**The Coupled Motion of the Tibiofemoral and Patellofemoral Joints During In-Vivo Weightbearing Knee Flexion**

Guoan Li1, Ramprassad Pappannagari1, Kyung Wook Nha2, Louis E. De Frate3,1, Thomas J. Gill1, Harry E. Rubash1

1Orthopaedic Surgery, Massachusetts General Hospital, Boston, MA; 2Orthopaedic Surgery, Ilsanpaik Hospital, Ilsan, South Korea; 3Orthopaedic Surgery, Duke University, Durham, NC

kozanek@gmail.com

**Introduction:** The knee joint includes both the tibiofemoral and patellofemoral articulations. However, the coupled motion of the patellofemoral and tibiofemoral joints has not been quantitatively examined in living subjects. This information is critical in understanding the mechanisms of patellar mal-tracking and for improving surgical treatment of patellar pathology. The objective of this study was to investigate the in-vivo 6 DOF kinematics of the tibia, femur, and patella during weight-bearing flexion using dual-orthogonal fluoroscopy and magnetic resonance (MR) imaging.

**Materials and Methods:** Ten normal, healthy subjects (4 males, 6 females; age 30±7 years) were recruited in this study with approval of the IRB. Each knee (6 rights and 4 lefts) was scanned using MR imaging to create a 3D anatomic knee models. Two fluoroscopes (OEC 9800, GE, Milwaukee, WI) were positioned to simultaneously capture orthogonal images of the knee at different flexion angles while the subject performing weightbearing single leg lunge. Each knee was imaged at full extension, 30°, 60°, and in increments of 15° thereafter, up to a maximum of 135° of flexion. The knee positions were reproduced in the Rhinoceros® software using the 3D knee models and the orthogonal fluoroscopic images captured at each flexion angle.

The positions and orientations of the femur and patella were measured relative to a tibial coordinate system (Fig. 1).

All data was measured within each subject as a function of the knee flexion. The correlation between the femoral and the patellar kinematics was investigated. A repeated-measures ANOVA was used to analyze the effect of flexion angles on the femoral and patellar kinematics. Differences were considered statistically significant where p < 0.05.

**Results:** Patellar flexion had a strong correlation with tibiofemoral flexion (R² = 0.91, p<0.05). The posterior translation of the patella was also strongly correlated to the posterior femoral translation (R² = 0.87, p<0.05) (Fig. 2). Both the lateral tilt and medial translation of the patella were found to correlate with external femoral rotation (or internal tibial rotation) (Fig. 3). The increase in external femoral rotation was accompanied with an increase in lateral patellar tilt (R² = 0.73, p<0.05).

**Discussion:** This study measured the 6DOF kinematics of the tibia, femur and patella simultaneously during a weight-bearing lunge from full extension to maximal flexion in living subjects. The data quantitatively indicate a strong kinematic coupling between the tibiofemoral and patellofemoral joints. Therefore, this kinematic coupling should be considered when investigating patellar pathologies and when developing surgical techniques to treat knee joint diseases. Further investigation is needed to determine how altered tibiofemoral kinematics affects patellar tracking in patients suffering from soft tissue injuries of the knee joint.

**References:**

**Acknowledgements:** This work was partially supported by a grant from National Institute of Health (R01-AR052408).