THE INFLUENCE OF FEMORAL COMPONENT ROTATION ON THE FLEXION GAP IN DEEP KNEE FLEXION

Introduction:
Deep knee flexion is important in many situations of everyday life, especially in Asia, however, patients even have good preoperative ROM, often lose deep flexion after total knee arthroplasty. During the total knee arthroplasty, we observed that flexion gap, which was rectangular in 90 degrees flexion, became asymmetrical with narrowing of medial gap in deep knee flexion. We concerned that this phenomenon might be a factor of preventing deep flexion, and affected longevity of prosthesis due to excessive stress on medial side of tibial insert. Among the several factors, rotational alignment of femoral component is known to directly affect the balance of flexion gap. In this study, we aimed to evaluate the influence of femoral component rotation on flexion gap in deep knee flexion.

First, we evaluated the change in the rotational alignment of normal subjects in deep flexion using MRI. We then evaluated the influence of femoral component rotation on the flexion gap in osteoarthritic patients underwent TKA.

Materials and Methods:
1. Normal Subjects
We evaluated 40 normal knees in 20 female and 20 male volunteers, using MRI. (1.5Tesla, Symphony®, Siemens AG, Munich, Germany). We obtained the coronal MR images of whole length of tibia with distal femur in 90 and 130 degrees of knee flexion. We then evaluated the change in the rotational alignment of normal subjects in deep flexion using MRI. We then evaluated the influence of femoral component rotation on the flexion gap in osteoarthritic patients underwent TKA.

First, we evaluated the relationship among the clinical transepicondylar axis, surgical transepicondylar axis, Whiteside’s line and the tibial mechanical axis in 90 degrees of knee flexion, and found that clinical transepicondylar axis of showed most perpendicular relationship with the line perpendicular to tibial mechanical axis and perpendicular relationship with Whiteside’s line. We then measured the angles between clinical transepicondylar axis (cTEA) and perpendicular line to the mechanical axis of tibia in 90 and 130 degrees of knee flexion. The relationship of the two lines represented the status of flexion gap in total knee arthroplasty (TKA) when using the classic method of bone resection (Fig. 1).

2. Osteoarthritic Patients
We performed preoperative, intraoperative and postoperative evaluation of 30 osteoarthritic knees. All patients were female and had varus deformity. Using multi-detector computed tomography, we measured the preoperative and postoperative angles between clinical transepicondylar axis (cTEA) and posterior condylar axis (PCA) (Fig. 2A,B). By the difference of these two angles, we calculated the amount of femoral component rotation during the total knee arthroplasty. Intraoperatively, we measured medial and lateral gaps in 90 and 130 degrees of knee flexion (Fig 3A,B). Analyzing the data, we evaluated the relationship between the amount of femoral component rotation and changes in flexion gap, as knee was flexed from 90 to 130 degrees. Pearson correlation test was used to determine statistical significance.

Results:
1. Normal Subjects (Fig. 1) The angles between cTEA and perpendicular line to the mechanical axis of tibia in 90 degrees flexion averaged 0.8 degrees in male and 0.2 degrees in female. In 130 degrees flexion, clinical TEA internally rotated relative to the perpendicular line to tibial mechanical axis with narrowing of medial side in all cases. The mean angles of internal rotation of clinical TEA were 2.3 degrees in male and 2.1 degrees in female.

2. Osteoarthritic patients
The preoperative and postoperative mean angles between clinical TEA and PCA were 6.2 degrees (2.9 to 8.8 degrees) and 1.7 degrees (-1.0 to 5.8 degrees), respectively. The amount of external rotation of femoral component during the TKA was 4.5 degrees (3.0 to 6.4 degrees). Even up to 6.4 degrees of external rotation, there was no case showed larger medial gap than lateral in 90 degrees flexion. In all cases, medial gaps were narrower than lateral in 130 degrees of knee flexion. In addition, medial gaps in 130 degrees flexion were narrower than those in 90 degrees without exception. The mean gap difference between medial and lateral side in 130 degrees of knee flexion was 6.2mm (3-10mm). As knees were flexed from 90 to 130 degrees, the medial gap decreased by 2.7mm and lateral gap increased by 2.3mm on average. The amount of external rotation of femoral components showed strong negative correlation with the medio-lateral gap differences in 130 degrees of knee flexion (p=0.01), and with the differences between medial gaps in 90 degrees and those in 130 degrees flexion (p=0.01).

Discussion and Conclusion
Among the several rotational axes, PCA is regarded as a practical guideline, and many total knee systems are designed to set 3 degrees of external rotation relative to posterior condylar axis for femoral component rotation. However, this study demonstrates that 3 degrees is insufficient ‘external rotation’ for optimizing flexion gap in deep flexion and even in 90 degrees flexion, especially in Asian female population. In our study, even up to 6.4 degrees of external rotation, there was no case showed larger medial gap than lateral one in 90 degrees flexion. In addition, medial gap in deep flexion was narrower that in 90 degrees flexion in all cases, even with increasing external rotation of 4.5 degrees on average. According to the results of normal subject, clinical TEA is an optimal reference axis, which produces symmetrical balanced flexion gap in 90 degrees flexion, and perpendicular relationship with Whiteside’s line, which possibly means more functional patellofemoral articulation. According to our study and previous reports, to set femoral component parallel to clinical TEA, about 6 degrees of external rotation is needed. Among the 20 female volunteers and 30 female osteoarthritic patients, only 5 subjects showed the angle between clinical TEA and PCA less than 5 degrees. Considering this, 5 degrees of external rotation relative to PCA, rather than conventional 3 degrees of external rotation, is a reasonable and safe guideline of femoral component rotation, and reduce excessive stress on medial compartment in deep knee flexion after TKA.

* This study was supported by a grant of A-Ministry of Health and Welfare, R.O.K. (0405-BO01-0204-0006)