Osteolysis in Well-functioning Fixed- and Mobile-bearing TKAs in Younger Patients

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Received: 1 October 2009 / Accepted: 22 March 2010 / Published online: 1 April 2010
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Abstract

Background Periprosthetic osteolysis is an increasingly prevalent complication of TKA. To reduce the polyethylene wear and periprosthetic osteolysis, particularly in young patients, the design of the contemporary fixed-bearing TKAs has been modified and mobile-bearing TKAs have been introduced.

Questions/purposes We asked whether the prevalence of osteolysis would be less in well-functioning mobile-bearing TKAs than in well-functioning contemporary fixed-bearing TKAs in young patients.

Patients and Methods We compared 488 patients (894 knees) who received fixed-bearing knee prostheses with 445 patients (816 knees) who received mobile-bearing knee prostheses. There were 187 men and 301 women (mean age, 58.6 years; range, 33–65 years) in the fixed-bearing group and 167 men and 278 women (mean age, 55.7 years; range, 33–65 years) in the mobile-bearing group. The mean followup was 12.6 years (range, 10–17 years) in the fixed-bearing group and 12.9 years (range, 10–17 years) in the mobile-bearing group.

Results The incidence of osteolysis was 1.6% (14 of 894 knees) in the fixed-bearing group and 2.2% (18 of 816 knees) in the mobile-bearing group at the final review. The mean postoperative Knee Society knee and function scores were 92.9 points and 83.5 points, respectively, in the fixed-bearing group and 90.7 points and 83.8 points, respectively, in the mobile-bearing group. The revision rates were 3.7% (33 of 894 knees) in the fixed-bearing group and 2.7% (22 of 816 knees) in the mobile-bearing group.

Conclusions We found the incidence of osteolysis, rate of revision, and implant survivorship were similar between fixed-bearing and mobile-bearing TKAs in younger patients.

Level of Evidence Level III, therapeutic study. See the guidelines for authors for a complete description of levels of evidence.

Introduction

Although TKAs using fixed-bearing prostheses have produced long-term survival rates of 90% or greater at 15 years [12, 25, 27], numerous authors have reported long-term polyethylene wear and osteolysis [3, 4, 21, 26, 28, 31, 34]. A mobile-bearing prosthesis was introduced to reduce polyethylene wear and osteolysis [5, 20]. Numerous studies of prostheses with a fixed-bearing design report an incidence of osteolysis ranging from 0.3% to 27% at 4.3 to 15.5 years followup after TKA [1, 7, 10, 14, 17, 18, 26–28, 30–32, 34]. Other studies of prostheses with a mobile-bearing design report an incidence ranging from 0% to 7% at 9 to 15 years followup [6, 8, 9, 21, 22, 25, 27, 33, 35]. However, all of these reports on the incidence of osteolysis present combined data for failed and/or well-functioning fixed- and mobile-bearing TKAs in an older population

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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(≥ 65 years). The number of wear particles increases with applied load, and number of cycles. Thus, more osteolysis is expected in younger and more active patients [7, 25, 38]. In a study of patients younger than 65 years with a mobile-bearing TKA, Sorrells et al. [36] reported an incidence of osteolysis of 0.9% (one of 171 patients) at an average followup of 8.5 years. As there have been few studies of osteolysis in well-functioning fixed- and mobile-bearing TKAs in younger patients (≤ 65 years), we wished to confirm the prevalence.

We therefore asked whether: (1) the incidence of osteolysis would be less in mobile-bearing TKAs; and (2) Knee Society knee (KS), and Hospital for Special Surgery (HSS) knee scores, component position, radiolucent line and osteolysis, implant survivorship, and complication rates would be similar between the mobile- and fixed-bearing TKAs.

Patients and Methods

We retrospectively reviewed the records of 933 prospectively followed patients (1910 knees) younger than 65 years who underwent primary TKAs between January 1992 and January 1999. Of these 933 patients, 488 (894 knees) had fixed-bearing knee prostheses and 445 patients (816 knees) had mobile-bearing knee prostheses. Our indications for fixed-bearing TKAs were end-stage osteoarthritis in 890 knees (99.6%) and traumatic arthritis in four knees (0.4%), and the indications for mobile-bearing TKAs were end-stage osteoarthritis in 756 knees (92%), traumatic arthritis in 56 (8%), and osteonecrosis in four (1%). Thus, patients were not randomized. During the same time, we performed 5130 primary TKAs in 2799 patients using contemporary knee prostheses. For this review, we excluded patients older than 65 years (1743 patients) and patients with rheumatoid arthritis (10 patients) because comparative implant survivorship and polyethylene wear performance are not adequately comparable for patients with a low activity level. With these exclusions, there were 1046 patients. Among the 549 patients with fixed-bearing TKAs, 29 died and 32 were lost to followup, leaving 488 patients available with a minimum duration of followup of 10 years (mean, 12.6 years; range, 10–17 years). Among the 497 patients with mobile-bearing TKAs, 21 died and 31 were lost to followup, leaving 445 patients available with a minimum duration of followup of 10 years (mean, 12.9 years; range, 10–17 years). One hundred five patients who did not have a minimum of 10 years of followup were recalled specifically for this study. We obtained approval of our institutional review board before beginning this study.

Several different implants were used in this study (Table 1). All of the femoral and tibial components in the

AMK (Anatomic Modular Knee, DePuy, Warsaw, IN) and LCS (Low Contact Stress Knee, DePuy) groups had a polished cobalt-chromium articular surface with a mean roughness of 0.01 μm or less. The polyethylene inserts of the AMK prosthesis were machined to its final shape from a ram-extruded bar of GUR 4150 resin. GUR 1020 resin was used in the manufacture of the polyethylene inserts of the LCS prosthesis. The polyethylene inserts of AMK and LCS prostheses were sterilized by gamma radiation in vacuum.

The femoral components of the fixed- and mobile-bearing PFC (Press Fit Condylar, DePuy) Sigma prostheses were made of cobalt-chromium. The cobalt-chromium tibial tray for the mobile-bearing PFC Sigma was modular and keel-shaped, as was the titanium tibial tray for the fixed-bearing PFC Sigma. The articular surface of the tibial tray for the mobile-bearing PFC Sigma was polished, but the upper surface of the fixed-bearing version was matte. GUR 1020 resin was used in the manufacture of the polyethylene inserts of the PFC Sigma fixed- and mobile-bearing prostheses and the inserts were sterilized by gamma radiation in vacuum.

The femoral components of the NexGen LPS (NexGen Legacy posterior-cruciate substituting knee prosthesis, Zimmer, Warsaw, IN) and NexGen CR (cruciate-retaining, Zimmer) prosthesis were manufactured from cobalt-chromium alloy. The tibial components of the NexGen LPS and NexGen CR prostheses were manufactured from titanium alloy. The articular surface of the tibial tray for both versions was matte. GUR 1050 resin was used in the manufacture of the polyethylene inserts of NexGen LPS and NexGen CR prostheses, which were molded to their final shape from a compression mold, and their inserts were sterilized by gamma irradiation in nitrogen. The mean shelf times of the polyethylene inserts between sterilization and implantation were 0.8 years (range, 0.5–1.0 years) in the AMK groups, 0.7 years (range, 0.3–0.9 years) in the LCS groups, 0.6 years (range, 0.3–0.8 years) in the PFC Sigma fixed- and mobile-bearing groups, and 0.4 years (range, 0.1–0.6 years) in the NexGen CR and LPS groups.

We used a pneumatic tourniquet in all patients. We made an anterior midline skin incision (10–12 cm in length) with a medial parapatellar capsular incision of the joint. In all knees except those with the LCS mobile-bearing prostheses, we prepared the femur first, and then the tibia. All patellae were resurfaced routinely with a polyethylene patellar prosthesis except the knees with an LCS meniscal-bearing prosthesis (a metal-backed cementless patellar prosthesis). All implants were cemented (except the LCS meniscal-bearing patellar prosthesis) using pulsed lavage, drying, and pressurization of the cement.

Table 1. Details of patients with fixed- and mobile-bearing prostheses

Parameter	Fixed-bearing prostheses				Mobile-bearing prostheses				p Value	
	AMK	PFC Sigma	NexGen LPS	NexGen CR	Overall	LCS meniscal-bearing	LCS rotating platform	LCS AP-Glide		PFC Sigma
Number of patients	145 (262 knees)	95 (174 knees)	189 (350 knees)	59 (108 knees)	488 (894 knees)	64 (116 knees)	183 (336 knees)	103 (190 knees)	95 (174 knees)	445 (816 knees)
Site (number of patients)										
Bilateral	117 (234 knees)	79 (158 knees)	161 (322 knees)	49 (98 knees)	406 (812 knees)	52 (104 knees)	153 (306 knees)	87 (174 knees)	79 (158 knees)	371 (742 knees)
Unilateral	28	16	28	10	82	12	30	16	16	74
Gender (male/female)	58/87	37/58	71/118	21/38	187/301	24/40	70/113	38/65	35/60	167/278
Age (years) [†]	59.8 (33–65)	57 (45–65)	58.3 (40–65)	59.2 (48–65)	58.6 (33–65)	55 (33–65)	56.9 (42–65)	54 (47–65)	57 (45–65)	55.7 (33–65)
Height (cm) [‡]	151.8 (148–185)	153.2 (140–179)	152.2 (140–180)	153.7 (145–181)	152.8 (140–185)	151.6 (146–184)	151.7 (146–186)	152.1 (145–185)	152.4 (140–171)	152.2 (140–186)
Weight (kg) [‡]	60.9 (48–85)	62.9 (41–86)	61.8 (40–84)	61.7 (45–82)	61.8 (40–86)	61.0 (47–84)	60.8 (47–84)	61.1 (46–85)	62.9 (40–85)	61.5 (40–85)
Body mass index (kg/m ²) [‡]	27.5 (21–35)	26.9 (20–36)	26.6 (21–35)	27 (22–35)	27 (20–36)	27.4 (21–35)	27.3 (20–36)	28.4 (21–38)	24.8 (20–29)	27 (20–38)
Diagnosis (number of knees)										
Osteoarthritis	258 (98%)	174 (100%)	350 (100%)	108 (100%)	890 (99.6%)	116 (100%)	304 (91%)	162 (85%)	174 (100%)	756 (92%)
Traumatic arthritis	4 (2%)				4 (0.4%)		28 (8%)	28 (15%)		56 (8%)
Osteonecrosis							4 (1%)			4 (1%)
Duration of followup (years) ^{††}	15.2 (15–17)	13.2 (12–15)	11.2 (11–13)	10.8 (10–12)	12.6 (10–17)	15.9 (15–17)	13.2 (13–16)	11.4 (12–14)	10.9 (10–12)	12.9 (10–17)

* Chi square test; [†] Student's t-test; [‡] values are expressed as means, with ranges in parentheses; AMK = Anatomic Modular Knee (DePuy, Warsaw, IN); NexGen LPS = NexGen Legacy posterior cruciate substituting (Zimmer, Warsaw, IN); NexGen CR = NexGen cruciate retaining (Zimmer, Warsaw, IN); LCS = low contact stress (DePuy, Warsaw, IN).

Starting with the second postoperative day, patients used a continuous passive-motion machine for passive ROM exercise twice daily for 30 minutes each time. On the same day, they started active ROM exercise and began standing at the bedside or walking with crutches or a walker twice daily for 30 minutes each time under the supervision of a physical therapist. Patients used crutches or a walker with full weightbearing for 6 weeks and used a cane when needed thereafter.

Two of us (YHK, JSK) assessed the patients, conducting a physical examination and knee scoring before surgery, 3 and 6 months after surgery, 1 year after surgery, and annually thereafter using the KS [16] and the HSS [23] scoring systems. The chance-corrected kappa coefficient [29] was calculated to determine interobserver agreement of knee score and ROM. Interobserver agreement ranged from 0.73 to 0.85. The level of activity was assessed further using the Tegner and Lysholm scores [37]. All of the clinical data in the medical records from the followup assessments were compiled by one observer (SML) who was not part of the surgical team.

Radiographs were obtained before surgery, 3 and 6 months after surgery, 1 year after surgery, and annually thereafter. Radiographs were available at all times for all patients. Standing AP views including the femoral head and ankle, and supine, lateral, and skyline patellar views, were taken under fluoroscopic control to allow initial examination of the interfaces. All radiographs were assessed by one observer (YWC), who was not part of the surgical team, for alignment of the limb, position of the component, and presence and location of all radiolucent lines at the bone-cement interface, according to the recommendations of the KS [16]. The skyline patellar radiographs were examined for patellar tilt, subluxation, or dislocation. Osteolysis was defined as any nonlinear region of periprosthetic cancellous bone loss with delineable margins. Minimal size for osteolytic lesions was defined as 0.5×0.5 cm. To assess intraobserver reliability of our measuring method, we took measurements three times (with a 3-day interval between each measurement). Data from all radiographs showed that for angular measurements, the mean intraobserver difference was 1.5° (range, 0.7° – 2.1°) and the intraclass correlation coefficient was 0.98. For linear measurements (width of radiolucent line and size of osteolysis), the mean intraobserver difference was 1.5 mm (range, 1.0–1.9 mm) and the intraclass correlation coefficient was 0.96. Bach et al. [2] reported mean kappa values of 0.46 to 0.96.

At the last followup, all patients underwent CT using a multislice scanner (General Electric Light Plus[®]; GE Medical Systems, Milwaukee, WI) to determine the rotational alignment of the components and osteolysis. The scan sequence was between 10 cm above the superior pole

of the patella and 10 cm below the tibial tuberosity, using contiguous 2.5 mm slices. Rotational alignment of the femoral component was determined by measuring the angle between the line joining the medial and lateral epicondyles of the femur and that joining the posterior margins of the femoral component. Rotational alignment of the tibial component was assessed by measuring the angle between the line connecting the tibial tuberosity anteriorly and the site of insertion of the posterior cruciate ligament (PCL) posteriorly and the AP line passing through the center of the anterior and posterior margins of the tibial component. Osteolysis was defined as any nonlinear region of periprosthetic cancellous bone loss with delineable margins. One author (YWC) examined all CT scans. The intraobserver kappa statistic for the CT examinations for osteolysis in our series was 0.93.

Fisher's exact test was used to compare the prevalence of osteolysis and the Wilcoxon rank-sum test was used for comparison of nonparametric ordinal data. The paired t-test was used to compare the knee scores and ROM. Kaplan-Meier [24] survivorship analysis was performed to determine the cumulative survival rates of the implants during the study period, with 95% confidence intervals (CIs). The end points for analysis were aseptic loosening and revision surgery for any reason or a recommendation for revision surgery by the senior author (YHK).

Results

The incidences of osteolysis detected by radiographs and CT scans were similar between the fixed-bearing (14 of 894 knees; 1.6%) and mobile-bearing (18 of 816 knees; 2.2%) groups.

We found similar mean preoperative KS knee scores ($p = 0.985$) and postoperative KS knee scores ($p = 0.756$), and similar mean preoperative KS knee function scores ($p = 0.679$) and postoperative KS function scores ($p = 0.861$) in the fixed- and the mobile-bearing groups. Similarly, the mean preoperative and postoperative HSS knee scores were similar between the groups ($p = 0.921$ and $p = 0.916$, respectively) (Table 2). The mean postoperative Tegner and Lysholm activity scores were 5.9 points (range, 5–7 points) in the fixed-bearing group and 5.7 points (range, 3–7 points) in the mobile-bearing group. The mean preoperative ROM was 127° (range, 70° – 150°) for the fixed-bearing group and 128.3° (range, 75° – 150°) for the mobile-bearing group. After surgery, the mean ROM was 133° (range, 80° – 150°) for the fixed-bearing group and 129.1° (range, 70° – 150°) for the mobile-bearing group (Table 2). There were no differences between groups for the following postoperative radiographic parameters (Table 3): knee alignment ($p = 0.152$), incidence of

Table 2. Clinical results of patients with fixed- and mobile-bearing prostheses

Parameter	Fixed-bearing prostheses				Mobile-bearing prostheses					p Value (Student's t test)	
	AMK	PFC Sigma	NexGen LPS	NexGen CR	Overall	LCS meniscal bearing	LCS rotating platform	LCS AP-Glide	PFC Sigma		Overall
Knee Society knee score (points)											
Preoperative	32.1 (17–39)	28.7 (2–35)	27.5 (4–50)	29 (9–50)	29.3 (2–50)	39 (15–51)	26.5 (6–53)	26.9 (3–55)	28 (7–36)	28.1 (3–55)	0.985
Postoperative	92.7 (62–100)	91 (75–100)	94 (87–100)	93.8 (83–100)	92.9 (62–100)	90.8 (52–100)	91.8 (56–100)	90.2 (45–100)	90 (59–100)	90.7 (52–100)	0.756
Knee Society function score (points)											
Preoperative	31 (17–49)	24 (8–48)	33.9 (20–50)	34.8 (30–48)	30.9 (8–48)	25 (5–45)	29 (12–48)	27 (7–39)	25 (5–45)	26.5 (5–48)	0.679
Postoperative	81 (30–100)	86 (32–100)	83.7 (60–100)	83.3 (75–100)	83.5 (30–100)	85 (45–100)	83 (35–100)	84 (45–100)	83 (30–100)	83.8 (30–100)	0.861
Hospital for Special Surgery knee score (points)											
Preoperative	48 (29–65)	32 (17–55)	46 (20–51)	38 (15–45)	41 (15–65)	45.7 (15–53)	47.3 (5–65)	46.8 (10–58)	41 (15–31)	45.2 (5–65)	0.921
Postoperative	89 (75–100)	90 (73–100)	89 (75–100)	91 (75–100)	90 (73–100)	89 (65–100)	88.6 (45–100)	89.4 (69–100)	88 (75–100)	88.8 (45–100)	0.916
Activity score (points)											
Preoperative	1.3 (0–3)	1.2 (0–3)	1.6 (0–4)	1.5 (0–4)	1.4 (0–4)	1.2 (0–3)	1.3 (0–3)	1.4 (0–4)	1.3 (0–2)	1.3 (0–4)	0.541
Postoperative	5.6 (5–7)	5.8 (5–7)	6.1 (6–7)	5.9 (5–7)	5.9 (5–7)	5.1 (3–6)	5.6 (3–7)	6.3 (3–6)	5.8 (3–7)	5.7 (3–7)	0.671
Range of motion (degrees)											
Preoperative	126 (90–150)	128 (80–150)	125 (80–150)	128 (70–145)	127 (70–150)	127 (80–150)	125 (80–150)	132 (95–150)	129 (75–150)	128.3 (75–150)	0.954
Postoperative	132 (95–150)	131 (80–150)	136 (85–140)	131 (90–150)	133 (80–150)	123.2 (90–140)	135 (90–150)	128.3 (70–150)	130 (80–140)	129.1 (70–150)	0.468

Values are expressed as means, with ranges in parentheses; AMK = Anatomic Modular Knee (DePuy, Warsaw, IN); PFC = Press Fit Condylar (DePuy, Warsaw, IN); NexGen LPS = NexGen Legacy posterior cruciate substituting (Zimmer, Warsaw, IN); NexGen CR = NexGen cruciate retaining (Zimmer, Warsaw, IN); LCS = low contact stress (DePuy, Warsaw, IN).

Table 3. Radiographic results of patients with fixed- and mobile-bearing prostheses

Parameter	Fixed-bearing prostheses				Mobile-bearing prostheses				p Value
	AMK	PFC Sigma	NexGen LPS	NexGen CR	Overall	LCS meniscal-bearing	LCS rotating platform	LCS AP-Glide	Overall
Alignment*									
Preoperative (degrees of varus)	11.5 (0–20)	12 (8–20)	12 (8–25)	12.5 (10–25)	12 (8–25)	11.2 (8–15)	9.8 (6–20)	8.8 (1–20)	7.9 (6–15)
Postoperative (degrees of valgus)	5.3 (0–7)	5.5 (0–7)	5.9 (3–7)	6.1 (3–7.5)	5.7 (0–7.5)	5.3 (0–6)	5.6 (0–7)	5.1 (0–8)	5.4 (0–8)
Radiolucent line overall (number of knees)									
Absence	224 (85.5%)	140 (80.5%)	298 (85.1%)	90 (83.3%)	752 (84.1%)	99 (85.3%)	272 (81%)	152 (80%)	144 (83%)
Presence	38 (14.5%)	34 (19.5%)	52 (14.9%)	18 (16.7%)	142 (15.9%)	17 (14.7%)	64 (19%)	38 (20%)	30 (17%)
Tibial radiolucent line (number of knees)									
Zone 1 (< 1 mm)	28 (10.7%)	27 (15.5%)	38 (10.9%)	12 (11.1%)	105 (11.7%)	12 (10.3%)	48 (14.3%)	21 (11.1%)	19 (10.9%)
Zone 1 and 2 (< 1 mm)	2 (0.8%)	1 (0.6%)	4 (1.1%)	1 (0.9%)	8 (0.9%)	2 (1.7%)	8 (2.4%)	6 (3.2%)	4 (2.3%)
Zone 4 (< 1 mm)	2 (0.8%)	0 (0%)	3 (0.9%)	0 (0%)	5 (0.6%)	1 (0.9%)	2 (0.6%)	5 (2.6%)	2 (1.1%)
All zone (> 1 mm)	2 (0.8%)	3 (1.7%)	2 (0.6%)	1 (0.9%)	8 (0.9%)	0 (0%)	1 (0.3%)	0 (0%)	1 (0.6%)
Femoral radiolucent line (number of knees)									
Zone 1	2 (0.8%)	1 (0.6%)	3 (0.9%)	3 (2.8%)	9 (1.0%)	2 (1.7%)	3 (0.9%)	3 (1.6%)	3 (1.7%)
Zone 4	2 (0.8%)	2 (1.1%)	2 (0.6%)	1 (0.9%)	7 (0.8%)		2 (0.6%)	3 (1.6%)	1 (0.6%)
External rotation of components by CT (degrees)*									
Femoral component	3.3 (3–4)	3.2 (3–5)	3.4 (3–5)	3.3 (3–5)	3.3 (3–5)	3.6 (2–5)	3.3 (3–5)	3.2 (2–4)	3.7 (3–5)
Tibial component	2.3 (2–3)	2.4 (2–4)	2.6 (2–3)	2.5 (2–4)	2.5 (2–5)	2.8 (2–4)	2.6 (2–4)	2.1 (2–3)	2.6 (2–4)
Osteolysis (number of knees)	5 (1.9%)	4 (2.3%)	4 (1.1%)	1 (0.9%)	14 (1.6%)	6 (5.1%)	5 (1.5%)	4 (2.1%)	3 (1.7%)

* Values are expressed as means, with ranges in parentheses; † Student's t-test; ‡ chi square test; AMK = Anatomic Modular Knee (DePuy, Warsaw, IN); PFC = Press Fit Condylar (DePuy, Warsaw, IN); NexGen LPS = NexGen Legacy posterior cruciate substituting (Zimmer, Warsaw, IN); NexGen CR = NexGen cruciate retaining (Zimmer, Warsaw, IN); LCS = low contact stress (DePuy, Warsaw, IN).

Table 4. Revision operations and survivorship of fixed- and mobile-bearing prostheses

Parameter	Fixed-bearing prostheses				Mobile-bearing prostheses				p Value (chi square test)		
	AMK	PFC Sigma	NexGen LPS	NexGen CR	Overall	LCS meniscal-bearing	LCS rotating platform	LCS AP-Glide		PFC Sigma	Overall
Revision (number of knees)	13 (5.0%)	11 (6.3%)	6 (1.7%)	3 (2.8%)	33 (3.7%)	6 (5.2%)	7 (2.1%)	5 (2.6%)	4 (2.3%)	22 (2.7%)	0.244
Poly-ethylene wear	5 (1.9%)	3 (1.7%)	1 (0.3%)	0 (0%)	9 (1.0%)	4 (3.4%)	0 (0%)	0 (0%)	0 (0%)	4 (0.5%)	0.219
Aseptic loosening	2 (0.8%)	3 (1.7%)	1 (0.3%)	0 (0%)	6 (0.7%)	0 (0%)	1 (0.3%)	0 (0%)	1 (0.6%)	2 (0.3%)	0.130
Instability	2 (0.8%)	2 (1.1%)	2 (0.6%)	1 (0.9%)	7 (0.8%)	1 (0.9%)	4 (1.2%)	3 (1.6%)	1 (0.6%)	9 (1.1%)	0.492
Infection	1 (1.2%)	1 (0.6%)	2 (0.6%)	2 (1.9%)	6 (0.7%)	1 (0.9%)	2 (0.6%)	2 (1.1%)	2 (1.1%)	7 (0.9%)	0.657
Osteolysis	3 (0.8%)	2 (1.1%)	0 (0%)	0 (0%)	5 (0.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0.9998
Survivorship	95% (95% CI, 0.90–0.98) (15.2 years)	93.7% (95% CI, 0.87–0.96) (13.2 years)	98% (95% CI, 0.93–1.0) (11.2 years)	97.2% (95% CI, 0.94–1.0) (10.8 years)	96.3% (95% CI, 0.87–1.0) (12.6 years)	95% (95% CI, 0.90–0.98) (15.9 years)	97.9% (95% CI, 0.98–1.0) (14.3 years)	97.4% (95% CI, 0.95–1.0) (13.4 years)	98% (95% CI, 0.94–1.0) (12.9 years)	97.1% (95% CI, 0.90–1.0) (14.1 years)	

CI = confidence interval; AMK = Anatomic Modular Knee (DePuy, Warsaw, IN); PFC = Press Fit Condylar (DePuy, Warsaw, IN); NexGen LPS = NexGen Legacy posterior cruciate substituting (Zimmer, Warsaw, IN); NexGen CR = NexGen cruciate retaining (Zimmer, Warsaw, IN); LCS = low contact stress (DePuy, Warsaw, IN).

radiolucent lines around femoral and tibial components ($p = 0.253$), and position of the femoral and tibial components ($p = 0.189$).

In the fixed-bearing group, 33 revisions (3.7%) were performed (Table 4). Nine knees (1.0%) were revised owing to polyethylene wear, six (0.7%) for aseptic loosening, seven (0.8%) for instability, six (0.7%) for infection, and five (0.6%) for osteolysis. In the mobile-bearing group, 22 revisions (2.7%) were performed. Four knees (0.5%) were revised owing to polyethylene wear, two (0.3%) for aseptic loosening, nine (1.1%) for instability, and seven (0.9%) for infection. No knee was revised for osteolysis in the mobile-bearing group. Kaplan-Meier survivorship with revision defined as the end point showed survival rates of 96.3% for the fixed-bearing prosthesis (95% CI, 0.87–1.0) at 13 years' followup and 97.1% for the mobile-bearing prosthesis (95% CI, 0.90–1.0) at 14 years' followup. There was a survival rate of 99% with aseptic loosening as the end point in both groups (95% CI for both, 0.94–1.0) at 13 and 14 years' followups, respectively.

Discussion

Periprosthetic osteolysis is an increasingly prevalent complication of TKA. To reduce the polyethylene wear and periprosthetic osteolysis, particularly in young patients, the design of contemporary fixed-bearing prostheses has been

modified and mobile-bearing prostheses have been introduced. There have been few studies [36] regarding the prevalence of osteolysis in well-functioning fixed- and mobile-bearing TKAs in younger patients. In our study, we asked whether (1) the incidence of osteolysis would be less in mobile-bearing TKAs, and (2) KS and HSS knee scores, component position, presence and location of radiolucent lines and osteolysis, implant survivorship, and complication rates would be similar between the mobile- and fixed-bearing TKAs.

There were some limitations to our study. First, many different implants were used, and the numbers were too small for individual comparative analysis of the implant. Second, although the minimum 10-year followup was too short to allow conclusive findings, we observed a low incidence of osteolysis after contemporary well-functioning fixed- or mobile-bearing TKAs in younger patients. Third, we performed no interobserver variability studies of the radiographic and CT measurements to confirm the measurements made by one observer, and this can lead to bias in interpreting radiolucent lines, osteolysis, and loosening, leading to errors of either underestimation or overestimation. Intraobserver agreements for the various radiographic and CT measurements were 0.96 to 0.98. Finally, although we included only nonobese patients in this study, all patients were younger than 65 years.

Polyethylene failure is a major risk for long-term survival of TKA [10]. In our fixed- and mobile-bearing

Table 5. Incidence of osteolysis after TKAs with fixed- and mobile-bearing prostheses

Study	Number of patients	Age (years)*	Followup (years)*	Incidence of osteolysis	Size of osteolytic lesion
Fixed-bearing					
Arora and Ogden [1] (2005)	82	68.7 $\pm$ 8.8	7.25 (5–13)	13/125 (10.4%)	0.5 $\times$ 0.5 cm
Collier et al. [11] (2005)	365	68 $\pm$ 8	5–10	99/365 (27%)	NA
Dixon et al. [14] (2005)	139	67 (17–89)	15.5 (15.0–16.9)	1/139 (0.7%)	NA
Ezzet et al. [17] (1995)	83	66 (46–83)	4.3 (2–6.5)	17/83 (20.5%)	NA
Faris et al. [18] (2008)	201	73 (50–90)	7.9 (2.5–17.4)	9/201 (0.5%)	NA
Kim et al. [27] (2007)	146	69.8 (42–80)	13.2 (11.0–14.5)	1/146 (0.3%)	NA
Kim and Kim [25] (2009)	61	48.3 (34–55)	10.8 (10–12)	6/61 (10%)	NA
Lachiewicz and Soileau [28] (2004)	193	68 (22–89)	7 (5–14)	8/193 (4%)	NA
Mikulak et al. [30] (2001)	557	65 (46–80)	4.7 (3–7.4)	16/557 (2.9%)	NA
O'Rourke et al. [31] (2002)	145	68.8 (49–84)	6.4 (5.0–7.9)	17/145 (12%)	NA
Current study	894	58.6 (33–65)	12.6 (10–17)	14/894 (1.6%)	NA
Mobile-bearing					
Callaghan et al. [9] (2000)	119	70 (37–88)	9.7 (9–12)	0/119 (0%)	NA
Callaghan et al. [8] (2005)	53	70 (37–88)	15.7 (15–18)	3/53 (5.7%)	1 $\times$ 2.5 cm
Kim et al. [27] (2007)	146	69.8 (42–80)	13.2 (11.0–14.5)	0/292 (0%)	NA
Kim and Kim [25] (2009)	61	48.3 (34–55)	10.8 (10–12)	4/61 (7%)	5 $\times$ 5 cm
Current study	816	55.7 (33–65)	12.9 (10–17)	18/816 (2.2%)	NA

* Values are expressed as mean $\pm$ SD or as mean, with range in parentheses; NA = not applicable.

groups, revisions for osteolysis or polyethylene failures were rare. Nine knees (1.0%) in the fixed-bearing group and four (0.5%) in the mobile-bearing group (all knees with an LCS meniscal-bearing prosthesis) underwent revision for polyethylene wear. Five knees (0.6%) in the fixed-bearing group and none in the mobile-bearing group underwent revision for osteolysis. The reported incidences of osteolysis range from 0.3% to 27% for fixed-bearing TKAs and from 0% to 7% for mobile-bearing TKAs (Table 5). The incidences of osteolysis in our two groups are within the ranges reported for other contemporary knee systems. Collier et al. [11] analyzed the risk factors for osteolysis after TKA. In that study, the risk factors were being male instead of female, the use of a prosthesis with a grit-blasted tibial proximal surface, the use of gamma-irradiated-in-air sterilization for prosthetic components, and increased shelf age of the polyethylene insert. Our findings of a low incidence of osteolysis for the fixed- and mobile-bearing groups may be related to our study's preponderance of female patients; a polyethylene insert sterilized by gas plasma, gamma-irradiation in a vacuum, or gamma-irradiation in nitrogen, and a short shelf life of the insert. It is possible the duration of followup was not sufficiently long to reveal osteolysis. The concept that a mobile-bearing prosthesis is associated with less wear and a lower prevalence of osteolysis than a well-designed fixed-bearing prosthesis remains to be confirmed with longer-term followup.

Kim et al. [27] compared ROM and knee and function scores of AMK fixed-bearing and LCS mobile-bearing prostheses. At a mean followup of 13.2 years, no differences in ROM, HSS knee scores, and KS knee and function scores were identified in the two groups. Gioe et al. [19] also compared ROM and knee and function scores for PFC Sigma fixed- and mobile-bearing rotating-platform prostheses. At a mean followup of 42 months, there were no differences between the groups regarding postoperative ROM, KS knee and function scores, or KS pain scores. We observed similar ROM, HSS knee scores, KS knee and function scores, and KS pain scores between fixed- and mobile-bearing TKAs. Kim et al. [26] reported no differences between the fixed- and mobile-bearing prostheses for the following radiographic parameters: knee alignment, positions of the femoral and tibial components in the coronal and sagittal planes, patellar angle, tibial surface area covered by the implants, joint line, posterior condylar offset, and radiolucent lines. We observed no differences between fixed- and mobile-bearing TKAs for these radiographic parameters in our series. Our complication rates were low and similar between the two groups, which is in line with rates reported in other studies [25, 27].

Although TKA is well accepted for patients older than 65 years, its use is controversial for younger patients

(≤ 65 years). Duffy et al. [15] reported a 95% survival rate at 15 years in patients younger than 55 years, and in a similar age group, Diduch et al. [13] reported an 87% survival rate at 18 years, using revision as an end point. Dixon et al. [14] reported a 92.6% survival rate at 15 years in patients with an average age of 67 years, using revision as an end point. Dalury et al. [12] found a slight age-related difference. They reported that the 10-year survival rate was 97.5% for patients younger than 55 years and 98.1% for older patients. They concluded that survival rate was slightly lower in the younger group. In our series, the survivorship of fixed-bearing TKAs was 96.3% at 12.6 years and that of mobile-bearing TKAs was 97.1% at 14.1 years. Our survival rates are within the range of reported survival rates for TKAs in younger patients.

Our study suggests that cemented fixed- and mobile-bearing prostheses are durable at a minimum followup of 10 years in patients younger than 65 years. We observed minimal evidence of osteolysis in well-functioning fixed-bearing (1.6%) and mobile-bearing (2.2%) TKAs in younger patients despite critical assessment by radiography and CT.

Acknowledgments We thank Sang-Mi Lee, BA, for compiling the medical records.

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