INTRODUCTION
One in two people will experience osteoarthritis in their lifetime [1]. With 25 million Americans suffering from osteoarthritis [1], it’s important that the causes of how osteoarthritis develops are found. Because osteoarthritis is the lessening of cartilage contact over time, knee kinematics that change cartilage contact over time could be the key in answering how osteoarthritis occurs.

Current anterior cruciate ligament (ACL) reconstruction consist of surgery being performed anatomically. Although the surgery itself is complex, it may not restore the knee to its pre-injury conditions. Alterations in these knee kinematics may cause abnormal cartilage contact in both strain and contact area. Previous studies have shown that alterations in knee joint contact are thought to be contributing factors to osteoarthritis progression [2, 3]. We also know based on previous research that osteoarthritis occurs more on the medial side of the femur and tibia [2]. Accurately identifying these changes in joint behavior is an important step in better understanding the course of post-traumatic osteoarthritis initiation.

Researchers have studied these interactions before, but they conducted quasi-static, passive tests [2]. These tests have the patient laying down while the researcher moves their reconstructed knee. This data isn't realistic, as most people who have ACL injuries don’t only passively move. Our lab collects dynamic data where kinematic assessment occurs while the patient is doing functional, realistic activities such as walking and running 6 months and 24 months post-surgery.

Realistic data could be the key in finding how knee alterations effect cartilage interactions and the onset of osteoarthritis.

OBJECTIVE
The purpose of this study was to assess in vivo knee cartilage behavior during a functional, dynamic activity following anatomic ACL reconstruction and comparing the reconstructed knees with the contralateral unaffected knees.

HYPOTHESIS
It is hypothesized that there would be differences in contact area, contact centroid location, and cartilage strain between reconstructed and contralateral, ACL-intact knees.

METHOD
Anatomic ACL reconstructions were performed on 50 patients (mean age 22 ± 7.5 years, 31% female). The patients were analyzed both 6 months and 24 months post-surgery, but this data set is on 6 month data only, as the other data is still being processes.

First, all patients were assessed using the IKDC Subjective Knee and KOOS scales. The IKDC Subjective Knee and KOOS scales are questionnaires that the patient can estimate the amount of pain that occurs in his/her affected knee as they perform daily activities. The more pain a patient has, the lower the pain score.

CT and MRI scans of patients’ knees were acquired, segmented, and rendered as subject-specific 3D tibiofemoral bone and cartilage models. Kinematic testing (downhill running 3.0 m/s, 10 slope) was performed on an instrumented treadmill inside a dynamic stereo x-ray (DSX) system (150Hz). The tibiofemoral kinematics were derived using a computer program, model-based tracking, which tracks the patient’s knee as it moves frame by frame on the DSX system to create bone models. Cartilage models were mapped onto the ends of the bone models and tibiofemoral cartilage interactions were estimated as the overlap of the tibiofemoral cartilage interactions using a validated algorithm [3].

The tibiofemoral contact area was divided into anatomically meaningful compartments shown on Figure 2. The femur cartilage was anatomically split along the medial-lateral axis. The tibia cartilage was anatomically split along the medial-lateral axis, while wedges cut into ellipses set at 45° angles from the anterior-posterior axes. Within each compartment contact area and cartilage strain were calculated for each frame of the gait cycle.

Cumulative strains were calculated for each region by summing the amount of strain that occurred as the patient moved and how long the strain occurred.

Differences between unaffected and reconstructed knees were assessed using an ANOVA model (limb state x % gait cycle) for contact area, while paired t-tests were employed to compare side-to-side differences in regional cumulative strains between individual time points.

Pearson’s correlations were used to explain the relationships between patient-reported outcomes and the amount and nature of joint contact (alpha=0.05).

RESULTS
Contact area in the medial compartment was on average 51mm² smaller for both femur and tibia in ACL reconstructed knees than contralateral knees (p=0.075) (Figure 1). Changes in lateral compartment contact areas were small, however there was some shifting of cartilage contact (Figure 1).

There was a decrease in cumulative strain (Figure 2) in the medial central (p=0.014) and outer regions (p=0.021) of the femur. Strain increased in lateral femoral central (p=0.013) and inner (p=0.043) cartilage regions. In the lateral tibia, posterior region strain decreased (p=0.006). Anterior lateral compartment strain increased slightly (p=0.066). The inner compartment anterior (p=0.014), internal (p=0.041), and external (p=0.044) subregions experienced increased strain.

KOOS Activities of Daily Living scores were positively correlated with increased lateral compartment (R=0.38, p=0.01) and medial compartment (R=0.36, p=0.017) contact area.
Increased medial contact area was also correlated with higher KOOS Pain Scores (R=0.31, p=0.04).

DISCUSSION

The results show that small alterations do occur in knee cartilage contact after anatomic ACL reconstruction. There was less cartilage contact area on the medial side of the reconstructed knee compared with the ACL-intact knee. This corresponded with research that states that osteoarthritis occurs more on the medial compartment than the lateral compartment [4]. However, the decrease of strain on the medial compartments of both the femur and tibia does not account for the osteoarthritis being more prominent there. This could be due to more pain on the medial side due to less cartilage contact area, so the patients are compensating by putting more strain on their lateral side. This new hypothesis is being tested with the 24 month data to see if any changes occur because we need more time points than the 6 month data to accurately investigate.

The 6 month data is still significant, showing shifts in cartilage contact that have previously under-loaded cartilage now bearing greater loads and previously loaded cartilage now bearing lesser loads. These alterations are believed to be the catalysts for the onset of osteoarthritis [2]. Positive correlations between contact area and the KOOS Pain Scores support the idea of maintaining pre-injury levels of joint contact is important for good patient outcomes. While some data points for the 6 months trial were not significant, research in the 24 month data will be a key component in understanding how the changes in kinematics and knee cartilage contact change over an array of time points. This new data will hopefully make our 6 month data clearer and how the changes in cartilage contact could affect the onset of osteoarthritis.

CONCLUSION

Early detection of alterations in cartilage contact during functional tasks is essential in understanding the processes that initiate osteoarthritis and its underlying causes. Our results showed that correlation between decreased area of contact and increased pain scores suggest possible mechanism for osteoarthritis development. We also found that strain is larger on the lateral compartment, which doesn’t coincide with osteoarthritis being more prevalent on the medial side. Research needs to continue to the 24 month data for more answers.

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REFERENCES