INTRODUCTION
Many researchers have investigated patellar kinematics using both in-vitro and in-vivo studies. However, there are many discrepancies in the literature in describing in-vivo normal patellar kinematics due to variability in coordinate systems, and accuracy of the methods. Limited data exists on patellar kinematics under weight-bearing conditions. The objective of this study was to investigate the in-vivo patellofemoral kinematics during weight-bearing flexion. A combined dual-orthogonal fluoroscopy and magnetic resonance (MR) imaging technique was used to capture the motion of the knee joint.

METHODS
Ten knees from normal, healthy subjects were MR scanned. The MR images were used to create 3D models of knee joint including the femur, tibia and patella (Figure 1). Next, each knee was imaged using a dual-orthogonal fluoroscopic system while the subject performed a single leg lunge from 0° to 135° of flexion. The 3D model and orthogonal fluoroscopic images were then used to reproduce the in-vivo motion of the knee joint within solid modeling software. The accuracy of this system in measuring translation was less than 0.1 mm, while the repeatability was less than 0.1 mm and 0.3°.

Then, coordinate systems were drawn on the tibia, femur and patella (Figure 1). On the tibia, the long axis was drawn first. The medial-lateral and anterior-posterior axes were drawn perpendicular to the long axis. On the femur, the long axis and transepicondylar axis were drawn. To reduce the variability in creating patellar coordinate systems, a box was fit to the patella so that it touches the superior-inferior (SI), anterior-posterior (AP) and medial-lateral (ML) borders. The center of the box was defined as the patellar center and a Cartesian coordinate system was created at the patellar center. The six degrees-of-freedom kinematics of the femur and patella were measured in the tibial coordinate system. From this data, patellar kinematics with respect to the femur were calculated. At each selected flexion angle, the medial-lateral translation, tilt and rotation of the patella with respect to the femur was reported.

RESULTS
The patella translated laterally with increasing flexion until 75° of flexion (Figure 2). At 75° of flexion, the patella was 12.0±4.4mm lateral to the femur. Beyond 75° of flexion, the lateral translation decreased and at 135° of flexion, the patella was 7.3±4.6mm lateral to the femur.

The patella tilted laterally with increasing flexion until 75° of flexion (Figure 3). At 75° of flexion, patella tilted 4.4±6.2° laterally with respect to TEA of the femur. Beyond 75° of flexion, the lateral tilt decreased and reached 0.1±7.3° at 135° of flexion.

The patella rotated externally with increasing flexion until 75° of flexion (Figure 4). At 75° of flexion, patella rotated 5.4±9.2° externally with respect to the femur. Beyond 75° of flexion, the external rotation decreased and reached 4.1±9.0° at 135° of flexion.

DISCUSSION
This study measured the patellar kinematics during weight-bearing flexion from 0 to 135°. The patella translated laterally, tilted laterally, and rotated externally with respect to the femur until 75° of flexion. Beyond 75°, we have observed decreased lateral translation, lateral tilt and external rotation. These data may be used as a base line for clinical evaluation of patients with patellar maltracking, and pain.

REFERENCES