INTRODUCTION:
A long-term effect of chronic anterior cruciate ligament (ACL) deficiency is development of degenerative changes in the knee [1]. Andriacchi et al. [2] noted cartilage homeostasis would not be maintained by abnormal kinematics after ACL rupture and cartilage degeneration would initiate. However, no study to date has compared kinematics between ACL deficient knees and primary osteoarthritic (OA) knees. Therefore, the aim of this in vivo study was to determine if a difference in knee kinematics exists between normal, ACL deficient, and primary medial OA knees. Using a leg press activity, we can examine semi weight-bearing lower limbs kinematics without complicating compensatory motions such as trunk lean, which occurs in squatting and gait.

METHODS:
Enrolled in this IRB approved study were nine ACL deficient knees and their contralateral 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. 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 ACL deficient patients were between 20 and 40 years and preferred ACL reconstruction. The other inclusion criteria for all groups was the ability to perform a leg press activity. Exclusion criteria included knee ligament injuries other than ACL, history of contralateral knee injuries, and age less than 20 years. An interval from injury to testing were between 1 and 38 months for the ACL injured knees. Normal knees were the contralateral asymptomatic knees of the ACL deficient knee and had no signs of radiographic knee OA. Informed written consent was obtained from all subjects.

Knee kinematics were analyzed using a 3D-to-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 of 90°. The resisting load for ACL deficient and OA knees were 10kg and 5kg, respectively, plus 8.7% of the 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 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 the leg press activity. The average maximum extension/flexion angle was 7 ± 5°/81 ± 8°. Statistical comparisons were performed using values between 10° and 65° of flexion, where observations from all knees were available. Repeated measures analysis of variance and post-hoc pair-wise comparison (Tukey-Kramer test) were used to compare the 3 knee groups. The level of significance was set at p<0.05.

RESULTS:
The OA knees demonstrated greater tibial external rotation during leg press than normal knees between 40° and 65° flexion (Fig 1a), and ACL deficient knees at 60° and 65° flexion. In addition, the OA knees demonstrated more anterior lateral femoral condylar contact between 10° and 65° flexion than normal and ACL deficient knees (Fig 1b).

DISCUSSION:
The OA knees showed greater external tibial rotation during the leg press activity for flexion over 20°, which was consistent with a study of a squatting activity by Saari et al.[5]. The kinematics between ACL deficient and contralateral knees showed no significant differences. Brandsson et al. [6] examined knee kinematics while ascending a platform (height 8 cm) from about 55°–65° of knee flexion to full extension, and reported that the tibial center in the ACL deficient knees was more dorsally displaced and the tibia more externally rotated than the contralateral side. Reasons for this inconsistency may include the activity, load, and/or hip position between the leg press and platform ascending activities.

A 3D-to-2D registration technique using lateral fluoroscopy or radiography is a well-established to measure dynamic weight-bearing knee kinematics in vivo with standard errors within 2.2 mm for translations and 1.8 degrees for rotations [3]. Moreover, the leg press activity can reduce the variability of loads, body positions, and hip kinematics, and more consistent kinematics are expected, providing greater sensitivity to detect changes in knee kinematics as a function of load and activity.

In conclusion, OA knees showed reduced tibial internal rotation than ACL deficient and normal knees during a leg press activity. The mechanism of knee OA secondary to ACL injury may not be same as in primary knee OA.

REFERENCES: