Analysis of non-weight-bearing flexion kinematics of mobile bearing CR TKA

INTRODUCTION:
In the navigated total knee arthroplasty (TKA), recent advance in computer technology has added another feature to the system regarding assessment of kinematic analysis. However, relationship between intra- and postoperative kinematics has not been well investigated. There have been several studies examining the three-dimensional in-vivo kinematics of the TKA implanted knee based on the 2D/3D image registration. The purposes of our study are (1) to examine passive non-weight bearing flexion kinematics of the mobile-bearing posterior cruciate-retaining (PCR) TKA intraoperatively using the navigation system and (2) to compare the kinematic results obtained from intraoperative navigation system and postoperative 2D/3D image analysis.

MATERIALS AND METHODS:
Twenty-two knees of the 20 subjects (3 men and 17 women) with osteoarthritis who underwent primary PCR TKA were included in the study. The mean age at surgery was 73.4 years (range, 64 to 84 years). Surgeries were performed using e-motion mobile-bearing PCR TKA (Aesculap, Tuttingen, Germany). In all cases, the CT-free navigation system (OrthoPilot® Aesculap) was used during the procedure.

Intra-operative kinematic analysis
Intra-operative passive flexion kinematics was measured by the dedicated software incorporated into the navigated TKA system. This software allows acquisition of three-dimensional flexion kinematic data. After skin closure, the operated knee was taken through passive range of motion and flexion kinematics was simultaneously recorded. During the measurement, an assistant held the thigh with the hip in flexion position, while the senior surgeon held the heel and gently moved the knee from full extension to full flexion by gravity.

Post-operative kinematic analysis
Post-operative kinematics of the knee implant was determined using the 2D/3D image registration technique based on the two-dimensional digital radiography (DR) images during passive range of motion. In this part of the study, 6 knees of the 4 subjects were analyzed. The mean age of the patients was 74 years. Intra-operative kinematic data were available for all patients. The measurements were performed at 3 weeks after surgery. During the measurement, the assistant and examiner moved the TKA implanted knee in the same condition as in the intraoperative measurement with the patient in the supine position.

RESULTS:
Intra-operative kinematic analysis assessed by navigation system
The values were recorded through flexion at each of 10-degree increments. The average axial rotation value during passive flexion showed the tendency of internal rotation of the tibia with increased flexion beyond 60 degrees (Fig.1A). The average anterior-posterior translation of the tibia showed the tendency of initial posterior translation followed by anterior translation of the tibia (posterior femoral rollback) in flexion beyond 80 degrees (Fig.1B).

Comparison of intra- and postoperative measurements
In the second part of the study, we compared the kinematic results obtained from intraoperative navigation system and postoperative 2D/3D image registration. The basic trend of the tibial axial rotation was similar in both of the two measurements (Fig.2A). By contrast, postoperative kinematics was different from the intraoperative kinematics in terms of the translation. In the postoperative measurement, translation was markedly restricted and no demonstrable anterior-posterior translation was observed during flexion (Fig.2B).

Figure 1: Results of intra-operative kinematic analysis by navigation system (n=22). The average tibial rotation (A), and translation values (B) at each of the 10-degree increments.

Figure 2: Comparison of intra- and postoperative measurements. (n=6) The average tibial rotation (A), and translation values (B) at each of the 10-degree increments.

DISCUSSION:
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 intraoperative measurement showed variable flexion kinematics in each individual. On average, however, internal rotation of the tibia and posterior femoral rollback in deep flexion range were observed. This kinematic pattern is thought to agree with the basic trend shown in the previous postoperative kinematic studies.

In the second part of the study, both intra- and postoperative kinematic analyses were performed for the same subject and the results were compared. Consequently, it was shown that postoperative kinematics at 3 weeks was different from the intraoperative kinematics as characterized by markedly decreased anterior-posterior translation.