Comparison of Anterior-Posterior-Glide and Rotating-Platform Low Contact Stress Mobile-Bearing Total Knee Arthroplasties

By Young-Hoo Kim, MD, and Jun-Shik Kim, MD

Investigation performed at The Joint Replacement Center of Korea at Ewha Womans University College of Medicine, Seoul, Korea

Background: The anterior-posterior-glide Low Contact Stress mobile-bearing knee prosthesis was developed to approximate the natural kinematics of the knee more closely than the rotating-platform Low Contact Stress mobile-bearing knee prosthesis does. The purpose of the present study was to compare the results associated with these two prostheses in patients managed with simultaneous bilateral total knee replacement.

Methods: One hundred and ninety patients received an anterior-posterior-glide Low Contact Stress mobile-bearing prosthesis in one knee and a rotating-platform Low Contact Stress mobile-bearing prosthesis in the contralateral knee. The mean age of the patients at the time of the index procedure was sixty-four years. Eleven patients were men, and 179 patients were women. The mean duration of follow-up was 6.4 years (range, five to seven years). The patients were followed clinically and radiographically with use of the knee-rating systems of the Knee Society and the Hospital for Special Surgery.

Results: The mean postoperative Hospital for Special Surgery knee score was 89.4 points for the knees treated with the anterior-posterior-glide mobile-bearing prosthesis and 88.6 points for those treated with the rotating-platform mobile-bearing prosthesis. Three knees in each group had a poor result. Two knees in each group had persistent moderate pain. One knee with an anterior-posterior-glide prosthesis had permanent tibial and deep peroneal nerve palsies, and one knee with a rotating-platform prosthesis had a permanent deep peroneal nerve palsy. No knee had aseptic loosening, revision, measurable wear of the tibial or patellar polyethylene bearing, or osteolysis.

Conclusions: After a minimum duration of follow-up of five years, the results associated with the anterior-posterior-glide and rotating-platform Low Contact Stress mobile-bearing total knee replacements were favorable and comparable.

Level of Evidence: Therapeutic study, Level II-1 (prospective cohort study). See Instructions to Authors for a complete description of levels of evidence.

The Low Contact Stress mobile-bearing knee prosthesis (DePuy, Warsaw, Indiana) was introduced to address the so-called kinematic conflict in fixed-bearing knees by allowing a highly conforming articular surface to coexist with free rotation[1-9]. The rotating-platform Low Contact Stress mobile-bearing prosthesis was designed to have unlimited rotation but a limited range of anteroposterior and mediolateral translation, which occurs primarily as a result of the femoral component sliding on the surface of the polyethylene insert[10] (Figs. 1-A and 1-B). A second-generation rotating-platform Low Contact Stress prosthesis (Anterior-Posterior Glide; DePuy) was developed to approximate the kinematics of the natural knee more closely by incorporating unlimited anterior-posterior translation and rotation. The anterior-posterior-glide prosthesis has a conforming rotating polyethylene tibial insert that can translate along a bar on the tibial component in the sagittal plane. This modification of the distal articulation allows for anteroposterior translation and rotary movement between the flat distal polyethylene surface and the highly polished proximal tibial tray (Figs. 2-A and 2-B).

The anterior-posterior-glide and rotating-platform Low Contact Stress mobile-bearing total knee replacements have been studied independently[4,6,7,9-14]. A comparison of the results in the same patients eliminates the variability that is introduced by differences in gender, age, weight, comorbidities, bone quality, and activity level and allows for a more meaningful comparison of the impact of fixation on the outcome of total knee arthroplasty. However, variability in terms of the preop-

TABLE I Clinical Results

Parameters	Knee Society Scoring System					
	Preoperative			Final Follow-up		
	Anterior-Posterior Glide	Rotating Platform	P Value*	Anterior-Posterior Glide	Rotating Platform	P Value*
Total knee score *(points)*	26.9 (3-61)	26.9 (6-63)	0.5242	90.2 (45-100)	89.2 (52-100)	0.7242
Pain score *(points)*	0.4	0.4		48.5	48.2	0.4652
Degree of pain *(no. of knees [%])*						
None	—	—		132 (69%)	134 (71%)	
Mild	—	1 (0.5%)		58 (31%)	56 (29%)	
Moderate	—	2 (1%)		—	—	
Severe	190 (100%)	187 (98%)		—	—	
Walking distance *(no. of knees [%])*						
Cannot walk						
<1 block						
1-5 blocks						
6-10 blocks						
Unlimited						
Average range of motion *(deg)*	7.0-132.0	6.8-131.6	0.6829	0-128.3	0-128.0	0.8578
Walking support *(no. of knees [%])*						
No support						
1 cane						
1 crutch						
2 crutches						
Stairs *(no. of knees [%])*						
Without support						
With support						

*The p values pertain to the comparison between the anterior-posterior-glide group and the rotating-platform group with use of the Student t test.

erative severity of the arthritis cannot be eliminated because the severity of the disease on both sides is rarely identical.

We performed a prospective, randomized study to compare the clinical and radiographic results associated with the anterior-posterior-glide and rotating-platform Low Contact Stress total knee replacements in patients who were managed with simultaneous bilateral total knee arthroplasty.

Materials and Methods

Between May 1996 and June 1998, the senior author (Y.-H.K.) performed 196 consecutive primary bilateral total knee arthroplasties in 196 patients (392 knees). All 196 patients were enrolled in the present study. The bilateral total knee arthroplasties were performed during the same anesthetic session, with one side treated immediately after the other. Six patients were lost to follow-up, leaving 190 patients (380 knees) available for inclusion in the study. The study was approved by our institutional review board, and all patients provided informed consent.

Randomization between the use of an anterior-posterior-glide Low Contact Stress mobile-bearing prosthesis or a rotating-platform Low Contact Stress mobile-bearing prosthesis was determined from a sequential pool on the basis of a table of randomized numbers. Each of the 190 patients received an anterior-posterior-glide Low Contact Stress mobile-bearing total knee component on one side and a rotating-platform Low Contact Stress mobile-bearing total knee component on the contralateral side. The order of insertion of the anterior-posterior-glide and rotating-platform mobile-bearing prostheses was assigned alternately to each side. Eleven patients (twenty-two knees) were men, and 179 patients (358 knees) were women. The mean age of the patients at the time of the index operation was sixty-four years (range, forty-seven to seventy-six years). The diagnosis was osteoarthritis for 162 patients and osteonecrosis of the medial femoral condyle for twenty-eight patients. One hundred and thirty-three patients (70%) had had no previous knee operation, and fifty-seven patients (30%) had had arthroscopic débridement of one or both knees.

All procedures were performed through a midline skin incision measuring 10 to 12 cm in length, with a subvastus approach into the joint. The anterior cruciate ligament was excised in all patients. The posterior cruciate ligament was relatively well preserved in all knees as none of the patients had inflammatory arthritis. In all knees that were treated with the

TABLE I *(continued)*

Hospital for Special Surgery Scoring System					
Preoperative			Final Follow-up		
Anterior-Posterior Glide	Rotating Platform	P Value*	Anterior-Posterior Glide	Rotating Platform	P Value*
57.9 (33-63)	57.3 (5-65)	0.5242	89.4 (69-100)	88.6 (45-100)	0.7242
6.0	6.0		28.4	28.2	0.4652
—	—		155 (82%)	149 (78%)	
1 (0.5%)	1 (0.5%)		35 (18%)	40 (21%)	
1 (0.5%)	1 (0.5%)		—	—	
188 (99%)	188 (99%)		—	1 (0.5%)	
4 (2%)	4 (2%)		0 (0%)	0 (0%)	
42 (22%)	42 (22%)		18 (9%)	18 (9%)	
85 (45%)	85 (45%)		14 (7%)	14 (7%)	
48 (25%)	48 (25%)		10 (5%)	10 (5%)	
11 (6%)	11 (6%)		148 (78%)	148 (78%)	
7.0-132.0	6.8-131.6	0.6829	0-128.3	0-128.0	0.8578
156 (82%)	156 (82%)		175 (92%)	175 (92%)	
30 (16%)	30 (16%)		11 (6%)	11 (6%)	
0 (0%)	0 (0%)		0 (0%)	0 (0%)	
4 (2%)	4 (2%)		4 (2%)	4 (2%)	
0 (0%)	0 (0%)		113 (59%)	113 (59%)	
190 (100%)	190 (100%)		77 (41%)	77 (41%)	

anterior-posterior-glide prosthesis, the posterior cruciate ligament was preserved. In all knees that were treated with the rotating-platform prosthesis, the posterior cruciate ligament was excised.

Ligamentous balancing was done, and an attempt was made to resect 10 mm of tibial bone distally from what was considered to be the intact articular surface in order to achieve a surface that was perpendicular to the shaft of the tibia in the coronal plane with a 7° posterior slope in the sagittal plane. The distal and posterior femoral condylar resection was done with an attempt being made to remove a length of bone that was equal to the thickness of the femoral component to be inserted. The patellar thickness was measured before the resection, and an attempt was made to remove a segment of bone that was equal to or slightly thicker than the component to be inserted. All implants were inserted with cement after pulsed lavage, drying, and pressurization of the cement.

A splint was applied with the knee in 15° of flexion and was worn for the first twenty-four hours after the operation. The knee then was placed in a continuous passive-motion machine. All patients began walking with crutches or a walker and started active and passive range-of-motion exercises on the second day after the operation. The patients used crutches or a walker, with full weight-bearing, for six weeks and then used a cane for six weeks.

Clinical and radiographic evaluations were done at six weeks, three months, six months, and one year after the operation, and then yearly thereafter. The mean duration of follow-up was 6.4 years (range, five to seven years). Each knee was rated preoperatively and postoperatively according to the systems of the Knee Society[15] and the Hospital for Special Surgery[16]. In addition, each patient completed a self-administered questionnaire that consisted of (1) a visual analog scale for the assessment of the severity, location, and frequency of pain and (2) a series of questions regarding the achievement of functional benchmarks (the ability to climb stairs, to walk a certain distance, and to participate in specific sports), the overall sense of well-being, and the level of satisfaction with the operative result.

Anteroposterior radiographs with the patient standing and supine, lateral radiographs, and skyline patellar radiographs were made preoperatively and postoperatively and were assessed for alignment of the limb, the position of the components, and the presence and location of radiolucent

Figs. 1-A and 1-B Photographs of the rotating-platform Low Contact Stress mobile-bearing prosthesis. **Fig. 1-A** The rotating platform features a single plastic bearing that freely rotates about its post, which is seated within a hole in the tibial tray. **Fig. 1-B** The rotating-platform Low Contact Stress mobile-bearing prosthesis has unlimited rotation but has a limited range of anteroposterior and mediolateral translation.

Fig. 1-A

Fig. 1-B

Fig. 2-A

Fig. 2-B

Figs. 2-A and 2-B Photographs of the second-generation rotating-platform anterior-posterior-glide Low Contact Stress mobile-bearing prosthesis. **Fig. 2-A** The anterior-posterior-glide prosthesis has a conforming rotating polyethylene tibial insert that can translate along a bar on the tibial component in the sagittal plane. **Fig. 2-B** The implant incorporates a highly conforming proximal articulation between the femoral component and the polyethylene tibial insert, maximizing contact surface area and reducing polyethylene stress. The modification of the distal articulation allows for anteroposterior translation and rotary movement between the flat distal polyethylene surface and the highly polished proximal tibial tray. The design lacks any mechanical stop anteriorly or posteriorly to limit anteroposterior translation and relies on soft tissues and the native ligamentous structures in the knee for stability in the sagittal plane.

lines at the bone-cement interface according to the recommendation of the Knee Society[15].

The levels of the joint lines were determined on anteroposterior radiographs made before and after surgery with the patient supine by measuring the distance between the tip of the fibular head and the distal margin of the lateral part of the femoral condyle preoperatively and between the tip of the fibular head and the distal margin of the lateral femoral component postoperatively. The skyline patellar radiographs were examined for patellar tilt, subluxation, or dislocation. Osteolysis around the three components was recorded. No intraobserver or interobserver analysis of the radiographic findings was done.

Statistical comparison of the clinical and radiographic re-

TABLE II Radiographic Results

Parameters	Anterior-Posterior Glide	Rotating Platform	P Value†
Alignment			
Preoperative *(no. of knees [%])*			0.4017
Varus			
1°-10°	98 (51.6%)	95 (50%)	
11°-20°	63 (33.2%)	75 (39.5%)	
Valgus			
1°-10°	29 (15.3%)	20 (10.5%)	
Postoperative *(deg)*			0.6877
Valgus	5.1° (–4.4° to 8°)	5.0° (–4° to 7°)	
Femoral component position (femoral angle)*			
Anteroposterior	96° ± 2.4° (90.2° to 108°)	95.7° ± 2.3° (88.7° to 105°)	0.3261
Sagittal	7.1° ± 3.6° (–0.3° to 17.9°)	6.9° ± 3.5° (0.3° to 16.5°)	0.5937
Tibial component position (tibial angle)*			
Anteroposterior	88.8° ± 2.6° (81.7° to 95.5°)	89.3° ± 2.4° (83.9° to 96.7°)	0.0424
Sagittal	84.3° ± 2.7° (77° to 90.6°)	83.9° ± 2.8° (78° to 94.2°)	0.1436
Patellar component angle*	1.2° ± 5.2° (–12° to 18.9°)	1.1° ± 5.6° (–19° to 21°)	0.8587
Tibial surface capping*	100.1% ± 2.0% (84.7% to 110.6%)	100.4% ± 1.9% (92.0% to 110.7%)	0.1524
Joint line* *(mm)*			
Preoperative	12.7 ± 5.1 (–9 to 25)	11.9 ± 5.2 (–7.5 to 26)	0.465
Postoperative	12.9 ± 3.8 (2.2 to 23.5)	13.2 ± 3.7 (0.8 to 26.8)	0.758
Radiolucent lines *(no. of knees [%])*			
Overall			
Absence	160 (84.2%)	173 (91.1%)	
Presence	30 (15.8%)	17 (8.9%)	
Tibial side			
Anteroposterior			
Zone 1 (<1mm)	26 (13.7%)	15 (7.9%)	
Zones 1 and 2 (<1mm)	4 (2.1%)	0 (0%)	
Sagittal			
Zone 2 (<1mm)	0 (0%)	1 (0.5%)	
Femoral side			
Sagittal	0 (0%)	0 (0%)	
Patellar side			
Zone 2 (<1mm)	0 (0%)	1 (0.5%)	
Lateral patellar tilt *(no. of knees [%])*	1 (0.5%)	0 (0%)	

*The data are given as the mean and the standard deviation, with the range in parentheses. †Student t test.

sults associated with the two groups was done with analysis of variance, chi-square analysis, and the two-tailed Student t test.

Survivorship analysis was performed to determine the cumulative rate of survival of the implant during the period of the study[17,18]. The end point for this analysis was revision surgery (or a recommendation for revision surgery) for any reason.

Results

Clinical Results

Knee Score

The preoperative and postoperative knee scores, pain scores, walking distance, range of motion, use of walking support, and ability to negotiate stairs in both groups are summarized in Table I. The preoperative Knee Society and Hospital for Special Surgery knee scores for the two groups were not significantly different (p = 0.5242). In the anterior-posterior-glide group, the mean postoperative knee score was 90.2 points (range, 45 to 100 points) according to the system of the Knee Society and 89.4 points (range, 69 to 100 points) according to the system of the Hospital for Special Surgery. In the rotating-platform group, the mean postoperative knee score was 89.2 points (range, 52 to 100 points) according to the system of the Knee Society and 88.6 points (range, 45 to 100 points) according to the system of the Hospital for Special

Surgery. The postoperative knee scores for the two groups were not significantly different, with the numbers available ($p = 0.7242$). Three knees in each group had a poor result.

Pain

The postoperative pain scores according to both knee-scoring systems were not significantly different between the groups, with the numbers available ($p = 0.4652$). At the time of the latest follow-up of the 190 knees in the anterior-posterior-glide group, 132 (69%) were not painful, fifty-eight (31%) were mildly painful, and none were moderately or severely painful according to the system of the Knee Society, whereas 155 (82%) were not painful, thirty-five (18%) were mildly painful, and none were moderately or severely painful according to the system of the Hospital for Special Surgery. In comparison, of the 190 knees in the rotating-platform group, 134 (71%) were not painful, fifty-six (29%) were mildly painful, and none were moderately or severely painful according to the system of the Knee Society, whereas 149 (78%) were not painful, forty (21%) were mildly painful, none were moderately painful, and one (0.5%) was severely painful according to the system of the Hospital for Special Surgery.

Ability to Walk

At the time of the latest follow-up, 148 patients (78%) were able to walk an unlimited distance without pain or with only mild discomfort, ten patients were able to walk six to ten blocks, fourteen patients were able to walk one to five blocks, and eighteen patients were able to walk less than one block. One hundred and seventy-five patients (92%) did not require support for walking, eleven patients required one cane, and four patients required two crutches. One hundred and thirteen patients (59%) were able to negotiate stairs without support, and seventy-seven patients used support.

Range of Motion

Preoperatively, the mean flexion contracture was 7° (range, 0° to 53°) in the anterior-posterior-glide group and 6.8° (range, 0° to 35°) in the rotating-platform group. The mean flexion was 132° (range, 95° to 150°) in the anterior-posterior-glide group and 131.6° (range, 85° to 150°) in the rotating-platform group. At the time of the latest follow-up, no knee had a flexion contracture. Postoperatively, the mean flexion was 128.3° (range, 70° to 150°) in the anterior-posterior-glide group and 128.0° (range, 90° to 150°) in the rotating-platform group; this differ-

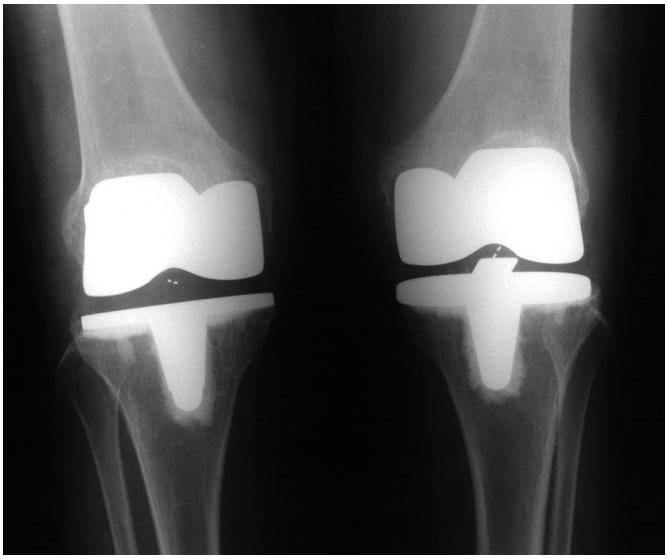

Fig. 3-A

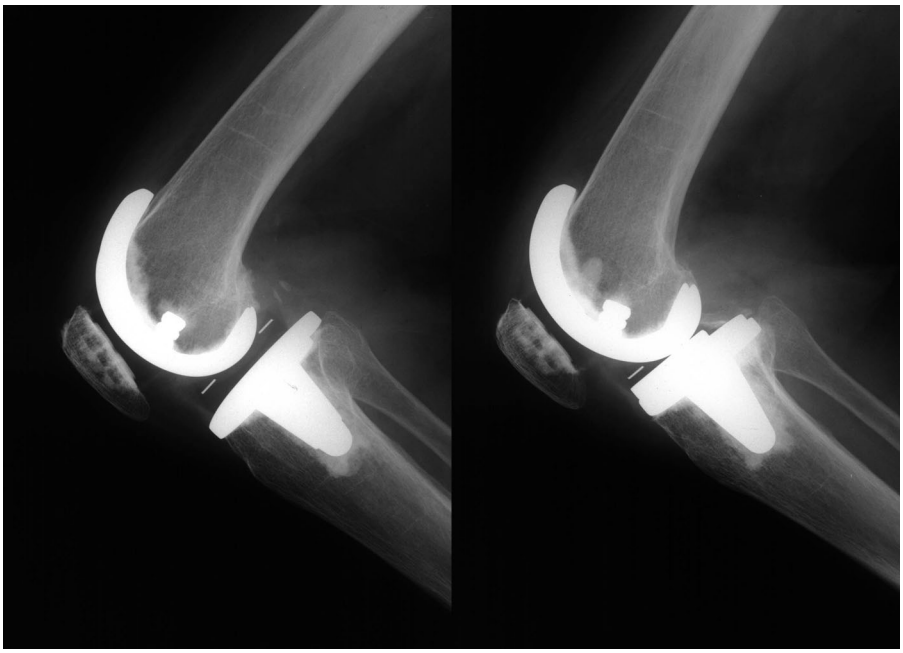

Fig. 3-B

Figs. 3-A through 3-D Radiographs of both knees of a sixty-one-year-old woman with osteoarthritis. **Fig. 3-A** Anteroposterior radiographs of both knees, made three months after surgery, showing the rotating-platform (left side of image) and anterior-posterior-glide (right side of image) Low Contact Stress mobile-bearing prostheses to be in a satisfactory position. **Fig. 3-B** Lateral radiographs of both knees, made three months after surgery, showing the rotating-platform (left side of image) and anterior-posterior-glide (right side of image) prostheses to be in satisfactory alignment.

ence was not significant (p = 0.8578), with the numbers available. Although all knees obtained at least 120° of passive flexion with the use of a continuous passive-motion machine during the hospitalization, the active range of flexion was reduced to 70° or 90° in several patients at the time of the final follow-up.

Satisfaction

With regard to the knees in the anterior-posterior-glide group, 114 patients (60%) were fully satisfied with the outcome of the operation, sixty-six patients (35%) were satisfied, and ten patients (5%) were dissatisfied. With regard to the knees in the rotating-platform group, 106 patients (56%) were fully satisfied, seventy-three patients (38%) were satisfied, and eleven patients (6%) were dissatisfied. Of the twenty-one patients in both groups who were dissatisfied, ten patients had constant mild pain and stiffness, four had constant moderate pain, and the remaining seven had an inadequate range of motion.

Radiographic Results

The radiographic results are summarized in Table II. With the numbers available, there were no significant differences between the groups with regard to the position of the femoral and tibial components in coronal and sagittal planes, the alignment of the knee, the patellar angle, or the tibial surface area covered by the implants ($p > 0.05$).

With the numbers available, the mean level of the joint line was not significantly different between the two groups preoperatively (p = 0.465) or postoperatively (p = 0.758). In both groups, while the mean range of motion (and standard deviation) was 115° ± 18.06° in the knees in which the postoperative joint line changed by >1 cm compared with the preoperative joint line, it was 125° ± 10.98° in the knees in which the postoperative joint line changed by <1 cm compared with the preoperative joint line. This difference was significant (p = 0.003).

One hundred and sixty knees (84%) in the anterior-posterior-glide group and 173 knees (91%) in the rotating-platform group had no evidence of radiolucent lines around any component (Figs. 3-A through 3-D). Therefore, the prevalence of radiolucent lines around one component was 16% (thirty knees) in the anterior-posterior-glide group and 9% (seventeen knees) in the rotating-platform group. This difference was not significant (p = 0.098), with the numbers available. No knee had loosening of the femoral, tibial, or patellar component. No knee had a patellar dislocation.

Kaplan-Meier analysis[17] with revision as the end point revealed a seven-year survival rate of 100% (95% confidence interval, 0.94 to 1.0) in both groups.

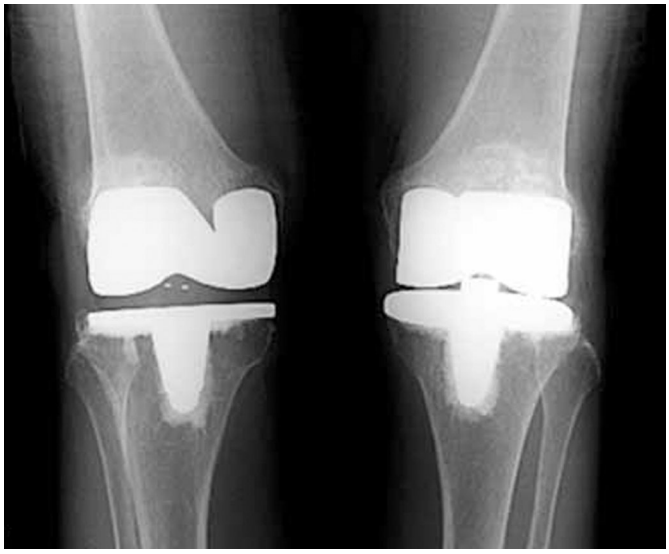

Fig. 3-C

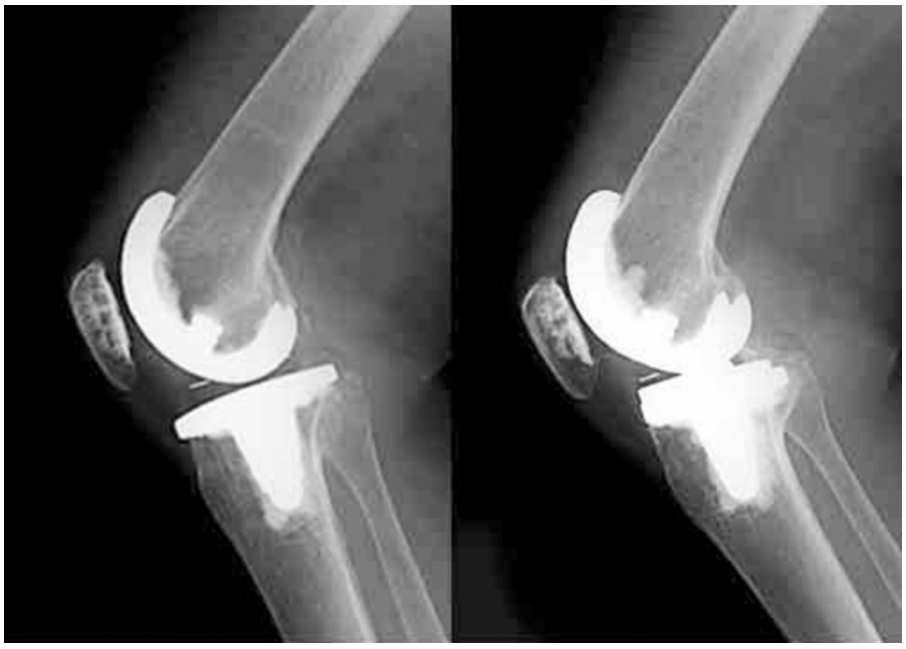

Fig. 3-D

Figs. 3-C and 3-D
Anteroposterior and lateral radiographs of both knees, made seven years after surgery, showing the rotating-platform and anterior-posterior-glide prostheses to be solidly fixed. There are no radiolucent lines or other signs of osteolysis around the tibial components.

Complications

One knee (0.5%) in the rotating platform group was associated with persistent severe pain. One knee with an anterior-posterior-glide prosthesis was associated with permanent tibial and deep peroneal nerve palsies, perhaps due to a compartment syndrome. One knee with a rotating-platform prosthesis had a per-

manent deep peroneal nerve palsy resulting from an unknown cause.

Discussion

The rotating-platform and anterior-posterior-glide Low Contact Stress mobile-bearing prostheses have been used successfully for many years[4,6,8,9,11-14,19]. The present study demonstrated gratifying results in association with both devices, with no differences between the two prostheses in terms of clinical and radiographic findings.

It has been demonstrated that a greater range of motion can be obtained with a properly inserted posterior cruciate-retaining anterior-posterior-glide Low Contact Stress prosthesis compared with a posterior cruciate-sacrificing rotating-platform Low Contact Stress prosthesis[14]. In the current study, the average range of motion was approximately the same in both groups. In a previous study, we evaluated factors affecting range of motion after fixed-bearing and mobile-bearing total knee arthroplasties and concluded that preoperative range of motion and restoration of the joint line were the most important factors[7]. The findings of the current study confirmed this view.

Oakeshott et al. reported synovitis and recurrent effusion in eighteen (60%) of thirty patients who had had a total knee arthroplasty with use of an anterior-posterior-glide Low Contact Stress prosthesis. The authors reported that these problems were due to impingement of anterior soft tissues and that they resolved after subsequent exchange of the tibial polyethylene[14]. In the current series, no patient with an anterior-posterior-glide Low Contact Stress prosthesis had synovitis or a recurrent effusion.

Waslewski et al. reported on thirteen patients (sixteen knees) who had early incapacitating instability secondary to posterior cruciate ligament deficiency following posterior cruciate-retaining total knee arthroplasty[20]. Morberg et al. reported that six of sixteen patients who had been managed with the anterior-posterior-glide Low Contact Stress prosthesis had adverse events related to excessive translation in the sagittal plane secondary to failure of the posterior cruciate ligament after surgery[21]. In the current study, no knee that had been treated with the anterior-posterior-glide prosthesis had early or delayed clinical failure of the posterior cruciate ligament. Careful assessment and protection of the posterior cruciate ligament during the operation is important. Leaving a bone island to protect the insertion of the posterior cruciate ligament on the posterior tibial plateau may minimize iatrogenic damage to the insertion site, but care must be taken to avoid impingement of the polyethylene insert against the bone island during anterior-posterior translation.

Buechel and Pappas[4] and Goodfellow and O'Connor[22] postulated that the mobile-bearing knee replacement would minimize bone-prosthesis stress at the tibial surface. In the current study, the prevalence of radiolucent lines in fewer than two zones around the tibial component was 16% in the anterior-posterior-glide group and 9% in the rotating-platform group. No knee had radiolucent lines in more than three zones around the tibial, patellar, or femoral component. Therefore, it appears that the mobile bearing minimizes bone-cement stress at the interfaces of all components.

Mobile-bearing total knee arthroplasty was introduced to increase articular conformity and to minimize contact stresses, thereby reducing linear wear and subsurface fatigue failure. The current study demonstrated no measurable wear of the tibial or patellar polyethylene bearing in either group. There also was no evidence of periprosthetic osteolysis in either group, although early detection of osteolysis after a total knee arthroplasty can be difficult on plain radiographs. Our finding of no osteolysis in either group suggests that solid fixation of these prostheses with good cementing technique limits the so-called effective joint space[23]. It is also possible that the rate of osteolysis was low because the duration of follow-up was not long enough.

The results associated with the anterior-posterior-glide and the rotating-platform Low Contact Stress mobile-bearing total knee replacements were favorable after a minimum duration of follow-up of five years. The results for the two groups were comparable with regard to the total knee score, pain and functional scores, range of motion, polyethylene wear, aseptic loosening, and periprosthetic osteolysis. ■

Young-Hoo Kim, MD
Jun-Shik Kim, MD
The Joint Replacement Center of Korea at Ewha Womans University DongDaeMun Hospital, 70, ChongRo 6-Ga, ChongRo-Gu, Seoul, Korea (110-126). E-mail address for Y.-H. Kim: younghookim@netsgo.com

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