FEMORAL TUNNEL POSITION AFFECTS ACL GRAFT FUNCTION: A CADAVERIC STUDY USING TWO ROBOTS

+University of Pittsburgh, Pittsburgh, PA, fax 412-648-2001; decenizod@msx.upmc.edu

Introduction: The placement of the femoral tunnel in ACL reconstruction is a continuing source of debate. Many surgeons position the graft to reproduce the anteromedial (AM) bundle of the ACL while others position the graft in an “isometric” position. Using knee kinematics alone to assess ACL reconstruction technique is inadequate as a prior biomechanical study showed that two unique femoral tunnel positions resulted in similar knee kinematics while the graft in situ forces were different in each [1]. This is important as the ACL graft in situ forces are critical in preventing damage to other soft tissue structures of the knee [2]. Past studies were also hampered by the inability to quantify femoral tunnel placement but a robotic surgery system (CASPAR, U.R.S. Ortho, Germany) was recently found to be accurate [3] and precise [4]. The objective of this study was to quantify the effects of femoral tunnel position on ACL graft in situ forces placing the tunnels with the CASPAR system. We hypothesized that a graft placed near the anatomic footprint of the intact ACL would result in higher graft in situ forces, more closely reproducing the function of the intact ACL, under both an anterior load and a combined valgus torque and internal tibial torque when compared to grafts placed at isometric or anterior positions.

Materials and Methods: Seven human cadaveric knee specimens (average age 47 ±8 years) were tested using a 6 degree of freedom (DOF) robotic/universal force-moment sensor (UFS) testing system [5]. Two external loads were applied to the intact knee at 15° and 30° of knee flexion; 1) a 134 N anterior tibial load and 2) a combined rotational load of 10 Nm valgus and 5 Nm internal tibial torque (“combined load”). The resulting 5-DOF knee kinematics in response to each load were recorded. The ACL was then transected and the robotic manipulator repeated the previously recorded kinematics of the intact knee, while the UFS measured the new forces and moments. By the principle of superposition the vector difference in force before and after ACL transection represents the in situ force in the ACL [6].

Three ACL resections were performed using the same knee and the same quadrupled hamstring tendon graft. To reduce variability, CASPAR, an active computer assisted surgery robotic system [reference], was used to drill the following three femoral tunnel locations as described by the quadrant method [7], (Figure 1): 40%/25% simulating an “anatomic” site, 8%/38%, simulating an “isometric” site, and 20%/50% simulating an anteriorly misplaced tunnel. Graft fixation was accomplished using a suture-post fixation and applying a 44 N pre-tension to the graft while applying a 67 N posterior tibial load on the knee flexed at 30° using the robotic manipulator. The kinematics of the ACL-reconstructed knee and in situ force in the ACL graft were determined using the same method as for the intact ACL. The femoral tunnels were studied in random order and filled with bone cement prior to drilling subsequent tunnels.

The data obtained included the in situ forces on the intact ACL and ACL replacement grafts when the knee was subject to a 134 N AP load and a combined 10 Nm Valgus and 5 Nm internal tibial torque. Variability in data could be minimized because all testing was performed in the same knee, allowing the data to be analyzed using a repeated measures analysis of variance with p<0.05.

Results: In response to a 134 N anterior tibial load only the reconstruction with the anatomic graft placement produced forces in situ in the ACL, that were similar to the intact ACL at 30° of flexion (Figure 2). While the in situ force in the anatomically placed graft was 86% that of the intact ACL, the isometric and anterior positioned grafts reproduced only 78% and 51% respectively. Only at 30°’ did anatomic and isometric positions demonstrate similarity, otherwise the three locations showed significant differences when compared to each other. In response to a combined load, no graft placement reproduced the intact ACL in situ forces neither at 15° nor at 30° of flexion (Figure 3). At 15°’ the three positions, anatomic, isometric, and anterior, reproduced only 46%, 32%, and 24%, respectively, of the intact ACL in situ force under the combined load. No significant difference was found between anatomic and isometric or isometric and anterior positions. However, there were significant differences between the anatomic and anterior placed grafts.

Discussion: Our data supported the hypothesis that the femoral tunnel position at the anatomic insertion site of the ACL resulted in higher in situ forces in the ACL graft than a graft placed at the isometric or anterior positions. However, none of the techniques restored in situ ACL force, results that were similar to prior study, [references] Testing with combined rotational loads most readily demonstrated these differences. While many promote the isometric position as an ideal method, it did not bear loads comparable to the intact ACL. Computer assisted surgery has potential to make the outcome of ACL reconstruction more repeatable, yet the ideal treatment for ACL rupture remains unknown. In the future we will study a double bundle ACL reconstruction technique.

Figure 1: Three femoral tunnel positions: anatomic (40%/25%), isometric (8%/38%), and anterior (25%/50%).

Figure 2: In situ forces in the intact ACL and ACL replacement grafts under a 134 N AP load. * significantly different when compared to intact.

Figure 3: In situ forces in the intact ACL and ACL replacement grafts under a combined 10 N-m valgus torque and 5 N-m internal tibial torque. * significantly different when compared to intact † significantly different when compared to anatomic

References:

Acknowledgement: Support of the NIH grant AR 39683.

49th Annual Meeting of the Orthopaedic Research Society
Poster #1290