

Weight Bearing CT Shows Altered Tibiofemoral Loading Following Combined ACL Reconstruction and Meniscus Treatment

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INTRODUCTION: The anterior cruciate ligament (ACL) and menisci act as stabilizers against anterior tibial translation [1]. Failure to fully restore native knee kinematics and stability with ACL reconstruction (ACLR) is theorized to shift tibiofemoral loading to unconditioned cartilage regions, contributing to osteoarthritic joint degeneration [2]. ACL-injured knees often have concomitant meniscal injuries, with certain types of meniscal pathologies known to accelerate joint space narrowing [3,4]. The objective of this study was to analyze whether meniscus tears treated concurrently during ACLR shifted loading kinematics of the knee by measuring changes in the tibiofemoral center of contact (CoC).

METHODS: Bilateral knee weight bearing CT (WBCT) scans were acquired for 66 patients (31M/35F, Age=23.07±12) approximately 12 months post-ACLR in semi-flexed (~20°) and fully extended positions. 3D joint space width (JSW) distributions in the medial and lateral compartments were calculated from WBCT using a semi-automated method [5]. The center of contact (CoC), defined as the centroid of articular sites where the narrowest 10% of JSW values were measured in each compartment, was evaluated with respect to the overall compartment centroid. Concomitant meniscus tear type, location, and treatment were recorded. CoC location and translation between scan poses for patients with meniscal tears were compared to patients with no meniscal tears and to the patient's intact contralateral knee. Group differences in CoC medial-lateral (ML) and anterior-posterior (AP) translation were assessed using one-way ANOVA with post-hoc Bonferroni correction, significance set at p=0.05.

RESULTS: A concomitant meniscus tear was treated during ACLR in 43 patients. 3D JSW and CoC data were available for 32 patients with meniscus tears (medial meniscus=17, lateral meniscus=23; possible overlapping tears) and 17 patients without tears. In the medial compartment, the CoC for patients with medial tears shifted significantly more medially as the knee moved from flexion to extension, compared to intact knees and ACLR knees with no tear (Figure 1). ACLR knees with concomitant medial meniscus tears demonstrated significantly more medial CoC translation when compared to ACLR only (P=.006) and intact knees (P=.02) (Figure 2). Although patients with lateral tears had a more medially shifting CoC in the medial compartment, it was not significant. There were no significant differences in AP translation between groups for medial and lateral tears.

DISCUSSION: ACL injury with meniscus tears altered tibiofemoral loading, despite meniscal treatment with either meniscus repair or partial meniscectomy during ACLR. Prior work showed that medial meniscus tears increase anterior tibial translation, while lateral tears increase rotation and translation, but only under a coupled valgus stress and internal-rotation torque/pivot shift test [1]. The shift in CoC between poses that was observed with medial meniscal tears is consistent with these prior results. This CoC shift may be due to residual changes to the secondary stabilizing function of the menisci, despite treatment. The subsequent altered tibiofemoral loading may explain subsequent joint degeneration due to cartilage loading in unconditioned regions, and WBCT may be able to help in identifying knees at greatest risk in this regard. One limitation of this study is the grouping of meniscus tears, where different tear types may have more pronounced influence on altered loading. Future work will analyze shifts in CoC in correlation to meniscus tear type and ACL graft type used.

SIGNIFICANCE/CLINICAL RELEVANCE: Accurate imaging biomarkers sensitive to changes in native knee kinematics can help predict the onset of joint degeneration, possibly leading to earlier intervention.

REFERENCES: [1] Mameri ES, et al. *Current Rev Musculoskeletal Med.* (2022). [2] Andriacchi TP, et al. *J Bone Joint Surg Am.* (2009). [3] Crema MD, et al. *Osteoarthritis Cartilage.* (2014). [4] Jones MH, et al. *Osteoarthritis Cartilage.* (2015). [5] Segal NA, et al. *Osteoarthritis Cartilage.* (2023).

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IMAGES AND TABLES:

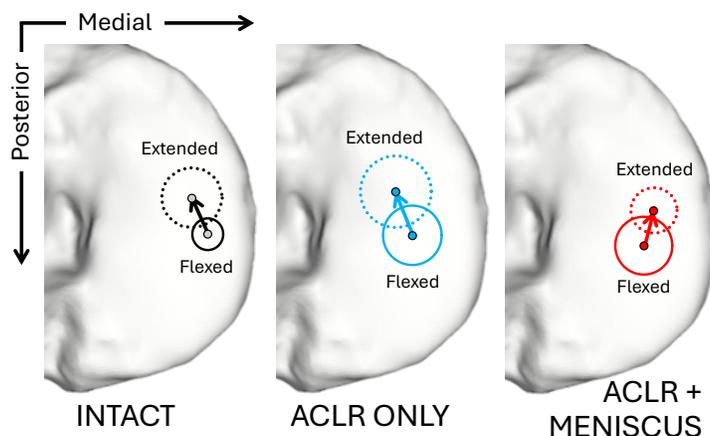


Figure 1. Tibiofemoral CoC location in the medial compartment for the various treatment groups.

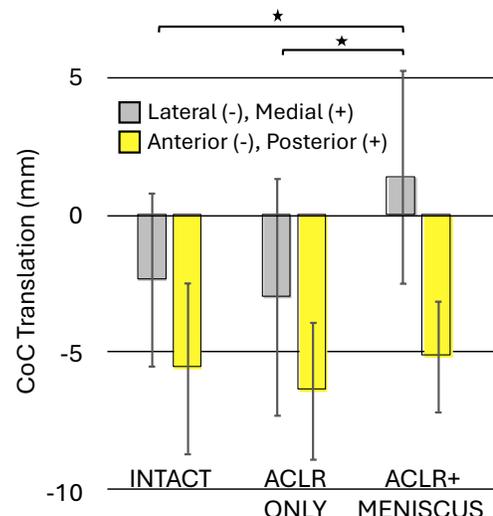


Figure 2. Anterior-Posterior and Medial-Lateral CoC translation in the medial compartment. (* p<.05)