Utilizing Weight Bearing CT to Evaluate Osteoarthritis Development Early After ACL Reconstruction

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INTRODUCTION: The risk of post-traumatic osteoarthritis (PTOA) and associated joint space narrowing after ACL injury is high, with roughly 50% of individuals experiencing symptoms 10 to 20 years after injury [1]. Efforts to mitigate PTOA risk after ACL injury have been stalled by the lack of sensitive, specific, and affordable early imaging markers. However, recent reports have linked the load-bearing pose of the knee following ACLR to early compositional MRI changes in articular cartilage consistent with PTOA [2]. We have developed a fully automated method to measure tibiofemoral 3D pose and joint space width (JSW) from weight bearing CT (WBCT) [3] that shows promise for early detection of PTOA [4]. The objective of this research is to evaluate the potential for WBCT to provide affordable, objective, and predictive knee pose information and 3D JSW measures following ACLR to identify early signs of PTOA.

METHODS: Forty-four individuals (17M/27F, age: 21.2±7.9 years) with a unilateral isolated partial or complete ACL tear reconstructed by one of three surgeons were recruited to participate in this IRB-approved study. Bilateral WBCT of the knee in a semi-flexed (~30°) position [4] were acquired 3.5±0.9 months after ACLR. Twenty-seven subjects also had a WBCT scan with the knee in a fully extended position at the same visit. Maps of the 3D JSW were generated for both intact contralateral and ACLR knees using fully automated measurement methods [3]. Margins of the tibiofemoral joint surface area were defined as regions with JSW<10 mm. Portions of the tibiofemoral joint with JSW<5 mm were used to define a meaningful approximation of the nominal contact area for monitoring future joint space narrowing.

RESULTS: Females demonstrated a higher percentage of values below the 5 mm threshold compared to males, with a difference of 23.9±21.1% for the medial side and 6.1±8.2% for the lateral for semi-flexed scans (Figure 1). There were more JSW values below the 5 mm threshold for the fully extended knee compared to the semi-flexed scan pose, especially in the lateral compartment. The difference in percentage was 6.6±26.8% for the medial side and 11.8±16.2% for the lateral side for ACLR knees. Distributions of ACLR and intact contralateral knees in each sex group demonstrated similar JSW distributions (Figure 2).

DISCUSSION: Consistent with previous reports based on weight bearing radiographs [5], females had overall smaller medial and lateral compartment JSW values than males. This led to females demonstrating a higher percentage of values below the 5 mm threshold in both the medial and lateral compartments. ACLR and intact contralateral knees demonstrated similar JSW distributions in the semi-flexed position. The fully extended scan position led to smaller lateral JSW distributions for both ACLR and intact knees, most likely due to the screw home mechanism of the knee during the last 20° of terminal extension. The smaller JSW distributions developed from the semi-flexed scan pose may allow for more consistent PTOA monitoring following ACLR.

SIGNIFICANCE/CLINICAL RELEVANCE: Promising new biologics to prevent or mitigate PTOA risk in the knee are emerging, but clinical trials that can control for PTOA risk and detect outcome earlier are needed to enable timely study of new interventions. The establishment of new WBCT-based 3D imaging markers that reliably and affordably assess PTOA risk and detect degenerative joint changes earlier can facilitate more efficient clinical studies to proceed.

REFERENCES: [1] Lohmander LS, et al. Am J Sports Med. (2007), 35(10):1756-69. [2] Lansdown DA, et al. J Orthop Res. (2020), 38(6):1289-95. [3] McFadden EJ, et al. Osteoarthritis Cartilage. (2022), 30(S1):S284-5. [4] Segal NA, et al. Osteoarthritis Cartilage. (2023), 31(3):406-13. [5] Beattie KA, et al. BMC Musculoskeletal Disorders. (2008), 9(119).

ACKNOWLEDGEMENTS: This research was supported by a grant from the Arthritis Foundation (Award #851789).

IMAGES AND TABLES:

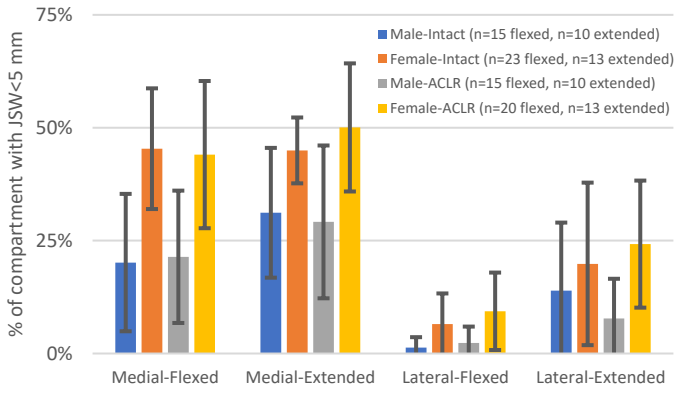

Figure 1. Comparison of Percentage of 3D JSW Distribution Below 5 mm Between Flexed and Extended Scans.

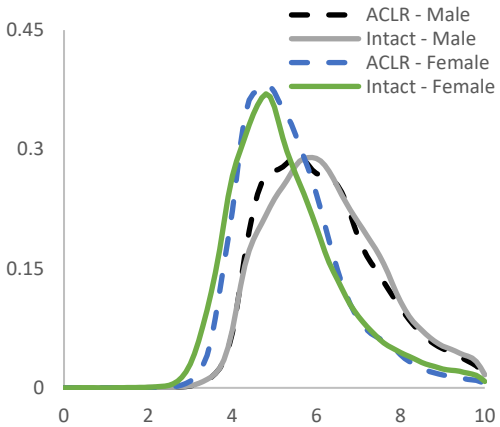

Figure 2. JSW Distributions for the Medial Compartment in a Semi-Flexed Position.