Intraoperative passive flexion kinematics of osteoarthritic knees before and after mobile bearing PCR-TKA

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INTRODUCTION
There have been several studies examining kinematics of the TKA implanted knees with 2D/3D image registration technique. However, no study has compared the pre- and postoperative kinematic differences. Therefore, significance of TKA procedure in restoring physiologic knee motion has not been investigated. Recent progress of computer navigation system in TKA has enabled us to evaluate the flexion kinematics of the knee intraoperatively. Thus, the purpose of this study was to examine and compare passive flexion kinematics of the osteoarthritic knees before and after mobile bearing posterior cruciate ligament retaining (PCR) TKA using a navigation system.

MATERIALS AND METHODS
Eighteen knees of the 17 subjects (5 men and 13 women) with the mean age of 74.4 years (60~80years) were included in the study. All subjects underwent a primary PCR-TKA for osteoarthritis. Surgeries were performed by the same surgeon using e-motion mobile bearing PCR TKA (Aesculap, Tuttlingen, Germany) with the assist of 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 dedicated software (OrthoPilot TKA Version 4.2 Kobe version). The software allows anatomical and kinematic acquisitions and provides real-time display of knee alignment during surgery and standard kinematic evaluations. With the help of this system, three dimensional tibio-femoral kinematics could be continuously monitored through range of motion with a sampling rate of 5/s per each of 10-degree increments during flexion. Kinematic recording was performed both before and after TKA implantation. During the kinematic measurement, an 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 inducing unconstrained motion. The kinematic measurement for the TKA implanted knee was performed after repair of the parapatellar arthroscopy and skin closure.

RESULTS
Flexion kinematics of the pre-implantation OA knee
Analysis of the axial rotation pattern during flexion, on average, showed the tendency of slight external rotation (2.2° ± 1.5°) of the tibia up to 60° of flexion, followed by internal rotation of the tibia with increased flexion beyond 60° (16.1° ± 7.9°).
Regarding the anterior-posterior translation during flexion, the average value showed slight posterior translation of the tibia up to 30° of flexion, followed by anterior translation of the tibia (i.e. posterior femoral rollback) with increased flexion (total amount of translation: 11.9 ± 6.8mm).

Flexion kinematics of the TKA implanted knee
The average axial rotation of the TKA implanted knee showed the similar pattern to the pre-implantation condition showing external rotation up to 60° of flexion followed by internal rotation with further flexion. However, the total amount of external rotation of the tibia up to 60° increased (2.2° ± 1.5° vs. 6.9° ± 0.4°) while the subsequent internal rotation value decreased (16.1° ± 7.9° vs. 14.3° ± 9.8°) in comparison of the pre- and post-implantation kinematic results. When the pre- and post-implantation data were compared in each knee, basically same pattern was maintained in majority of the knees while the rotational pattern was completely changed after TKA in a few knees.

The anterior-posterior translation showed difference both in pattern and total amount between pre- and post- implantation. Following TKA, the translation value during passive flexion showed the tendency of posterior translation of the tibia up to 90° of flexion (i.e. paradoxical anterior of femoral translation) followed by anterior translation of the tibia (posterior femoral rollback) with increased flexion (total amount of translation: 5.5 ± 2.4mm). When the kinematic comparison was made for each knee, majority of the knees followed the aforementioned pattern while a few knees exhibited the exceptional pattern of translation after the TKA implantation.

Fig. 1
The average tibial axial (external(+)/internal(-)) rotation value during passive flexion in OA knee before and after TKA (n=18). The value was recorded at each of 10-degree increments.

Fig. 2
The average tibial translation (anterior(+)/posterior(-)) value during passive flexion in OA knee before and after TKA (n=18). The value was recorded at each of 10-degree increments.

DISCUSSION
Kinematic analysis of the OA knee in this study showed unphysiologic kinematics characterized by reversed rotational and translational pattern (internal rotation and posterior translation of the tibia during early flexion phase) followed by physiologic pattern with increased flexion. This tendency was observed in majority of the examined knees. After implantation, this basic pattern of flexion kinematics could not be corrected even after apparent improvement of sagittal and coronal alignment as well as joint congruity.
The design features of the e-motion mobile-bearing PCR TKA are characterized by mobile bearing polyethylene insert allowing both axial rotation and translation with congruent femoro-tibial articulation. The results of the present study for the TKA implanted knee basically agree with the results reported in the previous studies employing different methodology. Therefore, it is assumed that the unphysiologic kinematic pattern of the OA knee cannot be fully corrected by TKA procedure regardless of the surgical technique and design of the implant.

REFERENCES