KINEMATICS OF INTACT KNEE, FIXED AND MOBILE BEARING TKAS DURING PASSIVE FLEXION.

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Introduction:
Currently, there is an increase in the demand for a high flexion total knee arthroplasty (TKA). Activities of daily living for many Asian and Middle Eastern patients involve kneeling and squatting and require extensive knee flexion. Furthermore, many patients are accustomed to sitting in a cross-legged position or are interested in recreational activities such as gardening. Posterior femoral translation on the tibia (also known as femoral rollback) during knee flexion improves flexion range of motion by preventing posterior impingement at high flexion angles [1]. Rollback in posterior stabilized implants is achieved by the interaction of the femoral cam with the tibial spine. Limited information regarding femoral translation at high flexion angles (>120°) in TKA is available. The objective of this study was to investigate posterior femoral translation at high flexion angles in fixed and mobile bearing TKAs (Zimmer Inc.) using robotic technology.

Material and Methods:
Five post-mortem human knee specimens (age 68.4±1.7; 2 males and 3 females) were tested using a robotic testing system [2]. Each knee was cut 25cm above and below the joint, leaving all soft tissues (capsule, ligaments, and muscles) around the knee joint intact. The femoral and tibial shafts were potted in cylinders to enable secure mounting of the specimen on the robotic system. The femur was rigidly fixed to a specially designed clamp that allows for the 6 degrees-of-freedom (DOF) positioning of the femur. The tibia was rigidly fixed to the robot arm through the 6-DOF load cell. This set-up allowed the tibia to move with the robot arm in 6-DOF about the femur. To avoid dehydration of the specimen, 0.9% saline was regularly sprayed on the specimen.

The native knee was tested first. After specimen installation, the robot determined the passive path from full extension to 150° of flexion using a force-moment control algorithm [2]. The passive path is defined as the path where the forces and moments, at all flexion angles, are minimized. Since minimal force is being applied to the knee along the passive path, the passive path is determined by the articular geometry and the surrounding soft tissue constraints.

An orthopedic surgeon then performed a fixed bearing TKA on the same knee (LPS-Flex, Zimmer, Inc.) and a new passive path was determined. Finally, a mobile bearing TKA (LPS-Flex, Zimmer, Inc.) was performed on the same knee and a new passive path was determined. The posterior translation of the femur (defined by the center point of the transepicondylar axis) and the internal tibial rotation were calculated as the knee flexed along the passive path. A repeated measure ANOVA of within factors was used to analyze the data [3]. Statistically significant difference was set as p<0.05.

Results:
Posterior femoral translation was observed for all knees at all flexion angles (Figure 1). The greatest posterior femoral translation was observed in the native knee (17mm and 22mm at 120° and 150° of flexion, respectively), as compared to both TKAs. The posterior femoral translation of the fixed bearing TKA reached 8mm and 13mm at 120° and 150° of flexion, respectively. This is significantly lower than that measured in the native knee. Posterior femoral translation in the mobile bearing TKA was observed for all flexion angles, reaching its maximum of 15mm at 150° of flexion.

Internal tibial rotation was noted for all knees at all flexion angles (Figure 2). Intact tibial rotation gradually increased with flexion angle and reached a maximum of 12° at both 135° and 150° of flexion. Fixed bearing TKA underwent a gradual increase in internal tibial rotation and reached a maximum of 13° at 150°. Internal tibial rotation of the mobile bearing TKA at 60° of flexion was 94% of that of the native knee and reached a maximum of 14° at 150° of flexion. In general, the kinematics of the mobile bearing TKA followed the native knee slightly closer than fixed bearing TKA. No significant difference between the two TKAs was noted (p>0.05).

Discussion:
This study indicates that posterior femoral translation occurs along the passive path of the native knee and of both TKAs. Both fixed bearing and mobile bearing TKAs partially restored native knee kinematics on the passive path. For example, at 150° of flexion, the posterior femoral translation of the fixed TKA was approximately 60% of the native knee, while the mobile bearing TKA reached 66% of the native knee at the same flexion angle. The mobile bearing TKA showed a similar rollback trend as the fixed bearing TKA but mimicked the native knee slightly better. The cam-spine interaction in both TKAs appears to contribute to femoral rollback at flexion angles greater than 90°, as evidenced by consistent increase of posterior femoral translation after 90°. Tibial rotation was reduced at lower flexion angles after TKA. However, both TKAs closely restored the tibial rotation in high flexion of knee. This study demonstrated that the kinematic behavior of the fixed and mobile bearing TKAs was similar in the entire range of knee flexion.

References:

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