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Effect of Graft Inclination Angle on Knee Kinematics in Single-Bundle Anterior Cruciate Ligament Reconstruction

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Summary:
Control of anterior knee laxity is the primary goal of ACL reconstruction. Different graft placements function differently in controlling anterior tibial displacement with knee flexion. A single graft position does not restore knee stability at all flexion angles and thought must be given to which range of knee flexion is anterior knee stability most important.

Abstract:
Purpose: Anatomic graft placement is gaining popularity in in anterior cruciate ligament reconstruction and graft inclination angle has been identified as one measure associated with anatomic graft placement [Illingworth, AJSM 2011]. The aim of this study was to evaluate the effect of the graft inclination angle on knee anterior tibial laxity in single-bundle ACL reconstruction.

Methods: Twelve cadaveric knees were tested in a robotic system with the ACL intact, ACL deficient and after three ACL SB reconstructions. In the reconstructions, the tibial tunnel was kept fixed at the midpoint of the tibial insertion of the ACL and three different femoral tunnel locations were considered: 1) at the center of the femoral ACL insertion site (Mid); 2) a “High” inclination femoral tunnel position and 3) a “Higher” inclination femoral tunnel position. (Figure 1) The order of the reconstructions was randomized. MRI and CT images were obtained to measure the inclination angle of the intact ACL and reconstructions [1]. In all reconstruction a 7 mm graft was tensioned at 40 N at 15° of knee flexion, with the graft size being chosen to allow for the three femoral tunnels to be placed in the knee with a 2 mm bone bridge.

The knees were loaded by a 89 N anterior tibial load using a robotic testing system at 0°, 15°, 30°, 45°, 60° and 90° of flexion and anterior tibial translation (ATT) was measured. The knee ATT was measure under simulated pivot shift loading (combined 7 N-m valgus and 5 N-m internal tibial torques) at 0°, 15° and 30° of flexion. Separate general linear models were created with a single within-subjects factor and used to detect differences in the data.

Results: The inclination angle was 52° for the intact ACL and 52° ($p=0.85$ compared to intact) 59° ($p<.001$) and 65° ($p<.001$) for the Mid, High and Higher tunnel positions, respectively. The anteior tibial translation for the intact ACL, ACL deficient knee and three reconstructed knee states are given in Figure 2 for anterior tibial loading and in Figure 3 for pivot shift loading.
At lower flexion angles (= 30°) the Mid reconstruction had a lower ATT than High and Higher reconstructions and was closer to that of the intact ACL. At 45° of flexion ATT of the reconstructions was similar and above 45° of flexion the ATT of Mid reconstruction became greater than the High and Higher reconstructions which were closer to the intact

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ACL. Under pivot shift loading the Mid reconstruction had a lower anterior tibial translation than the High and Higher reconstructions and was closer to that of the intact ACL.

Conclusion: Control of anterior knee laxity is the primary goal of ACL reconstruction. Different graft placements function differently in controlling anterior tibial displacement with knee flexion. A single graft position does not restore knee stability at all flexion angles and thought must be given to which range of knee flexion is anterior knee stability most important.