Anatomic Double-Bundle Anterior Cruciate Ligament Reconstruction: Kinematics and Knee Flexion Angle-Graft Tension Relationship

Introduction: Cadaveric studies have shown a reciprocal relationship between the anteromedial (AMB) and the posterolateral (PLB) bundles of the ACL, with the PLB functioning in relative knee extension, and the AMB in relative knee flexion. Recreation of that reciprocal relationship may be critical to restore normal joint mechanics. The purpose of this study is to investigate the effect of two different graft tensioning protocols on tension developed in the AM and PL bundles during knee range of motion in a cadaveric model of DB-ACLR, and to measure the effect of these protocols on the response of the reconstructed knee to loading.

Methods: Ten male, fresh-frozen cadaveric knees (average age = 49.7 years, range 28 to 64 years) were mounted on a knee simulator developed in the lab. Anatomic double-bundle ACL reconstruction (DB-ACLR) was performed by an experienced surgeon. The tibial side of each bundle was attached to a tensiometer (Futek, Irvine, CA) that provided dynamic tension force during cycling data (Figure 1).

Results: Of the ten specimens, three were excluded. The remaining seven specimens demonstrated easily identifiable two-bundle ACL anatomy. None had any evidence of prior surgery or pathologic laxity.

Kinematic Data

In analyzing the rotational data, a total arc of rotation which took into account the complex nature of tibial rotation was calculated. The measurements taken during kinematic testing were correlated to the actual rotational motion of the tibia relative to the femur as seen using computer navigation techniques and CT reconstructions. This model revealed that the center of rotation of the tibia was variable depending on the state of the ACL. These calculations result in a single measure of rotation, which is dependent on tibial translation as well as rotation (Figure 2).

Discussion:

Recreating normal bundle tension relationships in DB-ACLR may be critical to improve long-term outcomes. Although knee kinematics were equally restored with both tensioning protocols, the 45°/15° protocol created excessive tension in the AMB relative to the 20°/20° protocol, which could lead to early failure of the AMB. The 20°/20° protocol more closely restored a reciprocal bundle tension pattern.