Quantitative assessment of knee kinematics utilizing a new low profile pivot shift test

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Background: Variations in the pivot shift test have been proposed by many authors, though, a test comprised of rotatory and valgus tibial forces with accompanied knee range of motion is frequently utilized [3]. In a systematic review, Lane et al. [3] suggested that a valgus force is preferred in application of the pivot shift test. In addition, differences in applied forces between practitioners [1,2,4] and patient guarding [2] have been observed as possibly decreasing the reproducibility and reliability of the pivot shift test.

Purpose: Our study seeks to quantitatively understand the associated knee kinematics and mechanisms of the pivot shift test and, in an effort to simplify this clinical maneuver and possibly reduce patient guarding, we also seek to show that a new low-profile pivot shift test (LPPST) consisting of practitioner induced internal rotatory and anterior tibial forces (no applied valgus force) with subsequent patient knee range of motion can elicit knee rotational instability and effectively differentiate between the anterior cruciate ligament (ACL) deficient and ACL sufficient knee.

Methods: Twenty fresh, frozen cadaver knees were utilized in our study. Our quantitative assessment utilized computer assisted navigation (OrthoPilot®, Aesculap Implant Systems, Tuttlingen, Germany) to sample (10Hz) the anterior translation and internal rotation of the tibia as the LPPST force vectors were applied and the knee was taken through a full range of motion. Each knee specimen was tested with an intact ACL and again after ACL resection. For each specimen we tested across four operators in an effort to understand the repeatability of the LPPST. We subsequently analyzed our data for both the entrance pivot (tibial reduction with knee range of motion from extension into flexion) and the exit pivot (tibial subluxation with knee range of motion from flexion into extension).

Results: We observed a significant difference in anterior tibial translation and internal tibial rotation in the ACL deficient vs. ACL sufficient knee during the entrance pivot of the LPPST. The entrance pivot was found to have an average maximum anterior tibial translation of 7.83 mm in the ACL deficient knee specimens compared to 1.23 mm in the ACL sufficient knee specimens (p<0.01). We found the ACL deficient knees to exhibit an average maximum internal tibial rotation of 12.38 degrees compared to 11.24 degrees in the ACL sufficient specimens during the entrance pivot (p=0.04). The average knee flexion where the maximum anterior tibial translation occurred was 8.16 degrees in ACL deficient knees and 5.72 degrees in ACL sufficient knees during the entrance pivot. The average knee flexion where the maximum internal tibial rotation occurred was 29.8 degrees in ACL deficient knees and 30.84 degrees in ACL sufficient knees during the entrance pivot. We also observed a significant difference in the anterior tibial translation and internal tibial rotation in the ACL deficient vs. ACL sufficient knee during the exit pivot of the LPPST. The exit pivot was found to have an average maximum anterior tibial translation of 7.82 mm in the ACL deficient knee specimens compared to 1.44 mm in the ACL sufficient knee specimens (p<0.01). The ACL deficient knees exhibited an average maximum internal tibial rotation of 12.44 degrees compared to 11.13 degrees in the ACL sufficient knee specimens during the exit pivot (p=0.02). The average knee flexion where the maximum anterior tibial translation occurred was 9.23 degrees in ACL deficient knees and 9.12 degrees in ACL sufficient knees during the exit pivot. The average knee flexion...
where the maximum internal tibial rotation occurred was 28.05 degrees in ACL deficient knees and 30.18 degrees in ACL sufficient knees during the exit pivot. Our study found an average inter-operator difference of 1.78 mm (anterior tibial translation) and 1.53 degrees (internal tibial rotation) while administering the ACL deficient knee entrance pivot and 1.89 mm (anterior tibial translation) and 1.83 degrees (internal tibial rotation) during administration of the ACL deficient knee exit pivot.

**Discussion:** Our results help to introduce a physical exam maneuver (LPPST) which consists of practitioner induced internal rotary and anterior directed forces, with notable absence of valgus force, on the tibia while applying knee range of motion. Our results demonstrate that the LPPST can elicit significant anterior translation and internal rotary differences in an effort to differentiate between the ACL deficient and ACL sufficient knee. We also characterize knee range of motion with associated anterior and internal tibial translation during administration of the LPPST. Our work will next seek to explore the clinical applicability of our cadaver findings.

**References**