that we did not examine the PL bundle. A second 2008 study evaluated the AM portal technique for creating the ACL femoral tunnel at varying knee flexion angles, and a significantly shorter ACL femoral tunnel intraosseous length was reported at knee flexion of 90° (27.1-mm tunnel length) than at 110° (38.9 mm), 130° (38.8 mm), and maximum flexion (39.2 mm).6 Again, the hyperflexion distance is greater than the mean tunnel length with the AM portal technique that we reported.

We are unable to explain why we found shorter tunnels than in the studies cited previously.5,6 As expected, tunnel length correlates with donor height and weight; variations in specimens could explain the differences in tunnel lengths, in part.

Moreover, in support of our findings, other recent publications reported short ACL femoral tunnels using the AM portal technique. Specifically, another 2008 publication evaluating the AM portal technique at varying knee flexion angles reported, “PL and AM femoral tunnel length increased with knee flexion. PL tunnel lengths averaged 27.2, 31.5, and 31.7 mm at 90°, 110°, and 130° of knee flexion respectively. AM tunnel lengths averaged 24.2, 27.8, and 32.5 mm at 90°, 110°, and 130° of knee flexion respectively. Transtibial guidewire passage significantly increased AM tunnel length to 42.2 mm for trans-AM tunnel passage and 46 mm for trans-AM tunnel passage (P < .05).”7 Similarly, in 2007, the AM portal technique resulted in a very short ACL femoral tunnel length of 23 mm with the knee flexed to 120° (and compared with longer transtibial tunnels).3

A limitation of our study, in addition to our not evaluating the PL bundle as described previously, is that the outside-in femoral starting point and drill angle are arbitrary. This is in contrast to the AM portal drill angle, which is constrained because of the combination of knee hyperflexion and portal fixed position just above the medial meniscus and lateral to the medial femoral condylar articular cartilage.5,9 This flexibility with regard to the outside-in starting point may represent an actual clinical advantage of the outside-in technique, because the outside-in technique uses over-the-top guides, which allow intraosseous distance measurement before drilling by observing laser marks on the guide pin sleeve; if the distance is too short, manipulation of the drill angle and starting position can be performed to achieve a longer tunnel before drilling, whereas with the AM portal technique, intraosseous distance cannot be measured before pin passage. (However, in this cadaveric analysis, we used fixed bony landmarks [4 cm proximal to the lateral epicondyle] for outside-in drilling, and the drill angle was not manipulated.) Future research could more specifically dissect outside in to bone on the femur to standardize the anatomic starting position of the outside-in pin on the femur. This might reduce the variability of the results, but clinically (as described previously), outside-in skin dissection is avoided by use of a FlipCutter pin, where using a stab incision is less invasive than dissection.

Another limitation is that we did not measure pin proximity to neurovascular structures or articular cartilage comparing the outside-in and AM portal techniques for ACL femoral socket preparation. Future research could specifically test the hypothesis that the outside-in technique is safer than the AM portal technique for creating the ACL femoral socket, as has previously been suggested.9,15

CONCLUSIONS

The outside-in technique for creating the ACL femoral tunnel results in a longer mean tunnel length than the AM portal technique for creating the ACL femoral tunnel. The outside-in technique best prevents excessively short tunnels.

REFERENCES


