The Position of Components using the Modified Gap-Balancing Technique after Posterior Stabilized Type Total Knee Arthroplasty.

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Introduction: During total knee arthroplasty (TKA), the fixation of the femoral components using a modified gap-balancing (MGB) technique that is does not use bone landmarks of the femur as reference points, unlike the measured resection (MR) technique. In this study, we examined the differences between the bone landmarks, clinical transepicondylar axis (CEA) and surgical transepicondylar axis (SEA), and assessed the femoral component positioning by the MGB technique, using computed tomography (CT) before and after TKA. In addition, the difference between the positioning of tibial components using the range of motion (ROM) technique and that using referring with the anteroposterior (AP) axis of the tibia was also examined.

Methods: CT images were taken obtained before and after TKA in 53 patients (57 knees; 5 men, 48 women; varus osteoarthritis 53 knees, rheumatoid arthritis 4 knees). The mean age of the subjects was 73.9 ± 7.4 years (54-84 years). The components and surgical technique used for TKA were Scorpio NRG (Stryker Co.) and the MGB technique, respectively. The angle of the tibial shaft to the cutting surface of tibia in AP x-ray view, that is, the beta angle of tibia was 89.6º ± 1.5º. Lateral release was required for 36.8% of all knees. In the CT images of the femur before TKA, the angle between the CEA and the posterior condylar line (PCL), called the condylar twist angle (CTA; Fig.1a-1), and the angle between the SEA and the PCL, called the posterior condylar angle, (PCA; Fig.1a-2) were examined. In the CT images of the femur after TKA, the rotation of the femoral component defined by position of the PCL relative to the CEA and SEA was examined. The rotation of the tibial component was determined using the ROM technique, that is, the rotation of the tibial component was dependent on the rotational orientation of the femoral component and soft-tissue balancing. Next, the line of AP axis of the tibia, connecting the middle of the PCL and the medial border of the patellar tendon attachment, was examined before and after TKA (1). The line of AP axis of the tibia is usually used to determine the location of the AP axis of the tibial component for the MR technique during TKA. However, the line of AP axis of the tibia was not detected on the CT view after TKA because of the artifact on CT views, so it was matched according to the difference in tibial rotation before and after TKA in each case (Fig.1b). Then, we examined the rotation of the tibial component and the mean medial percentage width of the intersecting point of the patellar tendon attachment to the line of AP axis of the tibia after TKA.

Results: The mean values for CTA and PCA in the preoperative knee were 6.6º ± 1.5º and 2.6º ± 1.3º, respectively. The rotational position of the femoral component was 0.77º ± 1.6º internal rotation to the CEA, and 3.2º ± 1.6º external rotation to the SEA. The rotation of the tibial component to the line of AP axis of the tibia was 6.3º ± 4.8º external rotation in the merged position following TKA (Fig.2a). The
mean medial percentage width of the intersecting point of the patellar tendon attachment and the tibial component axis was 20.3% ± 14.7% (Fig.2b). The angle of the AP axis of the femoral component to the line of AP axis of the tibia was significantly correlated with the tibial component rotation to the line of AP axis of the tibia (R² = 0.54; Fig.3). Lateral release of the patella was not significantly affected by rotation of the femoral component to the CEA (P = 0.10), rotation of the tibial component to the line of AP axis of the tibia (P = 0.73).

**Discussion:** The rotational relationship between the femoral and tibial components has important functional and durable significance for TKA. Akagi et al. demonstrated that the AP axis of the tibia was defined as a line passing through the middle of the PCL and perpendicular to the SEA with the knee in an extended position, and the medial border of the patellar tendon attachment was an anterior anatomic landmark to help determine the AP axis of the tibia in the surgical field (1). Many surgeons are using these landmarks of the SEA as the femoral rotation and the line of AP axis of the tibia as the tibial rotation during TKAs with the MR technique. However, the rotational relationship between the femoral and tibial components during TKAs using the MGB technique was unclear. In this study, we demonstrated that the rotational position of the femoral component was close to the CEA and that of the tibial component was 6.3° external to the line of AP axis of the tibia when using the MGB and ROM techniques to determine the rotational alignment of the femoral and tibial components. The MGB technique, in which ligament tensioners are used to rotate the femur and stretch the medial and lateral ligaments to equal the load before the posterior and anterior femoral surfaces are cut parallel to the tibial surface, is used for positioning the femoral component in flexion. The collateral ligaments are normally more lax laterally, especially during flexion (2). Therefore, when tensioners are used to rotate the femur until the medial and lateral collateral ligaments are equally loaded, the femur is more externally rotated than during the MR technique, in which the anatomic landmark SEA on the femur is used to align the anterior and posterior femoral saw cut. When the rotation of the tibial component was dependent on the rotational orientation of the femoral component and soft-tissue balancing, the tibial components were also more externally rotated to the line of AP axis of the tibia than during the MR technique. Akagi et al. showed that the AP axis passed a mean 0.2% of the width of the patellar tendon at the level of the patellar tendon attachment to the tibial tubercle. They also mentioned that the mean angle between the line of AP axis of the tibia and the line connecting the middle of the PCL and the medial one-third of the patellar tendon at the level of the tubercle attachment was 10.0°; the tibial component would have approximately 10° excessive external rotation relative to the femoral component if the femoral component is set parallel to the SEA and the tibial component is set perpendicular to the line of AP axis of the tibia (1). Based on our finding that the mean medial percentage width of the intersecting point of the patellar tendon attachment and the tibial component axis was 20.3%, and the rotation of the tibial component after TKA was 6.3° externally rotated, the tibial component is suggested to be set in a more externally rotated position when using the MGB technique than when using the MR technique during TKA, but is less externally rotated than the medial one-third of the patellar tendon at the level of the tubercle attachment. In conclusion, the rotational position of the femoral component was close to the CEA and the tibial component should be placed at an externally rotated position than the line of AP axis of the tibia to avoid the rotational mismatch between the femoral and tibial components, when using the MGB technique during TKA.
**Significance:** This study represents the first demonstration of the positioning of the femoral and tibial components when using the modified gap-balancing technique during TKA.

![Diagram](image)

**Fig. 1**

a. The angle A and B are a condylar twist angle (CTA) and a posterior condylar angle (PCA), respectively. The solid line in a-1 is determined, connecting the medial epicondyle and the lateral epicondyle of the femur. The solid line in a-2 is determined, connecting the sulcus of the medial epicondyle and the lateral epicondyle of the femur. The dotted lines in a-1 and a-2 are determined as posterior condylar line of the femur.

b. The difference of tibial rotation between the before (b-1) and after TKA (b-3). It is defined the rotation as the line connecting the tip of tibial tuberosity and the center of fibula in the same CT plane. The dotted and solid lines are before (b-1) and after TKA (b-3), respectively. X: The difference angle between before and after TKA (b-2).
a. The rotation of post-operative tibial component to the line of AP axis of the tibia. dotted line: the assumed pre-operative the line of AP axis of the tibia; A': the perpendicular line to tibial component; Y": the angle of tibial component to the line of the AP axis of the tibia
b. The mean medial percentage width of intersecting point of patellar tendon attachment and tibial component axis was defined as m'/l' x100. l": the patellar tendon width; m": patellar tendon width medial to the intersecting point; dotted line: the line of the AP axis of the tibia
The correlation between the angle of the AP axis of femoral component to the line of AP axis of the tibia, and the post-operative tibial component rotation to the line of AP axis of the tibia.

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