Effect of Balanced Gap Total Knee Arthroplasty on Intraoperative Laxities and Femoral Component Rotation

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Abstract: The gap technique could lead to undesirable rotation of the femoral component in some knees. Using a navigation system, femoral component external rotations and varus-valgus laxities at 0° and 90° of flexion were measured intraoperatively in 44 patients. Significant improvements were observed at a minimum follow-up of 4 years with regard to clinical and radiologic outcomes. The balanced gap technique in total knee arthroplasty provided good intraoperative alignments and laxities of knees at 0° and 90°. However, increased femoral component external rotation was found to be correlated with increased varus alignment at 90° of knee flexion. This study shows that excessive external rotation of the femoral component during flexion gap balancing using the balanced gap technique in total knee arthroplasty can be avoided by additional soft tissue balancing guided by navigation. **Keywords:** gap technique, laxity, external rotation of femoral component, TKA.

Stability has been cited to be one of the most important factors of successful total knee arthroplasty (TKA) [1,2], and proper axial rotation of the femoral component is important in TKA to achieve stability in flexion [3-6]. Two surgical techniques can be used to determine rotation of the femoral component, namely, the measured resection technique and the balanced gap technique.

In TKA using the measured resection technique, rotational alignment of the femoral component is determined using 3 anatomic bony landmarks; the transepicondylar axis, the anteroposterior line, and at 3° of external rotation from the posterior condylar line [7-10]. In some TKAs using the measured resection technique, the flexion gap is simply balanced by 3° of external rotation of the femoral component or using the transepicondylar axis regardless of ligament tension, but this is not always correct and could result in trapezoidal flexion gap [4]. On the other hand, when the balanced gap technique is used, a cut parallel to the proximal tibial cutting surface is made to achieve rotational alignment of the femoral component after adequate soft tissue balancing in extension [4,11-15]. Advocates of the balanced gap technique report better flexion stability, patellar tracking, and reproducibility with respect to femoral rotation [4,12,13]. However, the rotation of the femoral component in TKA using this technique depends on soft tissue balance [4,6,13,16]. Hence, concern has been expressed that the balanced gap technique could lead to implantation of the femoral component in undesirable internal or excessive external axial rotation in some knees and thus cause rotational malalignment, patellofemoral maltracking, or early TKA failure [4,17].

Several studies have investigated femoral component rotation when the balanced gap technique is used, using a laminar spreader or space block. However, until recently, measurements of the accuracies of tibial cuts and of gap balances during surgery relied on subjective assessment. Navigation systems were introduced into TKA to improve cutting alignments and soft tissue balancing during surgery, which could be used in TKA using the balanced gap technique for the objective measurements of gap data. Moreover, it remains unclear to what extent malrotation of the femoral component during the balanced gap technique is tolerable without patellofemoral maltracking or poor functional outcomes after TKA.

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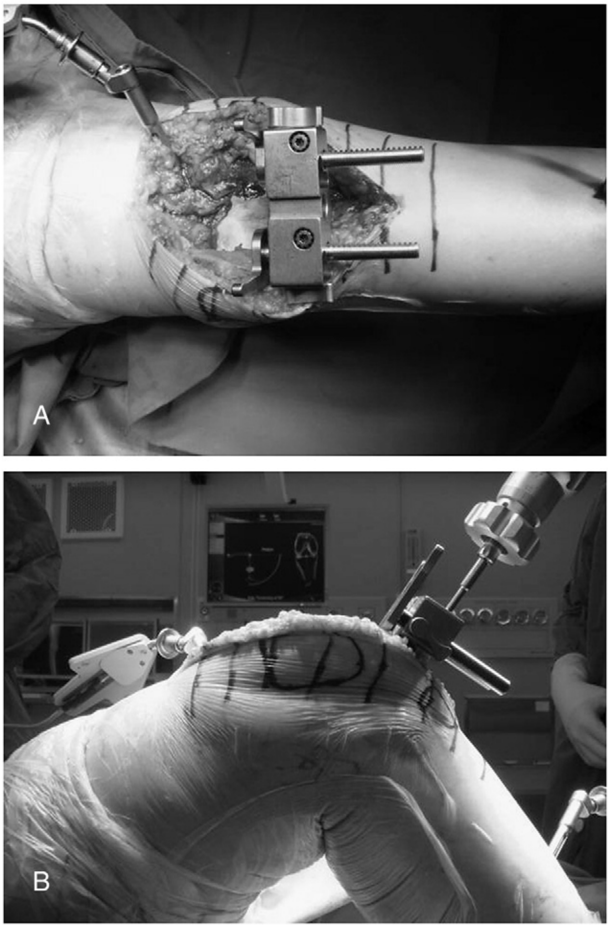

Fig. 1. (A-B) Photographs showing the measurements of extension gap (A) and flexion gap (B) using the tensioning device (V-STAT tensor).

The purposes of this study were to determine femoral component rotations and laxities using a navigation system during cruciate-retaining TKA using the balanced gap technique and to evaluate the effects of femoral rotation on knee function.

Materials and Methods

We enrolled 47 patients awaiting unilateral cruciate-retaining TKA for osteoarthritis. The exclusion criteria applied were a history of open knee surgery (except meniscectomy), a severe deformity (>20° varus or >30° flexion contracture), and a diagnosis other than osteoarthritis. Three patients died or were lost to follow-up before a minimum follow-up of 4 years. Accordingly, the cohort consisted of 44 knees in 4 men and 40 women with an average age of 68.8 years (range, 56-79 years). All TKAs were performed by the senior author, who had completed more than 20 cruciate-retaining TKAs using the balanced gap technique with computer-assisted navigation before this study was initiated. The minimum follow-up was 4 years (mean, 54.5 months; range, 48-68 months). Institutional review board approval and patient informed consent were obtained before surgery.

A medial parapatellar approach with patellar eversion was used in conjunction with the OrthoPilot (Version 4.08; B. Braun Aesculap, Tuttlingen, Germany) navigation system. This is an image-free system that uses kinematic analyses of hips, ankles, and knees and anatomic mapping of knees to build a working model of the knee. After medial parapatellar arthrotomy, deep medial collateral ligament release and osteophyte removal were performed to align legs close to neutral alignment. Proximal tibial bone cutting at 0° in the coronal and sagittal planes was performed under real-time navigation system control. During osteotomy, the bony block at the tibial insertion site of the posterior cruciate ligament (PCL) was preserved, and the PCL was confirmed to be anatomically intact by inspecting and checking its tension by probing its fibers. Extension gaps were measured at full extension using a tensioning device (V-STAT tensor; Zimmer, Warsaw, Ind) at 200 N and recorded using the navigation system. [18] (Fig. 1A). If a leg did not achieve neutral alignment (less than a 2° difference from the 180° hip-knee-ankle axis), further release of the semimembranosus and posteromedial capsules was performed. The flexion gap was then measured at 90° of flexion using a tensioning device at the same tension and recorded using the navigation system (Fig. 1B). A distal femoral cutting block was placed for a cut perpendicular to the mechanical axis of the femur, and the cut was completed under navigation control. A 4-in-1 cutting block was placed parallel to the tibial resection plane under real-time navigation control to equalize flexion and extension gaps for anterior and posterior cuts. Normally, femoral external rotation lies within the range 0° to 7°. We did not allow internal rotation of the femoral component. In cases beyond this range, we gently released the anterior fiber of the superficial medial collateral ligament and rechecked flexion and extension gap balance. Femoral external rotation was restricted to 7° or less to avoid deleterious patellar tracking effects. External rotation data of the femoral component were recorded using the navigation system. We accepted mediolateral imbalances of less than 2 mm or a flexion gap less than 2 mm larger than the extension gap. After confirming stability with a trial component to determine the size of the meniscal component required at 0° and 90° of flexion, the actual component was inserted using Simplex-P bone-cement (Stryker, Limerick, Ireland). The PCL was retained and the patella was not resurfaced, and e.motion (B. Braun, Aesculap, Tuttlingen, Germany) prostheses were implanted with cement for arthroplasties. These prostheses provide a large contact area by its high-conformity design of femorotibial articulation. The tibial base plate has a posterior slope of 3°, and the polyethylene insert is slightly dished in the sagittal plane with a slightly elevated anterior lip (Fig. 2). After patellar reduction and medial parapatellar arthrotomy closure using several