Biomechanical Evaluation of Posterolateral Corner Reconstruction with Suture Augmentation in a PLC and PCL Deficient Knee Model

Ajith Malige[1], Andrew Carbone[1], Dave T Huang[2], Shrey Kanjiya[1], Omar Rahman[1], Michael Banffy[1], and Melodie F. Metzger[2]
[1] Cedars-Sinai Kerlan-Jobe Institute, Department of Orthopaedic Surgery, Los Angeles, CA
[2] Cedars-Sinai Orthopaedic Biomechanics Laboratory, Los Angeles, CA.
Dave.huang@cshs.org

Disclosures: Ajith Malige (6: B Braun, Arthrex, 8: Arthroscopy, BMC Musculoskeletal Disorders, 9: AOA, AOSSM), Andrew Carbone (N), Dave T. Huang (N), Shrey Kanjiya (N), Omar Rahman (3B: Arthrex), Michael Banffy (2: Arthrex, Vericel, Smith and Nephew, Stryker, 3B: Arthrex, Vericel, Smith and Nephew), Melodie F. Metzger (5: Arthrex)

INTRODUCTION: The posterolateral corner (PLC) of the knee is constituted by key elements—the lateral collateral ligament (LCL), popliteus, and Popliteofibular ligament (PFL)—that jointly contribute to stability against varus and external rotation forces. Injuries to the PLC frequently result from an impacting force on the anteromedial aspect of the knee when the foot is firmly grounded[1]. Often, these injuries occur alongside other ligamentous damages. While non-operative approaches can be effective, particularly for milder cases, they fall short in reinstating knee stability in more severe instances, necessitating surgical intervention. The renowned PLC reconstruction method, known as the LaPrade technique, stands as the gold standard in PLC reconstruction[2]. This study delves into the biomechanical strength of both the classic LaPrade technique and a novel PLC reconstruction method (derived from the original LaPrade approach) that incorporates suture augmentation. The hypothesis posits that the introduction of suture augmentation will enhance the restoration of knee stability.

METHODS: Institutional review board approval was not required for this laboratory investigation utilizing de-identified cadaveric specimens. Eight matched pairs of all male cadaveric knees (n=16) were procured from an institute-approved tissue bank and divided into two groups, alternating laterality: (1) PLC reconstruction without suture augmentation (PLCR), and (2) PLCR with suture augmentation (PLCR-SA); both groups employed Laprade's technique by securing the LCL bone block via a SwiveLock, for the PCLR-SA group, an additional step was incorporated: pre-loading the SwiveLock with Fibertape. For kinematic testing, the prepared knee was inverted (anterior facing down) and placed onto a servo-hydraulic testing machine with the potted tibia attached to a load cell secured to the MTS actuator, and a 3D-printed jig was secured to the distal portion of the potted tibia. The femur was clamped into a custom jig that allowed controlled rotation of the femur in the sagittal plane (flexion/extension) (Figure 1). A 134 N posterior load was applied to the tibia using the MTS actuator at a rate of 1 mm/s, followed by a 10 N·m varus torque at 1 N·m/s. Next, an electronic torquemeter was attached to the 3D-printed jig, and 5 N·m/s torque was applied at 1 N·m/s. The tests were conducted for 4 flexion angles 0°, 30°, 60°, and 90°. Kinematic testing of each specimen was repeated in the (1) intact, (2) PLC and PCL deficient state, and (3) after PCLR or PCLR-SA. Rotation and displacement of the tibia relative to the femur during each load application were tracked using the motion tracking camera and converted to anatomically relevant joint angles using a customized post-processing script (Python 3.9).

RESULTS SECTION: Knees with PLCR and PLCR-SA both restored posterior tibial displacement, varus rotation, and external rotation to levels that were significantly less than the deficient state ($p<0.001$). The PLCR knees showed significantly greater posterior tibial displacement than the intact knees at every flexion angle, the PCLR-SA knees showed significantly greater displacement at 0° of flexion but not significantly different than intact knees at 30°, 60°, and 90° of flexion, Figure 2A. There were no significant differences between the intact, the PLCR, and the PLCR-SA knees in varus rotation at every flexion angle. The PLCR knees showed significantly greater external rotation than the intact state at every flexion angle, $p<0.05$. The PLCR-SA knees showed significantly less external rotation than the PLCR group at every angle except at 0° flexion, $p<0.01$, Figure 2B.

DISCUSSION: PLC reconstruction is a technically challenging technique that can improve knee stability back to native levels when done correctly. With suture tape augmentation, the reconstruction improves knee stability in a PLC and PCL deficient knee model when compared to the classic PLC reconstruction, particularly during posterior tibial translation and external rotation. The suture augmentation adds a simple but effective modification to PLC reconstruction that improves knee stability.

SIGNIFICANCE/CLINICAL RELEVANCE: The increase in biomechanical stability provided by suture augmentation may accelerate rehabilitation. Further clinical studies are needed to determine whether suture augmentation can improve patient outcomes beyond the immediate postoperative period.

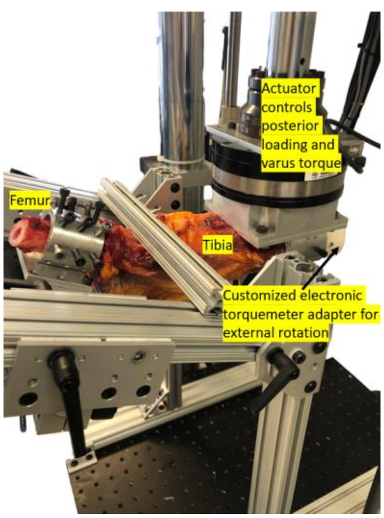

Figure 1. Kinematic testing set-up. The tibia was attached to the actuator of the MTS machine. A 3D-printed adapter was used for external rotation testing via electronic torquemeter

REFERENCES: [1] LaPrade RF et al., *Am J Sports Med.* 2002;30(2):233-8. [2] Pache et al., *Arthroscopy Techniques* 10(2): e487–e497, 2021

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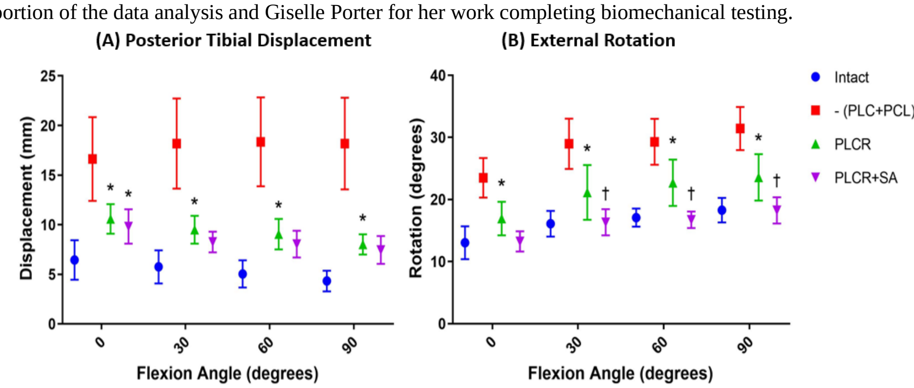

Figure 2A) Posterior displacement of the tibia with respect to the femur as a function of knee flexion. *$p<0.05$ compared to intact state. 2B) External rotation as a function of knee flexion angle. *$p<0.05$ compared to intact state. † Indicates PLCR+SA is significantly different than PLCR, $p<0.01$. PLCR+SA was marginally different than PLCR alone at 0° of flexion, $p=0.06$. The PLC/PCL deficient knees were significantly different than the intact, PLCR, and PLCR+SA knees at every angle of flexion tested for posterior displacement, varus rotation (not shown in the figure), and external rotation, $p<0.0001$