Biomechanical Evaluation of Posterolateral Corner Reconstruction with Suture Augmentation in a Posterolateral Corner and Posterior Cruciate Ligament Deficient Knee Model

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INTRODUCTION:

The posterolateral corner (PLC) is a group of laterally based structures which work synergistically with the posterior cruciate ligament (PCL) to provide knee stability during varus angulation, posterior tibial translation, and external tibial torsion. Injuries to the PLC rarely occur in isolation, and commonly occur with concomitant PCL injuries. Though PLC reconstruction has demonstrated success, failure rates remain relatively high at about 9%. Suture augmentation has been utilized in ligament repair and reconstructions in the hand, elbow, knee, and ankle to improve strength and clinical success rates of these surgeries. Research studies have also previously evaluated use of suture tape for PLC repair, but there are currently no biomechanical studies that have evaluated the efficacy of suture augmentation for PLC reconstruction. The purpose of this cadaveric biomechanical study is to determine whether suture tape augmentation of PLC reconstruction increases the translational and rotational stability of the knee compared to PLC reconstruction alone in a combined PLC-PCL deficient knee model.

METHODS:

Eight all-male matched pairs (n=16) of cadaveric knees were procured from an institute-approved tissue bank. An Achilles tendon-bone block graft was harvested from the same cadaver to serve as an autograft for the PLC reconstruction. The femur and tibia were cut 15cm from the joint line to prepare for attachment to the hydraulic mechanical system for biomechanical testing. Each knee was repeatedly tested in the following 3 conditions: 1) intact, 2) deficient PLC+PCL, and 3) PLC reconstruction with or without internal brace (suture augmentation). For biomechanical testing, the femur was clamped to the frame of the MTS machine on a hinged system to allow testing at specific angles between 0-90^{o} of flexion. The tibia was clamped to the actuator of the MTS for load application. Each knee was subjected to 10 N·m varus tibial rotation, 134 N·m of posterior load to the tibia, and 5 N·m of external tibial rotation at 0°, 30°, 60°, and 90° of knee flexion for each of the 3 testing conditions. After testing in the intact state, soft tissue dissection was utilized to isolate and section the native lateral collateral ligament (LCL), popliteal tendon (PT), popliteofibular ligament (PFL), and posterior cruciate ligament (PCL) at their native insertion sites. For PLC reconstruction, the LaPrade anatomic reconstruction technique was performed utilizing a split Achilles bone-block autograft. Eight of the knees underwent PLC reconstruction alone, while the other 8 knees underwent PLC with suture augmentation utilizing biocomposite anchors pre-loaded with collagen tape. This acted as an internal brace for the LCL. Joint kinematics (varus rotation, posterior displacement, and external rotation of the tibia) during physiological loading of PLC reconstruction with or without suture augmentation was recorded and compared using repeated measures ANOVA with Bonferroni correction with significance set at $p<0.05$.

RESULTS: The mean age of specimens used in this study was 46.25 ± 6.6 years. When a posterior load was applied to the tibia of intact knees, the average posterior displacement was 6.0 ± 0.9 mm, which significantly increased to 21.2 ± 1.2 mm when the PLC and PCL were resected ($p<0.05$). PLC reconstruction partially restored posterior tibial translation to 10.1 ± 1.1 mm without a brace and to 9.3 ± 1.4 mm with an internal brace, but both reconstruction techniques had greater posterior translation compared to intact knees. When loaded in varus, intact knees rotated 4.5 ± 1.0 degrees, which also significantly increased when the PLC and PCL were resected to 8.1 ± 2.0^{o} ($p<0.05$). Reconstruction, both with and without an internal brace, successfully restored valgus stability toward that of the intact knees. When an external rotational torque was applied to intact knees, they rotated an average 16.8 ± 2.9 degrees, which significantly increased to 30.2 ± 4.08^{o} ($p<0.05$). Reconstruction alone decreased external rotation to 22.4 ± 3.4^{o}, but the addition of an internal brace further reduced rotation to 15.9 ± 2.9^{o}, a rotation statistically similar to intact knees.

DISCUSSION AND CONCLUSION:

The results of this cadaveric biomechanical study demonstrate that PLC reconstruction with suture tape augmentation improves knee stability in a PLC and PCL deficient knee model when compared to PLC reconstruction alone, particularly during external rotation. This increased biomechanical strength may correlate with a short-term ability to accelerate rehabilitation and a long-term predictor of improved patient outcomes, but further testing is necessary to determine its true clinical significance.

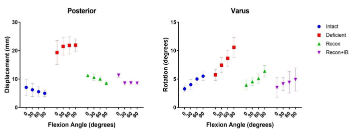

Figure 1. Total Displacement After a Posterior Force and Rotation after Varus Force is Applied in Each Testing Condition. Posterior tibial translation and varus rotation were significantly increased after resection of the PLC and PCL at all angles of flexion, $p<0.05$. Reconstruction of the PLC, with and without an internal brace (IB) helped restore varus stability to the knee.

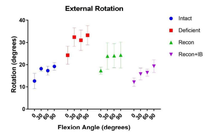

Figure 2. Total Rotation After an External Rotation Force is Applied in Each Testing Condition. Average external rotation of the tibia significantly increased in the PLC-PCL deficient state ($p<0.05$). Reconstruction of the PLC with an internal brace (IB) restored external rotational stability to that of the intact knee. Reconstruction without an IB remained significantly less stable compared to intact knees ($p<0.05$).