Comparison Of Intra-operative Flexion Kinematics
For Ultra-congruent (UC) And Posterior Stabilized (PS) Total Knee Arthroplasties

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Disclosures:

Introduction:
There have been several studies examining flexion kinematics of the total knee arthroplasty (TKA) implanted knees using 2D/3D image registration technique. Additionally, recent progress of computer navigation system in TKA has enabled intraoperative evaluation of the flexion kinematics before and after prosthetic implantation.

In the recent clinical practice, TKA implant system with hyper-congruent inserts, so-called ultra-congruent (UC) or deep-dished (DD) design, have been introduced as another mean of posterior stabilization and has gained popularity. Its design feature is characterized by increased height of the anterior rim of the polyethylene insert without post-cam mechanism as incorporated in the posterior stabilized (PS) design. Although potential advantages of this prosthetic type over conventional implant systems have been reported, kinematics of the knee implanted with this prosthesis design has not been clarified.

The purpose of this study was to examine and compare passive flexion kinematics of the osteoarthritic knees before and after UC and PS type TKA implantation using a navigation system.

Methods:
Twenty osteoarthritic knees undergoing primary TKA were included in the study, and results of intraoperative kinematic measurements were compared between two prosthesis models: 10 Columbus UC TKA (Aesculap, Tuttlingen, Germany) and 10 Columbus PS TKA (Aesculap, Tuttlingen, Germany). Surgeries were performed by two senior staff surgeons following the standardized procedure instructed for each prosthetic type. Intraoperative measurement of kinematics during passive flexion was performed using the CT-free navigation system (OrthoPilot, Aesculap).

CT-Free Navigation System
The Orthopilot® system used in this study is an image-free navigation system. Two trackers equipped with reference arrays was implanted in the distal femur and in the proximal tibia. Based on the kinematic and anatomical registration data, three-dimensional relationship between the tracker and each of the femur and the tibia was computed. TKA procedure was carried out using the resection block attached to this navigation system.

Kinematic analysis using the navigation system
Intra-operative passive flexion kinematics were measured by the Orthopilot® system and analyzed by the dedicated software (OrthoPilot TKA Version4.2 Kobe version). This software allows data acquisition of three-dimensional kinematics intraoperatively. Kinematic recording was performed both before and after TKA implantation. During the kinematic measurement, the assistant surgeon held the thigh to align it perpendicularly while the operating surgeon gently held the heel and passively moved the knee from full extension to full flexion by inducing unconstrained motion.

Results:
Flexion kinematics before TKA implantation
Analysis of the axial rotation pattern during flexion, on average, showed the tendency of slight external rotation of the tibia up to 40° of flexion, followed by progressive internal tibial rotation with flexion beyond 40°. Regarding the anterior-posterior translation during flexion, the average value showed slight posterior translation of the tibia up to 30° of flexion, followed by progressive anterior tibial translation (i.e. posterior femoral rollback) with flexion.

Flexion kinematics of the knee after implantation of the UC TKA
The average axial rotation of the TKA implanted knee showed the similar pattern to the pre-implantation condition, showing
external rotation of the tibia up to 40° of flexion followed by progressive internal tibial rotation with further flexion. The initial tibio-femoral relationship was slightly shifted to internal rotation of the tibia compared to the pre-implantation condition. When the pre- and post-implantation data were compared in each knee, basically same rotational pattern was maintained even after the TKA implantation in majority of the examined knees. The anterior-posterior translation results showed difference both in the pattern and the magnitude between pre- and post-implantation conditions. Following TKA, the initial position of the tibia was substantially shifted anteriority resulting in posterior shift of the tibio-femoral contact. With flexion, tibia moved posteriorly (i.e. paradoxical anterior femoral translation) up to 60-90° of flexion followed by anterior tibial translation (femoral rollback) with further flexion. When the kinematic pattern was examined for each knee, majority of the knees followed the forementioned pattern consistently after the TKA implantation.

**Flexion kinematics of the knee after implantation of the PS TKA**

The average axial rotation of the PS TKA implanted knees showed the same pattern as UC TKA. Regarding the anterior-posterior translation results, the PS implanted knees exhibited different kinematic pattern as compared to the UC knees. The knees with PS TKA showed different pattern in which the average value showed slight posterior translation of the tibia up to 30° of flexion, followed by progressive anterior tibial translation (i.e. posterior femoral rollback) with further flexion induced by the post-cam mechanism.
**Discussion**: Kinematic analysis of the OA knee in this study showed non-physiologic kinematics characterized by reversed rotational and translational patterns (external rotation and posterior translation of the tibia during early flexion phase) during early flexion followed by physiologic pattern with increased flexion. After implantation of the UC TKA, the postoperative rotational pattern during flexion was similar to the preoperative pattern. By contrast, distinct difference in coupled anterior/posterior translation was observed between pre- and postoperative conditions. Flexion kinematics of the UC TKA knees in sagittal dimension was characterized by substantial anterior-to-posterior tibial motion (paradoxical anterior femoral translation) during flexion up to 60-90° of flexion followed by anterior tibial translation (femoral rollback) with further flexion. This translation pattern was not observed for the PS TKA which showed fairly consistent anterior tibial translation (i.e. posterior femoral rollback) beyond 30° of flexion.

**Significance**: Apparently excessive translation during flexion in UC TKA knees raises a concern regarding the longevity of the implant of this type.

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References:

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