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A Comparison of 5 Models of Total Knee Arthroplasty in Young Patients

Young-Hoo Kim, MD [a,*], Jang-Won Park, MD [b], Jun-Shik Kim, MD [b]

[a] The Joint Replacement Center, Seonam Hospital, Ewha Womans University School of Medicine, Seoul, Republic of Korea
[b] The Joint Replacement Center, Mokdong Hospital, Ewha Womans University School of Medicine, Seoul, Republic of Korea

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ABSTRACT

Background: Several different total knee implants were introduced in an attempt to potentially improve outcomes of total knee arthroplasty in young patients. The object of this study was to compare the clinical outcomes of 5 models of total knee implants.

Methods: We compared 172 patients who received posterior substituting knee implants with an average 13.2-year follow-up, 182 patients who received high-flex knees with an average 11.8-year follow-up, 190 patients who received mobile-bearing knees with an average 13.9-year follow-up, 170 patients who received gender-specific knees with an average 10.8-year follow-up, and 192 patients who received oxidized zirconium knees with an average 13.5-year follow-up. There were 186 men and 720 women (mean age, 53.3 years; range, 40-60). The mean follow-up was 12.6 years.

Results: We found similar postoperative Knee Society knee and function scores ($P = .693$ and $P = .698$, respectively), postoperative Western Ontario MacMaster Universities Osteoarthritis Index score ($P = .523$), University of California, Los Angeles activity score ($P = .651$) and range of knee motion ($P = .417$), radiographic results ($P > .05$), revision rates ($P = .241$), and survivorship ($P = .981$) of the implants.

Conclusions: Range of knee motion, prevalence of polyethylene wear, osteolysis, revision rates, and survivorship of 5 models of total knee arthroplasties were similar. We believe that good designs with a good quality of polyethylene and defined surgical techniques provided good clinical and radiographic outcomes of these 5 models of total knee arthroplasties at this length of follow-up.

Although total knee arthroplasty (TKA) has provided durable long-term results [1,2], it is associated with higher rates of revision and with decreased patient satisfaction in younger patients [3,4]. In response to findings like these, several different implant designs including the high-flex, mobile-bearing, gender-specific, and oxidized zirconium total knee implant designs have been introduced in an attempt to potentially improve patient outcomes.

NexGen Legacy posterior substituting high-flex total knee design (NexGen LPS-Flex; Zimmer, Warsaw, IN) was introduced to increase the knee range of motion and to decrease polyethylene wear. Extension of the radius and the thickness (by 2 mm) of the posterior condyle in the femoral component of the NexGen LPS-Flex knee increases the articular contact area between the posterior femoral condyle and the tibial polyethylene at high flexion angles and thereby increases contact area at high flexion angles [5-9]. PFC Sigma rotating platform mobile-bearing total knee design (PFC Sigma RP; DePuy, Warsaw, IN) was introduced to decrease contact stress and to allow for femorotibial rotation [10,11]. NexGen Legacy gender-specific posterior cruciate substituting high-flex total knee implant (NexGen gender-specific LPS-flex; Zimmer) was developed to address purported gender-based difference in distal femoral geometry [12-16]. Oxidized zirconium knee design was introduced to lower polyethylene wear [17-19]. There are remaining questions whether these design modifications of total knee implants are able to improve clinical outcomes in young patients.

The object of this study was to determine whether these different models of TKA implants would provide (1) similar or better clinical results, including Knee Society knee and function scores, Western Ontario and McMaster Universities Osteoarthritis (WOMAC) index score, University of California, Los Angeles (UCLA)

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* Reprint requests: Young-Hoo Kim, MD, The Joint Replacement Center, Seonam Hospital, Ewha Womans University, #20, Sinjeongipen 1-ro, YangCheon-gu, Seoul, Republic of Korea, 158-070.

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activity score and range of knee motion; (2) similar or better radiographic results, including radiolucent line and aseptic loosening of implant; and (3) similar or better survivorship of TKAs using NexGen Legacy posterior substituting knee prosthesis (NexGen LPS; Zimmer), NexGen LPS-Flex, PFC Sigma RP, NexGen gender-specific LPS-flex, and Genesis II oxidized knee implants in patients younger than 60 years old.

Materials and Methods

We retrospectively analyzed the records of 934 prospectively followed patients (1228 knees) younger than 60 years old who underwent primary TKAs. We obtained the approval of our institutional review board before beginning this study. A detailed informed consent form was signed by each patient. Several different implants were used in this study. First, PFC Sigma RP was implanted in consecutive 190 patients (236 knees). Second, NexGen LPS knee was implanted in consecutive 172 patients (250 knees). Third, Genesis II oxidized zirconium knee was implanted in consecutive 192 patients (242 knees). Fourth, NexGen LPS-Flex knee was implanted in consecutive 182 patients (230 knees). Finally, NexGen gender-specific LPS-flex knee was implanted in consecutive 170 patients (232 knees; Table 1). All surgeries were performed by a senior author (YHK). NexGen LPS-Flex TKA was selected to increase knee range of motion and to decrease polyethylene wear. The main difference between the NexGen LPS and NexGen LPS-Flex is the posterior condyles radii, allowing a theoretical flexion up to 155° when the flexion version is used. PFC Sigma RP was selected to decrease contact stress and to allow for femorotibial rotation. Genesis II oxidized zirconium TKA was selected to decrease polyethylene wear and osteolysis. NexGen gender-specific high-flex knee was selected to adapt to purported gender-based difference in distal femoral geometry and to increase the range of motion of knee.

Patient's selection criteria included knee diseases that were severe enough to warrant TKA after an adequate trial of nonoperative therapy, and the patients were younger than 60 years old. Patients were excluded in 5 groups if they were older than 60 years, if they had inflammatory arthritis, if they had foot or ankle disorder that limited walking, or if the minimum follow-up was less than 10 years. Among 934 patients, 10 died, and 18 were lost to follow-up, leaving 906 patients (1190 knees) available with a minimum duration of follow-up of 10 years (mean, 12.6 years; range, 10-15 years). In the entire series, there were 186 men and 720 women. Mean age was 53.3 years (range, 40-60 years). Mean height was 162.2 cm (range, 150-187 cm). Mean weight was 71.3 kg (range, 55-97 kg). Mean body mass index was 27.2 kg/m^2 (range, 23.8-38.1 kg/m^2). The diagnosis was osteoarthritis in 1152 knees (96.8%), osteonecrosis in 26 knees (2.2%), and traumatic arthritis in 12 knees (1%).

We used a pneumatic tourniquet with inflation to 250 mm Hg in all patients. We made an anterior midline skin (12-15 cm in length) with a medial parapatellar capsular incision of the joint. In all knees, we prepared the femur first and then the tibia. We used the combined measured resection technique with the gap balancing technique. Ten millimeters of tibial bone was resected with a posterior tibial slope of 3°-7°. Anterior cortical reference was used for the anterior-posterior cut of the distal part of the femur. Femoral component rotation was determined mainly with the use of the transepicondylar axis. In addition to use the transepicondylar axis, the midtrochlear (Whiteside) line and 3° of external rotation relative to the posterior aspect of the condyles were referenced to assure the correct rotational alignment of the femoral components. Ligamentous balance was established first in knee extension and then in knee flexion with use of a tensor. Bone resection was performed by the use of the measured technique, but extension and flexion gaps were checked using gap balancing technique with the use of a tensor. Therefore, we used a combined measured and gap balancing techniques. All patellae were resurfaced routinely with a polyethylene patellar prosthesis. All knees except PFC sigma RP prosthesis were fixed-bearing posterior cruciate ligament substitution prostheses. All implants were cemented using pulsed lavage, drying, and pressurization of the cement.

The patients started active and passive range-of-movement exercise using a continuous passive motion machine on the second postoperative day. Also, they began standing at the bedside or walking with crutches or a walking frame twice daily for 30 minutes under the supervision of a physiotherapist. Patients used crutches or a walker with full weight-bearing for 6 weeks and used a cane when needed thereafter.

Two of the authors (YHK and JWP) assessed the patients, conducting a physical examination and knee scoring before surgery, 3 months and 1 year after surgery, and annually thereafter using the Knee Society [20] knee scoring systems. The WOMAC score [21] was recorded at each visit. The chance-corrected kappa coefficient [22] was calculated to determine interobserver agreement of knee score, WOMAC score, and range of knee motion. Interobserver agreement ranged from 0.79-0.87. The level of activity was assessed further using the UCLA activity score [23]. Patient satisfaction with outcome was assessed at a single point (at the final follow-up) on a 4-point Likert scale: the response options were very satisfied, satisfied, unsure, or dissatisfied. All of the clinical data in the medical records from the follow-up assessments were compiled by 1 observer (DRK) who was not part of the surgical team.

Table 1
A Comparison of Baseline Categorical Variables Between the Cohorts.

Variable	Traditional PS Knees	High-Flex knees	Mobile-Bearing Knees	Gender-Specific Knees	Oxidized Zirconium Knees	*P* Value
Number of patients (no. of knees)	172 (250)	182 (230)	190 (236)	170 (232)	192 (242)	.914[a]
Gender (male/female)	38/134	40/142	36/154	30/140	42/150	.818[a]
Age (y)[c]	55.3 (41-60)	54.8 (40-60)	51.8 (43-60)	52.6 (44-60)	52.2 (45-60)	.881[b]
Height (cm)[c]	161.8 (150-186)	162.2 (152-184)	163.1 (153-187)	161.6 (154-188)	162.5 (153-186)	.892[b]
Weight (kg)[c]	71.2 (58-96)	72.8 (55-94)	71.7 (56-95)	69.9 (57-96)	70.9 (52-97)	.819[b]
Body mass index (kg/m^2)[c]	27.4 (25.2-36.8)	28.0 (23.9-35.9)	26.6 (24.3-37.4)	26.9 (23.8-38.1)	27.3 (25-38.1)	.912[b]
Diagnosis (no. of knees)						
Osteoarthritis	238 (95%)	226 (98%)	232 (98%)	224 (97%)	232 (96%)	.761[a]
Osteonecrosis	8 (3%)	4 (2%)	—	8 (3%)	6 (2%)	
Traumatic arthritis	4 (2%)	—	4 (2%)	—	4 (2%)	
Duration of follow-up (y)[c]	13.2 (10-15)	11.8 (10-14)	13.9 (10-15)	10.8 (10-12)	13.5 (10-15)	.09[b]

PS, posterior cruciate ligament substituting knees.
[a] Chi-square test.
[b] Analysis of variance (ANOVA) test.
[c] Values are expressed as means, with range in parentheses.