Introduction: With most posterior cruciate (PCL) reconstruction techniques, the distal end of the graft is fixed within a tibial bone tunnel. Although the surgical goal is to locate this tunnel at the center of the PCL’s tibial footprint, errors in medial-lateral tunnel placement of the tibial drill guide are possible because the position of the tip of the guide relative to the PCL’s tibial footprint can be difficult to visualize from the standard arthroscopy portals. This study was designed to measure changes in knee laxity and graft forces resulting from mal-position of the tibial tunnel medial and lateral to the center of the PCL’s tibial insertion.

Methods: Ten fresh-frozen cadaveric knee specimens aged forty-three to sixty-nine years were used; the average age was fifty-six years. A cylindrical block of bone containing the posterior cruciate ligament’s femoral origin was mechanically isolated and attached to a custom designed load cell mounted on the femur. The knee was placed in a laxity test apparatus, an anterior-posterior (AP) force (+200 N) was manually applied to an undercarriage bar attached to the tibial fixture of the apparatus, and tibial displacement was recorded using a spring-loaded transducer. The tibia was fixed in neutral rotation during the tests. Laxity testing was performed at 0, 30, 60, 90, and 120 degrees of flexion. Knee laxity was defined as the total AP displacement of the tibia relative to the femur between the limits of 200N anterior tibial force and 200N posterior tibial force.

A posterior arthrotomy was made, the PCL was excised, and an eleven millimeter tibial tunnel hole was drilled at the center of the PCL’s tibial footprint. Grafts were prepared from tibia-patellar ligament-patella specimens obtained from a tissue bank. Each specimen was split longitudinally into two halves, yielding two grafts per specimen. A ten millimeter wide graft was prepared using the central portion of each half. Both bone blocks of the graft were intertwined with dual strands of a highly flexible 1.1mm diameter stainless steel wire cable. The distal cable strands exited the tibial tunnel anteriorly and were secured by a split clamp mounted to the tibia.

The proximal bone block of the graft was placed into an 11mm diameter cylindrical chamber within an aluminum canister fixed to the femoral load cell; the axis of the chamber was concentric with the axis of the load cell. The graft was pretensioned by applying force to the cable strands of the proximal bone block, which was free to retract proximally within the chamber; a constant 25N anterior force was applied to the tibia during pretensioning. The circular opening at the end of the chamber (through which the graft passed) was located 5mm anterior to center of the native PCL’s femoral footprint; this simulated graft placement at the approximate location of the anterolateral bundle of the PCL. A graft pre-tension was found which reproduced intact AP laxity within 1.0mm at 90 degrees of knee flexion (laxity match pretension), and AP laxity testing was repeated at all flexion angles listed above. The graft was always preconditioned prior to determining the laxity match pretension by applying four complete AP loading cycles to 200N force.

Resultant force in the graft was recorded using the femoral load cell as the knee was flexed from -5 degrees to 140 degrees of flexion. Then a series of constant tibial loading tests were performed during knee flexion from -5 degrees to 120 degrees. The tibial loadings applied were 100 Newton posterior tibial force, 5 N-m varus moment, 5 N-m valgus moment, 5 N-m internal torque, and 5 N-m external tibial torque. The graft was repositioned to the laxity match pretension at the start of each of the test series. Further details of the constant tibial loading tests can be found in our prior publications.

Once testing had been completed with the central tunnel, the hole was plugged with a press-fit cylinder of high density polyurethane foam and a new tunnel was drilled 5mm medial to the old tunnel at the same distance below the posterior margin of the tibial plateau. A new laxity match pretension was determined, and all tests described above were repeated. Finally, the medial hole was plugged with a foam cylinder, a new tibial tunnel was drilled 5mm lateral to the original central tunnel, a new laxity match pretension was determined, and all tests were repeated a final time. Appropriate statistical analysis was performed.

Results: Drilling the tibial tunnel 5mm medial or lateral to the center of the PCL’s tibial footprint had no significant effect on knee laxities.

The graft pretension necessary to restore normal laxity at 90 degrees of knee flexion (laxity match pretension) with the medial tunnel was 13.8 N (29%) greater than with the central tunnel (P< 0.0004) and 8.7 N (17%) greater that with the lateral tunnel (P=0.0004). During passive knee flexion-extension, graft forces with the medial tibial tunnel were significantly higher than those with the central tunnel for flexion angles greater than 65 degrees while graft forces with the central tibial tunnel were not significantly different than those with the lateral tibial tunnel (Figure 1).

Graft forces with medial and lateral tunnels were not significantly different from those with a central tunnel for 100N applied posterior tibial force, 5 N-m applied varus and valgus moment, and 5 N-m applied internal and external tibial torque.

Discussion: The central tunnel was drilled through the center of the native PCL’s tibial insertion (as viewed directly through a posterior arthrotomy); medial and lateral tunnels were referenced to this position. During surgery the tibial tunnel is normally made with the assistance of a drill guide which is designed to position the guide tip 1 cm below the tibial plateau; with some of the newer drill guides the superior-inferior position of the guide tip is adjustable. However the superior-inferior position of all drill guide tips can be varied by tilting the guide relative to the tibial plateau in the sagittal plane. Even though many surgeons use an accessory posterior arthroscopic portal to help assure correct placement of the guide tip, it can still be difficult to visualize the anatomic insertion site of the PCL. Accurate placement of the guide is dependant on adequate visualization of the PCL insertion by the surgeon. Since location of the central tunnel was likely more accurate in our study than would be expected in clinical practice, our results represent a “best case” scenario with respect to the goal of anatomical tunnel placement.

We conclude that surgical errors in medial-lateral placement of the tibial tunnel should be inconsequential with respect to laxity of the reconstructed knee. Errors in lateral tunnel placement would be preferable to placing the tunnel medially in terms of reducing graft force magnitudes during passive knee flexion beyond 65 degrees of flexion. The relatively small increase in laxity match pretension with the medially placed tibial tunnel suggests that a higher graft pretension would be necessary to restore intact knee laxity if this surgical error has been made.

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