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Staged bilateral mobile-bearing and fixed-bearing total knee arthroplasty in the same patients: a prospective comparison of a posterior-stabilized prosthesis

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Abstract Mobile-bearing total knee arthroplasty (TKA) has several theoretical advantages over fixed-bearing TKA. We conducted a prospective randomized trial to compare the results of mobile-bearing and fixed-bearing posterior-stabilized TKA in the same patients using the same femoral component design of a mobile-bearing prosthesis in one knee and a fixed-bearing prosthesis in the other knee in 25 patients with osteoarthritis. The mean follow-up was 40 months. No significant differences were found in the mobile-bearing and fixed-bearing knees in terms of clinical and radiographic results. No osteolysis, loosening, or revision occurred. One knee with a mobile-bearing prosthesis had a dislocation of the rotating bearing; however, spontaneous reduction occurred and the dislocation did not recur. Satisfactory early results can be achieved in both mobile-bearing and fixed-bearing knees. We could not demonstrate an advantage of a mobile-bearing TKA.

Keywords Total knee arthroplasty · Mobile bearing · Fixed bearing

Introduction

The long-term results of total knee arthroplasty (TKA) with a fixed-bearing design have shown a high degree of success. There is concern, however, with regard to problems of polyethylene wear and implant loosening. Debris-induced osteolysis due to polyethylene wear is a potential mechanism of long-term TKA failure [17, 21]. Mobile-bearing total knee prostheses were designed to provide dual-surface articulation at both the superior and inferior surfaces of the polyethylene insert. Highly congruent articulating surfaces result in reduced polyethylene contact stresses. In a simulator study, mobile-bearing prostheses exhibited reduced wear rates in comparison to fixed-bearing components [6, 19]. Mobile-bearing prostheses are also postulated to minimize bone prosthesis stress at the fixation surface of the tibial component [4, 6, 7, 19, 23]. Additionally, the self-aligning nature of the implants has been promoted as simplifying the surgical procedure, although the surgery involved requires perfect soft tissue balancing [25]. However, these advantages over fixed-bearing total knee prostheses are theoretical.

We conducted a single-blind, prospective, randomized, trial using the same femoral component design to compare the results of mobile-bearing and fixed-bearing TKAs in the same patients. To our knowledge, the present study is the first trial comparing the same design of a femoral component of a mobile-bearing prosthesis in one knee and a fixed-bearing prosthesis in the other with use of a posterior-stabilized TKA. We hypothesized that early clinical and radiographic results may demonstrate no differences between mobile-bearing and fixed-bearing TKAs.

Patients and methods

Between April 2003 and July 2006, 25 consecutive patients underwent a staged bilateral TKA, with a mobile-bearing TKA on one side and a fixed-bearing TKA on the other (average interval 8.7 months; range 2–28 months). Randomization regarding the use of either a mobile-bearing or a fixed-bearing prosthesis was determined using sealed envelopes. The patients were kept in ignorance as to which

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side had been chosen. The study was approved by the institutional review board, and all patients gave informed consent. Participants included 22 women and 3 men with a mean age at the time of surgery of 73 years (55–81). All patients had osteoarthritis. The mean height of patients was 150.1 cm (137–167) and their mean weight was 56.8 kg (45–75). The mean follow-up was 40 months (18–63). No patient was lost to follow-up.

All operations were performed by a single surgeon (MH) through a midline skin incision with a midvastus approach. Both the anterior cruciate ligament and posterior cruciate ligament were excised. Tibial preparation was done first followed by femoral preparation. The ligaments were balanced. A press-fit condylar Sigma mobile-bearing or fixed-bearing prosthesis (PFC Sigma, DePuy, Warsaw, IN) was used. All implants used a posterior-stabilized design with a post-cam mechanism. All components were fixed with cement. The femoral component in both groups was the same and was made of cobalt–chrome. The cobalt–chrome tibial tray for the mobile-bearing prosthesis was modular and keel shaped with the design of a rotating platform, as was the titanium tibial tray for the fixed-bearing prosthesis. The mobile-bearing tibial component was a highly polished baseplate with nearly full conformity in the coronal and sagittal planes. The polyethylene insert included a central cone that engaged a matching conical cavity in the tibial tray (Fig. 1) [23]. All patellae were routinely resurfaced using an all-polyethylene prosthesis. No cases required lateral retinaculum release. On the second day after surgery, the knee was placed on a continuous passive motion machine and the settings were advanced incrementally until the knee reached 120° of flexion. All patients were allowed full weight bearing 5 days postoperatively.

Preoperative and postoperative ratings according to the system of the Knee Society were obtained for all patients. These ratings included a knee score and a function score [13]. The range of movement (ROM) was measured. In addition, we asked for subjective preference of one knee over the other. We obtained radiographs, including anteroposterior views of both long leg standing and supine, supine lateral, and skyline patellar views before and after surgery. Radiographs were assessed by a single observer (AS) who was blinded to the type of prosthesis for alignment of the limb, the position of the component, and the presence of radiolucent lines at the bone–cement interface, according to the methods of the Knee Society [8]. Any detectable osteolysis around the three components was recorded.

Statistical analyses were carried out using the Wilcoxon signed rank test, Mann–Whitney's U test, and Fisher's exact test. $P < 0.05$ was considered statistically significant.

Fig. 1 Photographs of the mobile-bearing prosthesis in the right and fixed-bearing prosthesis in the left

Results

Clinical results

The preoperative knee score and function score were not statistically different between the mobile-bearing and fixed-bearing knees (Table 1). The scores at the time of the last follow-up were also not statistically different between the groups (Table 1). Both knee scores and function scores significantly improved postoperatively in the mobile-bearing and fixed-bearing TKAs ($P < 0.01$). The ROM in mobile-bearing and fixed-bearing knees was not statistically different either preoperative or postoperative evaluation (Table 2). Nine patients preferred the mobile-bearing side, 11 patients preferred the fixed-bearing side, and 5 patients indicated no difference between the two knees.

Radiographic results

The preoperative femorotibial alignment (anatomic axis) averaged 8.7° of varus (0–20) in 24 knees with a mobile-bearing prosthesis. In one knee with a mobile-bearing prosthesis, the preoperative femorotibial alignment was 11° of valgus. The preoperative femorotibial alignment averaged 8.9° of varus (3–20) in all knees with a fixed-bearing prosthesis. The postoperative femorotibial alignment

Table 1 Clinical scores according to the Knee Society

Patient number	Knee score				Function score			
	Preoperative		Postoperative		Preoperative		Postoperative	
	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed
1	43	33	100	100	35	55	80	80
2	33	38	100	100	20	40	80	80
3	36	23	100	100	45	75	80	80
4	35	26	95	95	60	65	100	100
5	30	27	94	94	55	55	55	55
6	0	0	100	100	40	40	100	100
7	57	37	100	100	60	70	100	80
8	1	14	95	95	0	0	50	50
9	50	0	100	100	15	40	80	80
10	8	0	79	88	20	20	100	100
11	7	12	100	100	45	45	80	80
12	35	20	100	100	35	35	100	100
13	23	52	100	94	30	70	70	70
14	16	28	98	98	45	45	70	65
15	21	44	100	100	45	55	80	80
16	6	40	100	100	35	50	70	100
17	22	29	88	95	45	35	90	90
18	47	33	100	100	35	40	80	80
19	10	0	100	100	70	45	80	80
20	27	35	100	100	35	40	80	80
21	46	26	88	98	65	35	90	90
22	23	31	94	97	70	50	100	100
23	33	0	95	95	55	35	75	90
24	29	5	100	95	35	35	80	80
25	15	35	100	100	65	65	100	100
Mean	26	24	97	98	42	46	83	84
P	0.61		0.86		0.63		0.72	

averaged 5.3° of valgus (1–8) in the mobile-bearing knees and 5.4° of valgus (2–8) in the fixed-bearing knees. In both groups, there were no significant differences in the position of the femoral and tibial components in the coronal and sagittal planes (Fig. 2; Table 3). Three (12%) of the 25 knees with a mobile-bearing prosthesis and 5 (20%) of the 25 knees with a fixed-bearing prosthesis had radiolucent lines around the tibial prostheses. All of the radiolucent lines were <1 mm and were nonprogressive. We found no significant difference between the mobile-bearing and fixed-bearing knees in the occurrence of radiolucent lines ($P = 0.70$).

Complications

One knee in the mobile-bearing group had a dislocation of the rotating bearing 4 days postoperatively. However, spontaneous reduction occurred 6 days after the dislocation, and the dislocation did not recur. This patient has muscle weakness in both legs due to cervical spondylotic myelopathy with severe varus deformity of the knee preoperatively. Both quadriceps deficiency and ligament laxity may contribute to the risk of dislocation [9].

No loosening, revision, or infection occurred in any patient.

Discussion

Several authors have compared the results of different types and designs of mobile-bearing and fixed-bearing TKAs. Most studies showed no difference between the mobile-bearing and fixed-bearing TKAs in terms of clinical score, ROM, and radiographic results as shown in the present study [1, 4, 5, 11, 14–16, 18, 22, 28]. For example, Kim et al. [14] compared the results of a mobile-bearing prosthesis (LCS meniscal-bearing, DePuy) and fixed-bearing prosthesis (AMK, DePuy) in 116 patients who had

Table 2 Range of movement

Patient number	Flexion				Flexion contracture			
	Preoperative		Postoperative		Preoperative		Postoperative	
	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed
1	130	135	135	135	15	10	0	0
2	130	130	140	140	5	5	0	0
3	120	100	145	130	5	10	0	0
4	115	120	125	130	15	5	0	0
5	125	125	120	120	0	5	0	0
6	120	115	140	135	20	20	0	0
7	130	125	130	130	10	15	0	0
8	95	120	130	125	5	15	0	0
9	130	105	135	130	10	15	0	0
10	110	110	115	115	45	20	10	0
11	100	125	125	135	15	15	0	0
12	120	120	130	135	10	20	0	0
13	105	120	130	120	5	0	0	0
14	110	135	135	130	30	5	5	5
15	100	110	130	130	10	5	0	0
16	120	135	135	130	15	0	0	0
17	100	110	110	130	5	5	5	0
18	110	105	135	125	0	5	0	0
19	90	100	130	125	15	25	0	0
20	110	120	125	140	0	10	0	0
21	120	120	115	115	5	5	0	0
22	90	120	100	110	0	5	5	0
23	130	95	135	140	15	30	0	0
24	125	125	145	140	20	15	0	0
25	120	135	140	135	20	0	0	0
Mean	114	118	129	129	12	11	1	0
P	0.16		0.69		0.71		0.24	

bilateral simultaneous TKA. At a mean follow-up of 7.4 years, no difference in the clinical outcome was identified in the two groups. The authors observed the same results in extended follow-up periods [16]. Woolson and Northrop [28] compared the results of 57 mobile-bearing prostheses (LCS rotating-platform, DePuy) and 45 fixed-bearing prostheses (NexGen PS, Zimmer, Warsaw, IN) for a mean follow-up of 41 months and found no differences clinically or radiographically. However, more patients with a mobile-bearing prosthesis required early revision for failure of rotating patellar components in two knees and tibial polyethylene spinout in one knee. Bhan et al. [4] compared the results of a mobile-bearing prosthesis (LCS rotating-platform, DePuy) and fixed-bearing prosthesis (Insall Burstein-II, Zimmer) in 32 patients who had bilateral simultaneous TKA. At a mean follow-up of 6 years, clinical and radiographic results showed no differences between groups. Two knees with a mobile-bearing prosthesis required a second operation: one had an early revision because of recurrent dislocation of the rotating bearing and another required conversion to an arthrodesis to treat a deep infection. Price et al. [22] compared the results of TMK mobile-bearing (Biomet Merck, Bridgend, UK) and AGC fixed-bearing (Biomet Merck) TKAs in 40 patients who had bilateral simultaneous TKA. At 1 year, the authors demonstrated a significant clinical advantage for the mobile-bearing knee. However, at 3 years, there were no significant differences in clinical outcome between the two prostheses [1]. Biau et al. [5] reported the 5-year results of two cohorts of 108 posterior-stabilized HLS prostheses (Hospital Lyon Sud, Tornier SA, Montbonnot, France), one cohort receiving the mobile-bearing design and the other receiving the fixed-bearing design. In all of these previous studies, different types and designs of prostheses were compared. This may have affected the clinical outcome. In a recent prospective randomized trial, Lädermann et al. [18] reported the 7-year results of two groups of 52 knees that were replaced using either a mobile-bearing or a fixed-

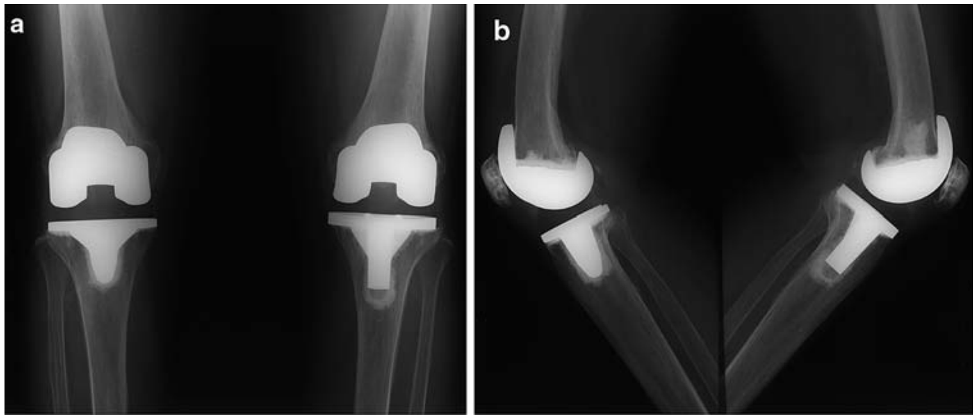

Fig. 2 Radiograph of an 80-year-old woman with osteoarthritis of both knees. **a** Anteroposterior and **b** lateral views with a mobile-bearing prosthesis in the right knee and a fixed-bearing prosthesis in the left knee, taken 4 years postoperatively. The components are well fixed and there are no radiolucent lines or osteolysis

Table 3 Component alignment in mobile-bearing and fixed-bearing TKAs

Patient number	Femoral component				Tibial component			
	Coronal		Sagittal		Coronal		Sagittal	
	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed	Mobile	Fixed
1	96	96	3	0	90	90	84	87
2	96	96	2	−3	90	90	85	87
3	93	96	−2	4	88	90	86	87
4	97	96	4	0	92	90	87	87
5	95	97	0	2	89	90	87	85
6	96	96	3	0	90	88	85	86
7	97	97	−4	0	90	88	87	85
8	97	96	0	0	90	88	83	87
9	95	95	0	0	90	90	87	87
10	96	96	0	0	90	90	87	86
11	96	96	3	4	90	90	86	86
12	96	97	0	0	90	88	88	84
13	95	97	0	0	89	88	87	84
14	96	98	−1	1	90	90	85	87
15	96	96	3	1	91	90	87	84
16	96	94	0	0	90	89	87	86
17	98	96	0	0	90	88	84	86
18	97	96	0	−3	91	90	84	87
19	95	96	0	−2	90	90	87	87
20	97	96	0	0	90	90	85	87
21	97	96	2	0	87	90	84	87
22	96	96	−1	2	88	90	86	87
23	97	96	1	1	90	90	87	87
24	94	96	4	0	90	90	85	84
25	98	96	0	0	92	88	86	87
Mean	96.1	96.1	0.7	0.3	89.9	89.4	85.8	86.2
P	0.88		0.59		0.09		0.4	

bearing variant of the same posterior-stabilized total knee prostheses (PFC Sigma) as was used in this study. Two knees with a mobile-bearing design required reoperation: one for persistent joint stiffness and another to treat septic loosening, however, no significant differences were demonstrated with respect to the clinical and radiographic results between groups. To our knowledge, only two studies have compared the same femoral component design of a mobile-bearing prosthesis in one knee with a fixed-bearing prosthesis in the other [15, 23]. In a case–control study, Ranawat et al. [23] compared the mobile-bearing rotating-platform TKA (PFC Sigma RP) to the fixed-bearing version of the same PFC Sigma design previously implanted in the opposite knee in 26 patients. All implants were posterior stabilized. At an average follow-up time of 16 months for the mobile-bearing side and 46 months for the fixed-bearing side, no significant differences were found in terms of clinical and radiographic results. Kim et al. [15] compared the results of a mobile-bearing PFC Sigma RP and a fixed-bearing PFC Sigma in 174 patients who had bilateral simultaneous TKA. All implants used a posterior cruciate-retaining design. At an average follow-up time of 5.6 years, the authors could not demonstrate any significant clinical advantage for the mobile-bearing TKA.

In terms of preference for the type of prosthesis, Price et al. [22] demonstrated that two of three patients who expressed a preference favored the mobile-bearing knee. Kim et al. [16] reported that 85% of patients expressed no preference for either knee. Our questionnaire also revealed no tendency for a preference between a mobile-bearing or fixed-bearing TKA.

No osteolysis was found in either group in the present study, and Callaghan et al. [7] reported no knee was revised because of loosening, osteolysis, or polyethylene wear at a minimum follow-up of 15 years for a mobile-bearing TKA. However, the prevalence of osteolysis in failed TKA was reported to be significantly higher in the mobile-bearing TKA (47%) than in the fixed-bearing TKA (13%) [11]. Huang et al. [12] showed that the mobile-bearing knees (LCS, DePuy) produced smaller particulate debris and more granular debris. Minoda et al. [20] compared the size, shape, and number of polyethylene wear particles found in synovial fluids of patients 1 year after implantation of well-functioning mobile-bearing and fixed-bearing total knee prostheses with a posterior-stabilized design and found no differences in these parameters between groups. These in vivo studies did not confirm the theoretical advantages of a mobile-bearing TKA. Recently, Ho et al. [10] examined worn tibial inserts, including mobile-bearing rotating-platform posterior cruciate-sacrificing dished prostheses (LCS, DePuy) and fixed-bearing posterior cruciate-retaining flat prostheses (Miller-Galante I, Zimmer), which were retrieved at revision surgery with an average implantation time of 115 months. Low-grade wear was more common in mobile-bearing knees, whereas high-grade wear was more common in fixed-bearing knees. The authors stated that mobile-bearing designs reduced the incidence of rotational asymmetric wear because of facilitation of movement of the insert relative to the tray when the knee rotates. The follow-up period in our study was not sufficient to evaluate the reduction of polyethylene wear as well as implant loosening. The other limitations of the study were the small sample size and particular type of population, including light mean weight (56.8 kg) and good preoperative mean range of movement (114°–118° of flexion).

After mobile-bearing TKA, dislocation or spinout can occur as a result of excessive rotation of the polyethylene bearing accompanied by translation of the femur on the tibia [2, 3, 9, 24, 25]. Although bearing dislocation is an unusual complication, it is the most important potential early complication. The reported incidence of polyethylene dislocation ranges from 0 to 9.3% [4, 12, 23, 26]. The causes of dislocation after TKA are multifactorial, including component malposition, prosthesis design, extensor mechanism dysfunction, hamstring spasm, extensive posterolateral release, and increased flexion laxity [3, 9, 24–26]. Many surgeons feel that the use of an unconstrained mobile-bearing TKA may be contraindicated in cases of severe varus and valgus deformity because of the difficulty in ligament balancing and the requirement for extensive soft tissue release; however, the degree of deformity that can be treated with mobile-bearing knees is unclear [5, 27].

Conclusion

Although it is difficult to draw valid conclusions from our small study and long-term results from our patients are required to provide useful information, early results indicate no significant differences in the clinical and radiographic findings between mobile-bearing and fixed-bearing posterior-stabilized TKAs using the same design of femoral component in the same patients. Satisfactory early results can be achieved in both prostheses. We could not demonstrate an early advantage for a mobile-bearing knee and our hypothesis was verified.

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