INTRODUCTION:
Knee osteoarthritis (OA) is a disabling disorder affecting up to 13% of individuals aged 65 years and older [1]. The medial compartment is most commonly affected. Many researchers suggest contributing biomechanical factors in the development of knee OA include body weight, knee alignment, muscle strength, knee kinematics, and strenuous activities [1-2]. Although gait and mechanical analyses are suggestive, no in vivo study to date has revealed the reason why the medial compartment is most commonly affected. There is little knowledge on knee pathokinematics as related to the development and progression of the knee OA. Therefore, the aim of this study was to determine if knee kinematics change with knee OA disease progression.

METHODS:
Enrolled in this IRB approved study were nine healthy knees of 9 male patients with a mean age of 27.0 (SD: 7.6) years, as well as 15 knees with primary medial OA of 9 patients (2 males and 7 females) with a mean age of 68.1 (SD: 8.2) years. Informed written consent was obtained from all subjects. All of the OA patients were over 40 years of age and indicated for surgical treatment. The radiographic grade of OA using the Kellgren–Lawrence System averaged 1.9±0.3 (grade 1: 5 knees, grade 2: 6 knees, grade 3: 4 knees). The other inclusion criteria for all subjects was the ability to perform a leg press activity. Exclusion criteria included knee ligament injuries, history of contralateral knee injuries, and age less than 20 years. Normal knees had no signs of radiographic knee OA.

Knee kinematics were analyzed using a 3D-2D registration technique utilizing CT scan and lateral fluoroscopic images [3]. During fluoroscopic imaging, subjects were seated in a leg press device with a fixed footplate and sliding seat. The leg press activity was repeated 3 times with target knee flexion over 90°. The applied resisting load for ACL deficient and OA knees were 10kg and 5kg, respectively, plus 8.7% of each subject’s body weight. Patients practiced the activity until they felt comfortable before a radiographic exposure.

All knees underwent CT scanning with a 0.5 mm slice pitch spanning approximately 150 mm above and below the knee joint line. Geometric bone models of the femur and the tibia were created from the images. The exterior cortical bone edges in the CT images were segmented using 3D-Doctor software (Able Software Corp., Lexington, MA) and were converted into polygonal surface models using Geomagic Studio (Geomagic, Research Triangle Park, NC, USA). The cylindrical axis of the posterior femoral condyles [4] and the tibial plateau plane with the posterior co-tangent at the level of the top of the fibular head were used as references for femoral and tibial coordinate systems, respectively.

Kinematics were analyzed in 5° flexion increments for leg press. The average maximum extension/flexion angle was 74±5/81±8° during leg press. Statistical comparisons were performed using values between 10° and 65° flexion where observations from all knees were available. Repeated measures analysis of variance (RMANOVA) and post-hoc pair-wise comparison (Dunnet T3) were used to compare the healthy knees and the 3 knee OA groups graded 1 to 3 between flexion 10° and 65°. The level of significance was set at p<.05.

RESULTS:
Dunnet test revealed tibial internal rotation was significantly reduced in the grade 2 knees as compared with the normal knees (Fig a). Lateral femoral condylar contact points were significantly posterior in the grade 2 and 3 knees compared to the normal knees at all flexion angles, while the grade 1 knees showed significant differences only at high flexion angles (Fig b). Medial femoral condylar contact points were significantly more anterior in grade 2 and 3 knees as compared to normal knees in low flexion angles (Fig c).

DISCUSSION:
The results of this study suggest that changes in knee kinematics occur before progression to grade 1 OA, as well as between progression to grade 2 OA. Normal knees demonstrated medial pivot condylar kinematics, while OA knees showed more anteroposterior condylar translation (Fig c). Lateral condylar translations were significantly affected with more severe knee OA (i.e., grade 2 and 3). Knees of grade 1 OA had significant differences only at high flexion angles (Fig b).

These findings suggest knee pathokinematics initiate at high flexion angles. Scarvell et al. [5] reported contact in the lateral and medial compartments of OA knees were more anterior on the tibial plateau than normal knees. This discrepancy may be due to the methodology. This study has several limitations. First, the approach to analyze joint contact ignores the degenerated menisci. Second, a 3D-2D image registration method using single-plane fluoroscopy provides less accurate measurement accuracy for out-of-plane motion [6]. Third, we used the uninjured knee in subjects with a contralateral ACL injury as the normal control group. Finally, a small sample size in this study may have caused beta errors.

To conclude, knee kinematics would change in high flexion angles in the earlier stages of knee OA, and in all flexion angles in the later stages.

REFERENCES: