Changes In MR Knee Kinematics Are Correlated To Cartilage Degeneration As Measured By Quantitative T1ρ MRI 1 Year Following ACL Reconstruction.

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Introduction: Anterior cruciate ligament (ACL) injuries are one of the most common injuries of the knee. While ACL reconstruction enables patients to return to active lifestyles (1), previous studies have demonstrated 50% of the patients develop radiological changes of osteoarthritis 10-15 years following surgery (2). Lower extremity kinematics are known to be altered following ACL injury (3-5), and one goal of surgical treatment is to restore function and stability to the knee. Post-operative knee kinematics have been evaluated extensively with both imaging and motion analysis. While previous studies have demonstrated T1ρ MRI quantification can detect cartilage damage in its early stages (6-7), no studies have utilized both T1ρ MRI and MR kinematics to longitudinally assess the ACL injured knee, nor have studies longitudinally examined how altered lower extremity kinematics correlate to cartilage damage. The goal of our study was to examine the longitudinal interrelationship between cartilage T1ρ and MR kinematics in the ACL reconstructed knee. Kinematic MR-imaging was utilized in conjunction with quantitative T1ρ MR images from patients prior to ACL reconstruction and then 6 months and 1 year following surgery. We hypothesize that increased anterior tibial translation, measured from kinematic MRI, is correlated with increased cartilage T1ρ values 1 year following ACL reconstruction.

Methods: Fifty-one patients with isolated ACL injuries were recruited and are currently being followed prospectively. A subset of nine patients (average age 33.6 years, average BMI 23.2, 6 females) who finished 6-month and 1-year follow up was analyzed for this study. Patients with other ligamentous injuries, history of arthritis, previous knee surgery, or those requiring meniscal repair at the time of ACL reconstruction were excluded from this study. All patients underwent arthroscopic ACL reconstruction and were treated with a standard post-operative rehabilitation protocol. MR images were obtained of the injured and uninjured knee within 6-month of the ACL tear and prior to surgery, and then at 6 months and 1year post reconstruction. Kinematic images were obtained in extension and 30 degrees of knee flexion with the knee loaded with 25% of total body weight. Comprehensive quantification of T1ρ relaxation times of the medial and lateral femoral condyle and tibial cartilage were measured using customized software. To examine the specifics of cartilage loading, femoral condyle cartilage was divided into subcompartments (Figure 1). Knee kinematic measurements including anterior tibial translation (ATT) between knee flexion and extension were calculated from T2 FSE MR images using customized software. To correlate MR kinematic findings with T1ρ values, a Spearman's Rho correlation coefficient was calculated with a value of more than 0.7 suggesting a strong correlation and a p-value of less than 0.05 suggesting statistical significance.

Results: At 1 year, anterior tibial translation is correlated to increased T1ρ relaxation times in the injured knee. ATT is correlated with increased T1ρ relaxation times of the average of all medial femoral condyle (MFC) cartilage sub-compartments [Figure 2] (Spearman's Rank Correlation Coefficient = 0.883, p=0.002) and the 3rd medial femoral condyle sub-compartment (Spearman's Rank Correlation Coefficient = 0.783, p=0.013). ATT at 6 months post reconstruction is correlated to the difference of cartilage T1ρ values at 6 months and 1 year in the average of all medial femoral condyle cartilage sub-compartments [Figure 3] (Spearman's Rank Correlation 0.717, p=0.03).

Discussion: Anterior tibial translation is correlated to increased cartilage T1ρ relaxation times in the medial femoral condyle cartilage compartment This result suggests that alterations in knee kinematics following ACL reconstruction are related to detectable cartilage degeneration as soon as 1 year post reconstruction. Additionally, our data suggest that anterior tibial translation at 6 months is correlated to an increase in T1ρ relaxation times from 6 months to 1 year. This finding demonstrates a longitudinal relationship between kinematic findings at 6 months and cartilage T1ρ values at 1 year, with increased ATT in the ACL reconstructed knee at 6 months being predictive of higher future T1ρ values and thus cartilage changes. While previous studies have demonstrated a relationship between altered knee kinematics and increased T1ρ relaxation time (8), this study is unique as it longitudinally follows patients to examine the how altered kinematics relate to cartilage damage over time. Understanding the interrelationship between the kinematics in the ACL reconstructed knee and signs of early cartilage changes may provide insight into the development of osteoarthritis in the ACL reconstructed knee. One of the limitations of the study is the small sample size that had 1 year follow-up in our larger cohort of 51 patients. Our study proposed to follow the current cohort up to 3 years post-surgery.

Significance: The results of our initial study suggest that increased anterior tibial translation in the ACL reconstructed knee is associated with detectable cartilage changes in the medial knee compartment at 1-year post ACL reconstruction. The novel data from this study will allow us to further characterize the interrelationship between kinematics in the ACL reconstructed knee and

the development of osteoarthritis.

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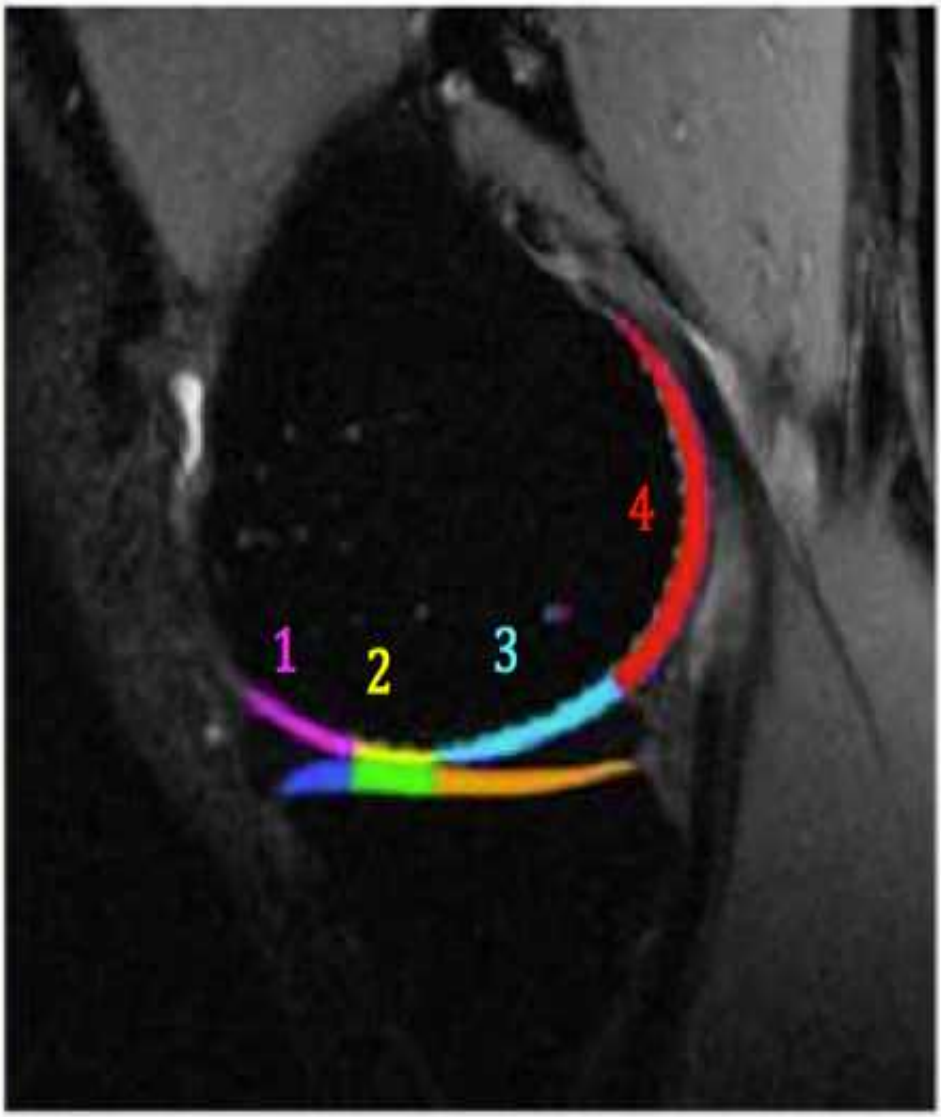

Figure 1: Femoral cartilage subcompartments.

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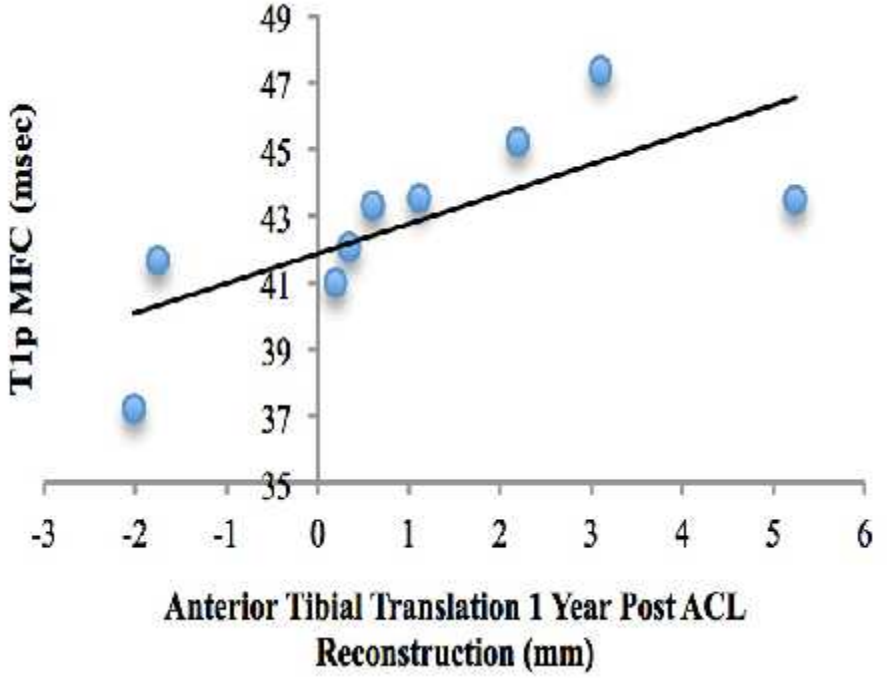

Figure 2: Anterior tibial translation at 1 year following ACL reconstruction correlates to T1ρ relaxation times in the medial femoral condyle cartilage. Spearman's rank correlation coefficient 0.833, p=0.002.

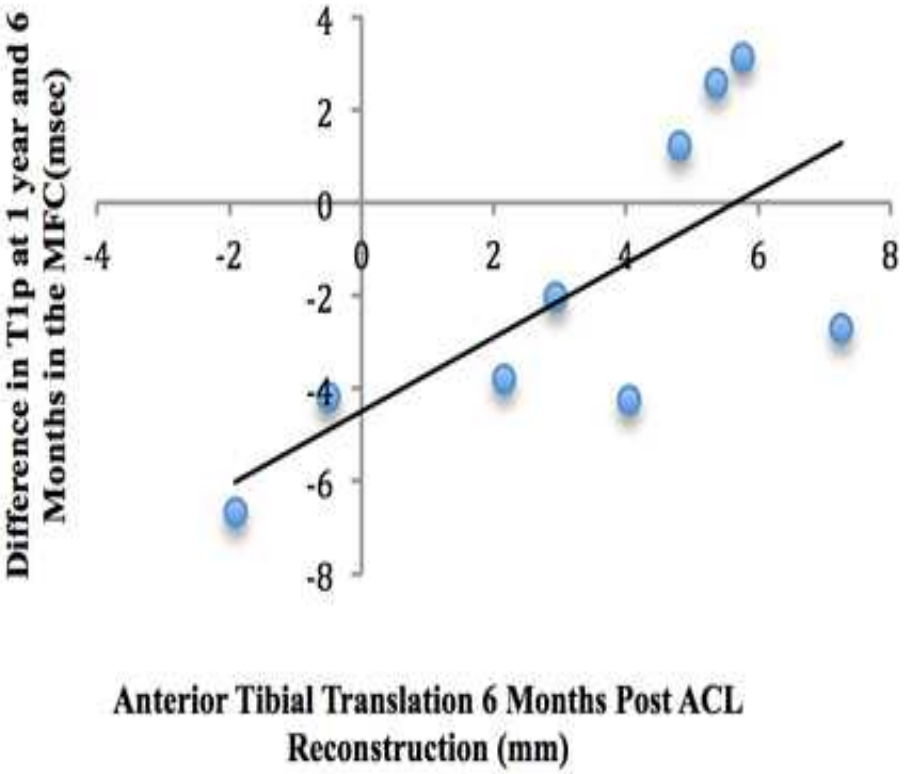

Figure 3: Anterior tibial translation at 6 months following ACL reconstruction correlates to the difference in T1ρ relaxation time at 1 year and 6 months. Spearman's rank correlation coefficient 0.717, p=0.03.