Early Results of Total Knee Arthroplasty Using a Built-in 3-Degree External Rotation Prosthesis

Young-Joon Choi, MD, Ki-Won Lee, MD, and Jun-Seok Park, MD

Department of Orthopaedic Surgery, Gangneung Asan Hospital, University of Ulsan College of Medicine, Gangneung, Korea

Purpose: We compared the outcomes of total knee arthroplasty (TKA) using the Genesis II prosthesis in which 3° of external rotation was incorporated into the femoral component and Nexgen LPS prosthesis in which the degree of external rotation was determined by the extent of intraoperative bone cutting.

Materials and Methods: Of the patients who underwent TKA for osteoarthritis between November 2006 and December 2009, 326 patients (572 knees) were included in this study. The prosthesis of choice was Genesis II in 199 knees and Nexgen LPS in 373 knees. The mean follow-up was 27 months (range, 24 to 51 months). The American Knee Society score (KSS) and function score (FS) were used for clinical assessments. The maximum flexion angle and patellar tilt were compared between the groups.

Results: At the final follow-up, no significant intergroup difference was observed regarding the KSS ($p=0.217$), FS ($p=0.238$), maximum flexion angle ($p=0.124$), and patellar tilt ($p=0.156$).

Conclusions: There was no significant difference in the clinical outcomes and patellar tilt between the prosthesis in which 3° of external rotation was incorporated into the femoral component and the prosthesis in which external rotation was determined based on bone cutting.

Keywords: Knee, Osteoarthritis, Arthroplasty, Femoral rotation, Patellofemoral complication

Introduction

Obtaining correct rotational alignment of the femoral component in total knee arthroplasty (TKA) is crucial to proper patellar tracking and varus-valgus balance in flexion. Since external rotation of the femoral component has been known to produce the closest to the normal varus-valgus stability¹⁾, it has been generally recommended to externally rotate the femoral component parallel to the transepicondylar axis during implant placement²⁾. In spite of this, the femoral component is commonly placed 3°–5° externally rotated relative to the posterior condylar axis due to

the difficulty of the intraoperative visualization of the medial epicondyle. However, external rotation of the femoral component may increase the risk of notching on the anterolateral femoral cortex and result in excessive shear forces and stresses on the patella during $\geq 90^\circ$ flexion³⁾. To overcome these disadvantages, a new type of femoral component with a varying thickness of the posterior condyle was designed to produce the same effect of external rotation. The incorporation of external rotation into the femoral component can be effective in improving patella tracking and patellofemoral joint stability³⁾, but this has yet to be established with more follow-up research.

In this study, we compared the outcomes of TKAs using the Genesis II (Smith & Nephew Inc., Memphis, TN, USA) prosthesis in which 3° of external rotation was incorporated into the femoral component and the Nexgen LPS (Zimmer Inc., Warsaw, IN, USA) prosthesis in which the amount of external rotation was determined based on the extent of intraoperative bone cutting.

Received April 26, 2012; Revised (1st) September 28, 2012;

(2nd) February 7, 2013; Accepted May 13, 2013

Correspondence to: Ki-Won Lee, MD

Department of Orthopaedic Surgery, Gangneung Asan Hospital, 38 Bangdong-gil, Gangneung 210-711, Korea

Tel: +82-33-610-3239, Fax: +82-33-641-8050

E-mail: osteotome@hanmail.net

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Materials and Methods

1. Patients

Of the patients who underwent TKA for osteoarthritis by the same surgeon from November 2006 to December 2009, 326 patients (572 knees) who were available for ≥ 2 years of follow-up without any evidence of complications, such as infections or fractures were included in this study. The prosthesis of choice was Genesis II in 110 patients (199 knees) and Nexgen LPS in 216 patients (373 knees). The mean follow-up period was 27 months (range, 24 to 51 months). In the Genesis II group, there were 98 females and 12 males with a mean age of 64.2 years (range, 52 to 82 years). The mean body mass index (BMI) was 27.08 (range, 18.2 to 38.5), the mean preoperative range of motion (ROM) was 134.0° (range, 80° to 145°), the mean preoperative degree of deformity was 4.36° varus (range, 15° valgus to 18° varus). In the Nexgen LPS group, there were 208 females and 8 males with a mean age of 67.3 years (range, 50 to 86 years). The mean BMI was 28.13 (range, 20.3 to 47.8), the mean ROM was 133.8° (range, 75° to 150°), and the mean degree of deformity was 5.49° varus (range, 28° valgus to 25° varus) (Table 1). The results of TKAs performed by the same surgeon during the same period were compared retrospectively between the two groups classified according to the prosthesis type. The patients randomly received a

Genesis II prosthesis or a Nexgen LPS prosthesis.

2. Surgical Technique

All the operations were performed by the same surgeon using the medial parapatellar approach. Posterior cruciate ligament-sacrificing implants were secured with bone cement fixation in all patients. The patella was resurfaced in all patients, taking care not to increase the thickness of the patella. More than 2 mm gain in the thickness was avoided even in knees with a preoperative thickness of <20 mm. Thus, a ≥ 2 mm increase in the thickness was observed in none of the patients postoperatively. Lateral retinacular release was carried out if the towel clip test that was performed during surgery in knees with poor patellar tracking even after tourniquet release revealed the presence of patellar tilt.

Regarding the extent of femoral resection, a femoral cut made was parallel to the posterior condylar axis in order to equalize the thickness of the resected bones from the posterolateral and posteromedial condyles in the Genesis II group. In the Nexgen LPS group, femoral resection was performed at the 3° externally rotated position with respect to the posterior condylar axis in order to make the thickness of the resected bone from the posteromedial condyle greater than that from the posterolateral condyle (Fig. 1). The radiographic assessments and clinical and functional evaluations were performed 6 weeks, 3 months, and 6 months postop-

Table 1. Demographics, Radiographic Data and Preoperative Knee Score

Parameter	Genesis II (n=199)	Nexgen LPS (n=373)	p-value
Age (yr)	64.2 (52–82)	67.3 (50–86)	0.283
Body mass index (kg/m ²)	27.08 (18.2–38.5)	28.13 (20.3–47.8)	0.374
Preoperative ROM (°)	134.0 (80–145)	133.8 (75–150)	0.873
Tibiofemoral angle (°)	4.36 (valgus 15–varus 18)	5.49 (valgus 28–varus 25)	0.196
Knee Society score	29.96 (0–58)	28.66 (0–54)	0.248
Function score	41.05 (0–80)	45.46 (0–70)	0.083

Values are presented as mean (range).

ROM: range of motion.

Fig. 1. Application of a cutting jig for external rotation of the femoral component. (A) The thickness of the resected bone from the posteromedial condyle is equal to that from the posterolateral condyle in Genesis II prosthesis. (B) The thickness of the resected bone from the posteromedial condyle is thicker than that from the posterolateral condyle in Nexgen LPS prosthesis.

eratively, and yearly thereafter on an outpatient basis.

3. Assessments

The patient characteristics, such as age at the time of surgery, BMI, preoperative ROM, and preoperative deformity were compared between the groups. The Knee Society score (KSS) and function score (FS) at the last follow-up were used to assess clinical outcome in both groups. Maximal flexion that was defined as the angle created by lines drawn from each midpoint of the soft tissue of the thigh and calf was measured on the lateral radiograph taken with the knee in maximum active flexion (Fig. 2). Patellar tilt was measured as the angle created by two lines tangential to the floor of the trochlear groove and to the patellar resection surface on the Merchant view taken with the knee in 45° flexion as suggested by Bindelglass et al.⁴⁾ (Fig. 3). Radiographic measurements were performed on plain radiographs acquired with a computed radiography system and picture archiving and communication system (Petavision for Clinics version 2.0 [Asan Medical Center, Seoul, Korea]). The mean values of the measurements performed twice each by two surgeons (an orthopedic knee surgeon and a chief resident) were used for radiographic evaluation. Statistical analysis was done using the Student's t-test with SPSS ver. 14.0 (SPSS Inc., Chicago, IL, USA) and $p < 0.05$ was considered significant. The intraobserver reproducibility and interobserver reliability were assessed using the intraclass correlation coefficients described by Shrout and Fleiss⁵⁾: grade 0 was defined as no correlation, 0.00–0.39 as poor, 0.40–0.74 as moderate, ≥ 0.75 as excellent, and 1 as complete correlation.

Fig. 2. Maximal flexion is the angle between lines drawn through midpoints of soft tissue of the thigh and calf on the lateral radiograph of the actively flexed knee.

Results

There was no significant difference between the groups regarding the age, BMI, preoperative varus deformity, KSS, FS, and ROM (Table 1). The mean KSS and FS at the last follow-up were 92.3 ± 17.0 and 93.6 ± 28.2 , respectively, in the Genesis II group and 93.7 ± 18.0 and 92.6 ± 28.9 , respectively, in the Nexgen LPS group, showing no notable intergroup difference ($p = 0.217$, $p = 0.238$). There was no significant difference between the Genesis II group and the Nexgen LPS group in maximal flexion angle ($116.3^\circ \pm 27.8^\circ$ vs. $118.9^\circ \pm 29.4^\circ$; $p = 0.124$) and patellar tilt angle ($8.7^\circ \pm 11.0^\circ$ vs. $9.6^\circ \pm 14.8^\circ$; $p = 0.156$). The intraobserver reproducibility and interobserver reliability for patellar tilt angle measurement were relatively high, 0.901 and 0.792, respectively. Patellofemoral incongruence was observed after tourniquet release during surgery in 17 knees (8.6%) in the Genesis II group and in 37 knees (9.9%) in the Nexgen LPS group. A lateral retinacular release was performed in 5 (2.5%) of the former 17 cases and in 8 (2.2%) of the latter 37 cases and component loosening was not observed during the follow-up period (Table 2).

Fig. 3. Patellar tilt is the angle between a line tangential to the floor of the trochlear groove and a line drawn through the margin of the patellar prosthesis.

Table 2. Comparison of Postoperative Clinical Outcomes

Parameter	Genesis II (n=199)	Nexgen LPS (n=373)	p-value
Knee Society score	92.3 ± 17.0	93.7 ± 18.0	0.217
Function score	93.6 ± 28.2	92.6 ± 28.9	0.238
Maximal flexion angle (°)	116.3 ± 27.8	118.9 ± 29.4	0.124
Patellar tilt angle (°)	8.7 ± 11.0	9.6 ± 14.8	0.156
Lateral release (%)	5 (2.5)	8 (2.2)	

Values are presented as mean $\pm$ standard deviation or number (%).

Discussion

Obtaining correct rotational alignment of the femoral component in TKA is crucial to patellofemoral joint stability and varus-valgus balance in flexion. One of the most important characteristics of Genesis II prosthesis is built-in external rotation, which enables bone resection to be performed with 0° of external rotation of the femoral component. In contrast, most of the conventional prostheses require bone resection to be done with 3° of external rotation relative to the posterior condylar axis. As a result, the thickness of the resected bone from the posterolateral condyle is greater than that from the posteromedial condyle on the anterior view, which increases the risk of notching of the lateral femoral condyle³⁾ or component instability in the medial condyle due to insufficient bone resection. Notching was observed in 3 knees in the Genesis II group and in 5 knees in the Nexgen LPS group, none of which was clinically significant (<1 mm) or resulted in complications. The occurrence of an anterior femoral notch is considered to be more dependent on the experience of the surgeon and surgical technique than the type of prosthesis. However, we believe that anterior placement of the femoral component with built-in external rotation for the purpose of avoiding notching could result in insufficient resection of the medial condyle and increase patellofemoral compression.

The rotational alignment of the femoral and tibial components could affect the postoperative clinical outcome. Nicoll and Rowley⁶⁾ reported that internal rotation or rotational incongruity of the femoral and tibial components was the major cause of postoperative pain. A biomechanical study by Thompson et al.⁷⁾ showed that internal rotation of the femoral component could limit the ability to perform daily living activities, such as kneeling and getting up from a chair, due to quadriceps weakness. Thus, it has been recommended to externally rotate the femoral and tibial components in most cases. On the other hand, Ries et al.⁸⁾ suggested that a relatively constant angle of rotational congruity could be maintained with use of a neutrally rotated femoral component based on their observation that external rotation of the femoral component resulted in 3.53° of rotational incongruity in extension when the tibial component was not externally rotated, and 3.23° of rotational incongruity in flexion when the tibial component was externally rotated. Liao et al.⁹⁾ reported that Genesis II prostheses were useful for obtaining correct rotational alignment because the contact area was relatively well maintained regardless of the changes in the rotational position. The use of a downsized tibial component for the purpose of preventing anteromedial overhang in external rotation could result in reduced

coverage of the resected surface of the tibia. There was no case of anteromedial overhang of the tibia in our patients. However, the number of posterolateral overhang was higher in the Nexgen LPS group. Although the difference was not clinically significant, we thought that the asymmetrical shape of the Genesis II prosthesis (medial condyle of the tibial component is bigger than the lateral condyle) partly contributed to the relatively low occurrence of overhang¹⁰⁾. In the absence of objective standards to assess clinical differences caused by alignment incongruity of the femoral and tibial components, the incidence and type of polyethylene insert wear should be monitored for a long-term period.

Normal trochlear groove is situated 4–5 mm lateral to the midline of the femur, and thus it is located relatively laterally when a symmetrical femoral component is placed. On the other hand, external rotation of a femoral component results in a lateral shift of the proximal portion of the trochlear groove, which leads to normal patellar tracking in extension, whereas medialization of the patella in flexion. High flexion may increase shear force on the patellofemoral joint, which eventually leads to patellar component wear or patellar fracture³⁾. The Genesis II prosthesis is designed to have a more lateralized trochlear groove to replace the lateral shift of the trochlear groove that occurs when a prosthesis is inserted laterally rotated. In a study by Kaper et al.³⁾, the prosthesis reduced the need for lateral retinacular release and improved patellar tracking, whereas we could not find a significant difference between the Genesis II group and the Nexgen LPS group (2.5% vs. 2.2%). No notable intergroup difference was observed in the patellar tilt as well. However, it is difficult to assign significance to this result, considering that patellar tilt can be affected by the measurement method or the extent of flexion during assessment as well as postoperative muscle strength or rehabilitation program even in knees treated with an appropriate surgical procedure for proper patellar tracking. The patellar grind test for anterior knee pain was positive in 10 knees (5.0%) in the Genesis II group and in 16 knees (4.3%) in the Nexgen LPS group, showing no significant intergroup difference. Thus, no correlation could be found between the patella tilt and anterior knee pain.

The extent of knee flexion affects joint function for daily living activities and patient satisfaction especially in Asians. According to the meta-analysis of Bhandari et al.¹¹⁾, the Genesis II prosthesis allows for high flexion and exhibits encouraging survival rates. Accordingly, we expected that the high-flexion polyethylene insert we used in our patients would enable greater flexion than do conventional prostheses, but we could not observe significant difference between the prostheses. McCalden et al.¹²⁾ reported

that there was no difference in the range of flexion between knees with a standard insert and those with a high-flex polyethylene insert. We also believe that the postoperative range of flexion is more influenced by the patient's characteristics and surgical technique than the prosthesis design. In our opinion, the stability of the prosthesis for high flexion positions and polyethylene wear rate need to be assessed for a longer-term follow-up period. The flexion angles among our patients were smaller than those reported in recent studies and the preoperative values. This can be primarily attributable to the use of lateral views taken with the knee in maximum active flexion position instead of the passive flexion position to improve the measurement reliability in the radiographic assessment. Partly, the results may reflect the fact that TKA could result in a decrease in active ROM. The limitations of this study include that other knee functions, such as squatting, sitting cross-legged on the floor, and stair climbing were not included in the clinical assessment that was solely based on the KSS and FS.

Conclusions

The Genesis II prosthesis with built-in 3-degree external rotation of the femoral component did not exhibit significant improvement in terms of the clinical outcome and patellar tilt during the short-term follow-up period compared to the Nexgen LPS prosthesis in which the level of external rotation is determined intraoperatively according to the extent of bone cutting.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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