High Early Failure Rate of the Columbus® Posterior Stabilized High-flexion Knee Prosthesis

Woon-Hwa Jung MD, Jae-Heon Jeong MD,
Yong-Chan Ha MD, Young-Kyun Lee MD,
Kyung-Hoi Koo MD

Received: 30 May 2011 / Accepted: 15 November 2011 / Published online: 27 November 2011
© The Association of Bone and Joint Surgeons® 2011

Abstract

Background Most studies report high survivorship rates for TKAs, however, we observed higher than anticipated rates of dislocation and femoral component loosening after implanting a Columbus® posterior stabilized prosthesis.

Questions/purpose We therefore determined (1) the incidence of dislocation and aseptic loosening that occurred after implantation of posterior stabilized high-flexion prostheses in TKAs, (2) the causative factors of dislocation and aseptic

femoral component loosening when comparing two designs of prostheses, and (3) the mechanisms of dislocation.

Methods We retrospectively reviewed 319 patients who underwent 384 TKAs from May 2007 to July 2008. These patients had been assigned alternately to receive a Scorpio® posterior stabilized knee prosthesis (Group I, 158 patients, 187 knees) or a Columbus® posterior stabilized knee prosthesis (Group II, 161 patients, 197 knees). We followed the patients with clinical and radiographic evaluations for a minimum of 24 months (mean, 26 months; range, 24–38 months). Ten retrieved prostheses were examined visually.

Results Ten dislocations (5.1%; 10 of 197 knees) and seven aseptic loosening of femoral components (3.6%; seven of 197 knees) occurred in Group II at a mean of 10.9 months postoperatively. However, no dislocation or loosening occurred in patients in Group I. Most dislocations were associated with varus flexion or flexion rotation movements during normal daily activities. The cam jump distance at 90° flexion for the Columbus® prosthesis was lower than for the Scorpio® prosthesis.

Conclusions We observed a high rate of early failure during short-term followup after implantation of a Columbus® posterior stabilized prosthesis. It appears that early failures of the Columbus® design were related to a different cam-post design attributable to a low jump distance during knee flexion. We no longer recommend using this device.

Level of Evidence Level II, prognostic study. See the Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she, or a member of their immediate family, has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request. *Clinical Orthopaedics and Related Research* neither advocates nor endorses the use of any treatment, drug, or device. Readers are encouraged to always seek additional information, including FDA-approval status, of any drug or the device prior to clinical use. Each author certifies that his or her institution approved the reporting of this case report, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

W.-H. Jung
Department of Orthopaedic Surgery, Murup Hospital,
Changwon, South Korea

J.-H. Jeong, Y.-C. Ha (✉)
Department of Orthopaedic Surgery, Chung-Ang University
College of Medicine, 224-1 Heukseok-dong, Dongjak-gu,
Seoul 156-755, South Korea
e-mail: hayongch@naver.com

Y.-K. Lee, K.-H. Koo
Department of Orthopaedic Surgery, Seoul National University
Bundang Hospital, Seongnam, South Korea

Introduction

The long-term survivorship after TKA has improved owing to advances in surgical techniques and prosthesis design.

Two typical types either substitute for a resected posterior cruciate ligament or allow its preservation [3, 23], and the survivorship rates for the two designs are similar [13, 20, 23]. However, many surgeons prefer posterior stabilized knee prostheses to correct moderate to severe deformities. These designs have several advantages such as being easier to implant, having a fixed rollback, and being less sensitive to joint line changes [15, 17, 20].

Several groups of investigators have introduced posterior stabilized total knee prostheses that can flex to high degrees and are intended to improve ROM after TKA [18, 24]. These implants theoretically allow patients to sit in the tailor or cross-legged position. For this ROM, the design of these posterior stabilized prostheses was modified to reduce the complications that occur at full knee flexion. However, some studies [1, 2, 8, 9, 18] have reported complications, such as increased contact stress at full flexion, dislocation, and a high rate of early loosening of femoral components in the short term for these modified posterior stabilized prostheses.

In a prospective study, we alternately used a posterior stabilized Columbus[®] total knee prosthesis (B. Braun Aesculap, Tuttlingen, Germany) and posterior stabilized Scorpio[®] total knee prosthesis (Scorpio Superflex PS[®], Stryker Howmedica Osteonics, Allendale, NJ, USA) from May 2007 to July 2008. However, we observed early failures, including dislocation and femoral component loosening, during short-term followup of patients who received the posterior stabilized Columbus[®] total knee prosthesis.

We therefore determined (1) the incidences of dislocation and aseptic loosening after implantation of posterior stabilized Columbus[®] and Scorpio[®] posterior stabilized high-flexion prostheses, (2) factors associated with dislocation and aseptic femoral component loosening, and (3) the mechanisms of dislocation.

Patients and Methods

From May 2007 to July 2008, we performed 413 primary TKAs in 346 patients. All patients undergoing primary TKA with a diagnosis of osteoarthritis or secondary osteoarthritis were eligible for this study. For this study we excluded patients with sequelae of severe infection, fused knees, and severe instability of the knee preventing insertion of a posterior stabilized knee prosthesis. This study originally was designed as a prospective long-term survivorship comparison study for two different designs of posterior stabilized knee prostheses. Therefore, we alternately implanted two different posterior stabilized high-flexion knee prostheses during the study. One hundred seventy-two patients (202 knees) had TKAs with implantation of a posterior stabilized Scorpio[®] total knee prosthesis, and the other 174 patients (211 knees) had

TKAs with implantation of a posterior stabilized Columbus[®] total knee prosthesis. We used no other implant designs during the study period. Two-hundred ninety-two patients (350 knees) were women and 54 (63 knees) were men. The overall mean age of the patients at index surgery was 70.3 years (range, 51–83 years). Of the 346 patients, seven (eight knees) in Group I and four (five knees) in Group II died of illnesses unrelated to the arthroplasty. During the followup, seven patients (seven knees) in Group I and nine (nine knees) in Group II were lost to followup before 2 years, and therefore the latest followups were performed at a minimum of 24 months (mean, 26 months; range, 24–38 months) in 319 patients (Fig. 1). Institutional review board approval for the design and protocol of this retrospective study was received. We informed patients that their medical data might be used in a scientific study and all provided consent.

We compared patients in Groups I and II in terms of preoperative demographics: sex, age, BMI, diagnosis, preoperative and postoperative knee and function scores, preoperative varus angle, postoperative correct alignment, and preoperative and postoperative ROM. The percentage of men in Group I (29/158 patients; 18.4%) was greater ($p = 0.020$) than in Group II (17/161 patients; 10.6%), and the preoperative ROM for patients in Group I was worse ($p = 0.039$) than for patients in Group II. Otherwise, we found no obvious differences between the two groups in terms of preoperative demographics (Table 1).

The femoral component of the posterior stabilized Scorpio[®] knee prosthesis had a single AP and mediolateral

Fig. 1 The schematic shows subject involvement in the study.

Table 1. Comparison of demographic and clinical data between the groups

Variable	Group I (n = 158 patients, 187 knees)	Group II (n = 161 patients, 197 knees)	p value
Men: women	29:129	17:144	0.020
Age (years) [†]	70.2 ± 6.0	70.5 ± 4.3	0.551
Body mass index (kg/m ²)	24.8 ± 3.8	24.4 ± 2.8	0.187
Diagnosis			0.635
Osteoarthritis	141 (168)	143 (174)	
Secondary arthritis	17 (19)	18 (23)	
Preoperative Knee Society score (points)			
Knee score	45.0 ± 2.6	45.3 ± 12.8	0.985
Knee function score	40.1 ± 10.7	42.1 ± 17.9	0.188
Preoperative varus angle (°)	11.5 ± 6.7	11.4 ± 8.1	0.954
Preoperative range of motion (°)			
Total range of motion	124.5 ± 19.9	128.4 ± 16.2	0.039
Flexion contracture	4.6 ± 8.3	4.1 ± 6.6	0.528
Active maximal flexion	129.3 ± 14.9	132.6 ± 13.2	0.022
Postoperative Knee Society score (points)			
Knee score	91.1 ± 10.0	91.5 ± 8.6	0.985
Knee function score	79.0 ± 16.6	80.6 ± 14.7	0.188
Postoperative varus angle (°)	−0.4 ± 2.3	−1.3 ± 9.5	0.200
Postoperative alignment (AP) (°)			
Femoral flexion (α)	96.5 ± 1.8	96.3 ± 1.7	0.125
Tibial angle (β)	90.2 ± 1.8	90.5 ± 6.84	0.582
Postoperative alignment (lateral) (°)			
Femoral flexion (γ)	3.0 ± 1.7	2.9 ± 1.8	0.528
Tibial angle (σ)	1.4 ± 2.2	1.3 ± 1.9	0.457
Postoperative range of knee motion (°)			
Total range of motion	130.2 ± 14.2	131.8 ± 10.7	0.204
Flexion contracture	1.0 ± 3.7	1.0 ± 3.7	0.996
Active maximal flexion	131.2 ± 13.4	132.8 ± 9.0	0.161
Postoperative complications			< 0.001
Infection	1	0	
Dislocation	0	10	
Loosening	0	7	

femoral radius, a deepened patellofemoral groove which provided secure guidance of the patella, increased flexion, and reduced peak stresses throughout ROM. The surface roughness of the femoral component was produced by a microstructured porous coating process. The femoral component of the posterior stabilized Columbus® knee prosthesis had an anatomic lateral femoral condyle, deep trochlear groove, shorter posterior condyles, and a smooth femoral condylar curve, which also provided secure guidance for the patella, and increased flexion, and reduced peak stresses throughout ROM. The surface roughness of the femoral component was produced by sandblasting (Fig. 2).

We performed all operations using the standard medial parapatellar approach. The ACL and PCL were excised in all patients. After balancing the soft tissues, we used a gap technique to adjust the gap between extension and flexion. We replaced the patella with a polyethylene button cemented to the posterior surface of the patella. In cases with poor patellar tracking, lateral release was performed using the no thumb technique [21]. All implants were fixed using polymethylmethacrylate which penetrated the porous cancellous bony surfaces. Pulsatile lavage was used to remove blood, fat, and debris, and proper cleaning of the cancellous bone permitted uninhibited penetration of cement. The tibial component was fully cemented using the cement in a doughy

Fig. 2A–D Anterior views of the (A) Columbus[®] and (B) Scorpio[®] prostheses and axial views of the (C) Columbus[®] and (D) Scorpio[®] knee prostheses are shown.

state and pressurizing it digitally into the proximal tibia. For femoral fixation, cement was placed on the cut surface of the bone and only the inside of the posterior condyle of the component before it was impacted onto the prepared femur.

Patients performed a straight leg raising exercise the first day after surgery. Two hours of daily physical therapy consisting of isometric exercise, passive ROM, active assisted ROM, quadriceps and hamstring strengthening, and gait training under the supervision of a physiotherapist was initiated on the second day. Continued active motion during the knee exercise reached 90°. Patients were instructed to walk with the aid of two crutches for 6 weeks after surgery.

Patients underwent clinical and radiographic followups at 6 weeks, 3, 6, and 12 months, and every 6 months thereafter. Clinical evaluations were performed using Knee Society scores [12]. Radiographic analysis included a weightbearing AP view, nonweightbearing AP view, lateral view at 30° flexion, and skyline patellar view. We assessed all radiographs using the Knee Society radiographic scoring system to evaluate component alignment and radiolucencies around the component [12]. Thirty-one patients who did not attend regularly scheduled followups were contacted by telephone and/or direct contact, with the most recent contact made between 24 and 26 months postoperatively. The patients were questioned about pain, stair climbing, walking distance, and use of walking aids. Therefore, all patients had some followup. Complications were considered to be major if they required the patient to undergo reoperation owing to infection, dislocation, aseptic component loosening, or periprosthetic fracture. Minor complications included any problem related to the surgical wound that required oral antibiotics or increased outpatient surveillance.

We examined the state of the 10 retrieved polyethylene liners (nine Columbus[®] and one Scorpio[®] knee prostheses) by means of visual inspection. We sagittally sectioned both types of components for comparison to evaluate the reasons for dislocation of the Columbus[®] knee prosthesis.

We compared preoperative Knee Society knee scores with the latest followup scores using the paired t-test.

We compared the two study groups for age, sex, BMI, primary diagnosis, preoperative and postoperative Knee Society knee and function scores, preoperative and postoperative varus angles, postoperative correct alignment, postoperative major complications, and ROM. For subgroup analysis in Group II, we compared patients with an early complication with those who did not experience any complication, for age, sex, BMI, primary diagnosis, preoperative and postoperative Knee Society knee and function scores, preoperative and postoperative varus angles, postoperative correct alignment, and ROM. We examined differences between the two groups using chi-square or Fisher's exact test for categorical variables and the paired t-test or Mann-Whitney U test for continuous variables. All statistical analyses were performed using SPSS version 12.0 (SPSS, Chicago, IL, USA).

Results

Major complications (those requiring revision surgery) occurred in 15 women (16 knees) and one man (one knee) in Group II. These patients experienced 10 dislocations (10 patients) and seven aseptic femoral loosening (six patients). The mean age of these 16 patients was 70.7 years (range, 63–78 years). Dislocations occurred at a mean 7.4 months (range, 2–14 months) after index TKA and all 10 dislocations (10 patients) were treated by closed reduction and nonoperative management, however, seven patients experienced recurrent dislocations. In Group I, one infection occurred in one woman, but there were no dislocations and no aseptic loosening of the femoral component. Major complications were more common ($p < 0.001$) in patients in Group II than in patients in Group I.

We found no factors associated with dislocation or loosening. Specifically, we observed no differences in postoperative Knee Society knee ($p = 0.739$) or function scores ($p = 0.738$), total ROM ($p = 0.494$), flexion contracture ($p = 0.924$), active maximal flexion ($p = 0.440$), or postoperative varus angles ($p = 0.516$). Subgroup

analysis for Group II revealed no differences between patients with complications (dislocation and aseptic loosening) and those without (Table 2).

All 17 dislocations occurred during knee flexion during normal daily activities. Knee dislocations occurred during varus flexion or flexion rotation movements, that is, while

Table 2. Comparison of Group II subgroup analysis

Variable	Complication group (n = 17 complications, 16 patients)	Dislocation group (n = 10 complications, 10 patients)	Aseptic loosening group (n = 7 complications, 6 patients)	Noncomplication group (n = 180, 145 patients)	p value (1)	p value (2)	p value (3)	p value (4)
Men: women	1:15	0/10	1/5	16/129	1.000	0.604	0.514	0.529
Age (years) [†]	70.6 ± 4.9	72.5 ± 3.3	68.0 ± 6.0	70.5 ± 4.3	0.867	0.142	0.145	0.065
Body mass index (kg/m ²)	23.6 ± 3.8	23.5 ± 1.8	23.8 ± 3.2	24.4 ± 2.7	0.254	0.312	0.547	0.836
Diagnosis					1.000	0.252	0.182	0.154
Osteoarthritis	15	10	5	159				
Secondary arthritis	2	0	2	21				
Preoperative Knee Society score (points)								
Knee score	44.7 ± 14.9	48.0 ± 16.6	40.1 ± 11.6	45.0 ± 12.7	0.939	0.483	0.314	0.229
Knee function score	45.9 ± 25.5	50.5 ± 24.4	38.6 ± 27.3	41.5 ± 17.0	0.549	0.124	0.772	0.360
Preoperative varus angle (°)	16.1 ± 7.1	14.3 ± 6.3	17.4 ± 8.5	11.0 ± 6.6	0.002	0.045	0.013	0.566
Preoperative range of knee motion (°)								
Total range of motion	130 ± 10	131.0 ± 11.5	128.6 ± 8.0	128.2 ± 16.7	0.513	0.600	0.953	0.638
Flexion contracture	3.5 ± 6.8	3.0 ± 6.7	4.3 ± 7.3	4.2 ± 6.6	0.693	0.404	0.972	0.714
Active maximal flexion	133.6 ± 7.0	134.0 ± 9.1	132.9 ± 3.9	132.4 ± 13.7	0.734	0.136	0.953	0.760
Postoperative Knee Society score (points)								
Knee score	91.0 ± 9.5	89.7 ± 9.0	92.4 ± 11.2	91.5 ± 8.4	0.739	0.505	0.793	0.586
Knee function score	79.4 ± 15.2	76.0 ± 14.5	84.3 ± 17.2	80.7 ± 14.7	0.738	0.329	0.525	0.299
Postoperative varus angle (°)	0.2 ± 3.2	1.2 ± 3.9	0.4 ± 1.9	-1.4 ± 9.9	0.516	0.505	0.828	0.139
Postoperative alignment (AP) (°)								
Femoral flexion (α)	96.0 ± 1.9	95.0 ± 2.4	96.1 ± 2.1	96.2 ± 1.7	0.677	0.129	0.470	0.167
Tibial angle (β)	90.5 ± 2.2	90.5 ± 2.1	90.1 ± 2.3	90.5 ± 7.1	0.988	1.000	0.871	0.688
Postoperative alignment (lateral) (°)								
Femoral flexion (γ)	2.9 ± 1.5	3.0 ± 1.5	2.8 ± 1.6	2.9 ± 1.9	0.932	0.731	0.885	0.651
Tibial angle (σ)	1.3 ± 1.5	1.4 ± 1.8	1.2 ± 0.9	1.3 ± 1.9	0.867	0.975	0.837	0.837
Postoperative range of knee motion (°)								
Total range of motion	133.5 ± 11.4	133.5 ± 11.4	128.6 ± 15.5	131.7 ± 10.6	0.494	0.119	0.459	0.139
Flexion contracture	1.0 ± 3.6	0.0 ± 0.0	2.1 ± 5.6	1.0 ± 3.7	0.924	0.404	0.418	0.356
Active maximal flexion	134.4 ± 8.5	137.0 ± 6.3	130.7 ± 10.2	132.6 ± 9.1	0.440	0.136	0.585	0.136

Complication group = total number of patients with dislocation and aseptic loosening in Group II; p value (1) = comparison between complication group and noncomplication group; p value (2) = comparison between dislocation group and noncomplication group; p value (3) = comparison between aseptic loosening group and noncomplication group; p value (4) = comparison between dislocation group and aseptic loosening group.

Fig. 3 The position of the patient during dislocation is shown in this drawing. This position suggests that the mechanism of dislocation involved varus flexion or flexion rotation of the knee.

putting on stockings (two knees), sleeping (two knees), extension from flexion, and rising from a chair or the floor (six knees) and standing, and unknown (seven knees) (Fig. 3). Four of the 10 patients with dislocations underwent revision surgery. Original tibial components and femoral stems, which were well fixed were retained, and damaged tibial inserts were replaced with an ultra congruent type of insert (B. Braun Aesculap, Tuttlingen, Germany) (Table 3). Aseptic loosening of the femoral components occurred at a mean 16 months (range, 11–26 months) after index TKA and the seven knees with aseptic femoral loosening (six patients) underwent revision surgery. Radiographic evaluations before the revision surgery showed the aseptic loosening was isolated to the femoral component and was not associated with osteolysis. Radiolucent lines were observed beneath the anterior flanges of the femoral components in seven knees and posterior condyle in three knees. All seven femoral components were easily removed by hand from their cement mantles.

Table 3. Patients with dislocation of the knee after TKA

Patient number	Sex	Age (years)	Final range of motion (degrees)	Postoperative mechanical axis angle (normal range, $180^\circ \pm 3^\circ$)	Time of dislocation after surgery (months)	Position at dislocation	Type of revision surgery
1*	Female	74	130	182	13	Extension from flexion	Closed reduction
					19	Unknown	Ultra congruent type tibial insert change
2	Female	69	145	177	14	Sleeping in flexion position	Closed reduction
3*	Female	73	135	182	7	Flexion while putting on socks	Closed reduction
					29	Standing up from sitting on a chair	Ultra congruent type tibial insert change
4*	Female	74	130	188	12	Flexion to extension	Closed reduction
					22	Unknown	Ultra congruent type tibial insert change
5**	Female	74	140	179	2	Sleeping in flexion position	Closed reduction
					2	Unknown	Closed reduction
6**	Female	70	135	183	4	Rising from floor to standing position	Closed reduction
					4	Unknown	Closed reduction
7	Female	66	145	182	7	Extension from flexion while on floor	Closed reduction
8	Female	77	130	181	10	Trying to sit on the bed	Closed reduction
9	Female	72	135	176	2	Flexion while putting on socks	Closed reduction
					3	Unknown	Closed reduction
					3	Trying to flex to get into bed	Closed reduction
10*	Female	76	145	182	29	Unknown	Ultra congruent type tibial insert change

* For Patients 1, 3, 4, and 10, the tibial insert was revised using a more congruent type of tibial insert; ** for Patients 5 and 6, dislocation of the knee recurred within 2 weeks after closed reduction.

In five knees (four patients), femoral and tibial components were replaced with different prostheses for revision TKAs. Tibial components were retained in the other two knees (two patients) and femoral components were replaced with the same types of femoral component with a different type of tibial insert (ultra congruent type [B. Braun Aesculap]) (Table 4).

All four dislocated tibial inserts had a similar wear pattern. The posterior lip was severely worn (on one side of one insert and on both sides of three inserts) and notching was present on the anterior side of the post on all inserts (Fig. 4). We observed no backside tibial insert wear. In all seven patients with aseptic loosening, the tibial inserts showed visible pitting and burnishing on both sides, and severe wear on the posterior lip of the tibial insert was observed in two.

The femoral components removed from these seven knees showed the cement was attached only to the posterior condyle of the femoral component (Fig. 5). Compared with the Scorpio® design, the Columbus® knee prosthesis had a more anterodistal-positioned femoral component cam, smaller posterior radius, and more posteriorly positioned tibial post than the Scorpio knee prosthesis (Fig. 6).

Discussion

The reported incidence of dislocation after TKA ranges from 0% to 2.5% [7, 8, 10, 16, 22]; however, rates of 0.15% to 0.5% have been reported owing to designs with modified tibial polyethylene post heights and anterior

Table 4. Patients with aseptic femoral loosening after TKA

Patient number	Sex	Age (years)	Final range of motion (degrees)	Postoperative mechanical axis angle (normal range, $180^\circ \pm 3^\circ$)	Time of aseptic loosening after surgery (months)	Type of treatment
1	Female	66	130	180	11	Revision with new femoral and tibial components
2	Male	67	135	179	13	Revision with new femoral and tibial components
3	Female	75	130	180	12	Femoral component change and different type of tibial insert
4	Female	78	135	179	26	Femoral component change and different type of tibial insert
5	Female	65	135	177	14	Revision with new femoral and tibial components
6*	Female	64	130	180	17	Revision with new femoral and tibial components
		64	135	180	19	Revision with new femoral and tibial components

* Patient 6 had aseptic loosening in both knees after TKA.

Fig. 4A–C A 73-year-old woman experienced dislocation after undergoing TKA. (A) The lateral radiograph obtained 6 weeks after surgery is shown. (B) Another lateral radiograph shows the patient's dislocated knee. (C) The polyethylene liner removed during revision surgery has a severely worn posterior lip and notching at the anterior side of the post.

Fig. 5A–C A 75-year-old woman was diagnosed with aseptic loosening of the femoral component. **(A)** A lateral radiograph shows a radiolucent line beneath the anterior flanges of the femoral components and detachment between the cement and the femoral

component. **(B)** An intraoperative photograph shows the loosened femoral component is displaced and easily removed by hand, and **(C)** a photograph of the retrieved femoral component shows cement attachment to the posterior condyle alone.

Fig. 6A–B **(A)** A sagittal view of the Scorpio[®] prosthesis is shown. The apex of the cam (arrowhead) was oriented distally, and jump distance was relatively high in 90° flexion. **(B)** A sagittal view of the Columbus[®] prosthesis is shown. The apex of the cam (arrowhead) was oriented posteriorly, and jump distance was relatively low in 90° flexion.

translations [10, 16]. Nevertheless, early aseptic femoral loosening after primary TKA has been reported for high-flexion design prostheses [9, 11, 14]. We therefore determined (1) the incidence of dislocation and aseptic loosening after TKAs with implantation of posterior stabilized Columbus[®] and Scorpio[®] posterior stabilized high-flexion prostheses, (2) the causative factors of dislocation and aseptic femoral component loosening by comparing two prosthesis designs using retrieved analysis, and (3) the mechanisms of dislocation.

Our study had some limitations that warrant consideration. First, we prospectively alternately implanted two different posterior stabilized high-flexion knee prostheses. Although the sex and preoperative ROM differed in the

two groups, we believe these would not influence our key findings. Second, our data should be viewed as exploratory because they are based on descriptive data. A mechanical analysis study should be performed to confirm the reasons for femoral component dislocation and aseptic loosening.

The most important findings of our study were the high rates of dislocation (5.1%) and aseptic femoral loosening (3.6%) at a minimum of 24 months after surgery for the Columbus[®] posterior stabilized knee prosthesis (Table 5). The dislocations occurred during normal daily activities in patients who had received a posterior stabilized Columbus[®] prosthesis. At 90° flexion, the cam jump distance for the Columbus[®] prosthesis was too low to resist dislocation (Fig. 3). Although the design of the Columbus[®] knee

Table 5. Studies of the incidence of dislocation and aseptic loosening of femoral components after primary posterior stabilized TKA

Study	Type of prosthesis	Number of TKAs	Number of complications (%)
Dislocation			
Lombardi et al. [16]	IB-I	1978	4 (0.2)
	IB-II	398	10 (2.5)
	IB-II modified	656	1 (0.2)
Galinat et al. [7]	IB-I	832	2 (0.2)
Gidwani & Langkamer [8]	Kinemax		3
Current study	Columbus®	197	10 (5.1)
Aseptic loosening of femoral component			
Han et al. [9]	Nexgen® LPS-flex	72	27 (38)
Current study	Columbus®	197	7 (3.6)

IB = Insall-Burstein posterior stabilized condylar prosthesis (Zimmer, Warsaw, IN, USA); Kinemax (Howmedica Osteonics Corp, Mahway, NJ, USA); Nexgen® LPS-flex (Zimmer, Warsaw, IN, USA); Columbus® (B. Braun Aesculap, Tuttlingen, Germany).

prosthesis improved rollback during knee flexion, it might have been more susceptible to dislocation. Our findings agreed with those of Delp et al. [5], who performed a simulation study using a computer model of a posterior stabilized knee prosthesis, which was altered to analyze the effects of five design parameters: (1) tibial spine height, (2) spine AP position, (3) femoral component posterior radius, (4) femoral cam AP position, and (5) femoral cam distal-proximal position. They showed that modification of the cam-post in the posterior stabilized knee prosthesis involved a tradeoff between maximum knee flexion and prosthesis stability, and thus, dislocation. Modification of the cam (anterodistal position and decreased posterior radius) and a tibial post (posterior position) design provided a low jump distance during knee flexion in the Columbus® knee prosthesis, and probably makes it more susceptible to dislocation. Arnout et al. [2] reported four cases of dislocation associated with a posterior stabilized knee prosthesis, and suggested that the cause of dislocation was a low jump distance attributable to the relative position of the cam, post height, and a rounded post design. Other possible causes of dislocation in TKA are implant malposition, flexion-extension gap mismatch, excessive soft tissue release (usually in the presence of valgus deformity with extensive posterolateral release), extensor mechanism incompetence (ie, patellectomy), surgical error such as cementing technique, and inappropriate primary implant selection [4, 6, 19].

Aseptic femoral component loosening in a posterior stabilized knee prosthesis is considered relatively rare.

However, Han et al. [9] reported the incidence of loosening of the femoral component after implantation of a Legacy posterior stabilized flex prosthesis was 38% (27/72 knees) at a mean followup of 32 months. They supposed the reasons for this high rate of aseptic loosening of the femoral component were asymmetric loading on the medial and lateral aspects of the femoral component in deep knee flexion, high peak contact stress at the post-cam mechanism, and a cement-metal interface problem. In our patients with aseptic loosening, the retrieved femoral component had cement attachment only to the posterior condyle, which seems to be related to our cement technique. However, King and Scott [14] reported difficulty with cementing the posterior interface. They reported manual coating of this inverted, obscured surface was usually unsatisfactory, while filling the posterior flange with cement before press fitting the component affords only minimal cement penetration. Therefore, we consider our cement technique to be acceptable. In addition, King and Scott [14] suggested that early implant loosening and osteolysis of the distal femur were initiated by high shearing and tensile forces caused by compressive forces on the posterior condyle that possibly caused micromotion. We found the possible cause of aseptic femoral component loosening to be implant micromotion attributable to higher shearing and tensile forces caused by compressive forces on the posterior condyle [14]. In addition, shortness of the posterior condyle in the Columbus® prosthesis was one of the causal factors of septic loosening because small contact areas lead to increased contact force on the posterior tibia. Our findings were consistent with those of previous reports regarding aseptic loosening of the femoral component in posterior stabilized knee prostheses.

Based on questioning patients, we presumed the mechanism of dislocation during knee flexion involved varus flexion or flexion rotation movement. This concurs with interpretations of Lombardi et al. [16], who reported a dislocation rate of 0.5% (15/3032) using an Insall-Burstein posterior stabilized condylar prosthesis. They proposed that the mechanism of dislocation involved flexion and rotation in the Taylor position, instability of the prosthesis in flexion, and slight collateral ligament laxity, which allowed subluxation and impingement of the spine posterior to the cam. Sharkey et al. [22] reported seven patients who underwent TKAs and experienced posterior dislocations. They postulated that extensor weakness coupled with flexion instability was the predominant cause of dislocation. Arnout et al. [2] proposed that varus flexion movement was a possible mechanism of dislocation, but they also reported that three of four dislocated knees had a normal range of radiographically determined component alignment. We concur, as eight of our 10 dislocated knees had a normal radiographically determined postoperative mechanical axis angle.

Our patients experienced a high incidence of early complications, such as dislocation and aseptic femoral component loosening, after implantation of the posterior stabilized Columbus[®] prosthesis, and we have discontinued its use. Our observations suggest the cam and post design in posterior cruciate ligament-substitution type total knee prostheses is important to prevent dislocation.

Acknowledgments We thank Jae-Hoon Ha, Hyun-Soo Kim, and Chung-Woo Cheon, MD for their efforts in enrolling and interviewing patients for this study.

References

1. Akagi M, Nakamura T, Matsusue Y, Ueo T, Nishijyo K, Ohnishi E. The Bisurface total knee replacement: a unique design for flexion. Four-to-nine-year follow-up study. *J Bone Joint Surg Am*. 2000;82:1626–1633.
2. Arnout N, Vandenuecker H, Bellemans J. Posterior dislocation in total knee replacement: a price for deep flexion? *Knee Surg Sports Traumatol Arthrosc*. 2011;19:911–913.
3. Bourne MH, Rand JA, Ilstrup DM. Posterior cruciate condylar total knee arthroplasty: five-year results. *Clin Orthop Relat Res*. 1988;234:129–136.
4. Dawson-Bowling S, Tavakkolizadeh A, Cottam HL, Butler-Manuel PA. Multiple sclerosis and bilateral dislocations of total knee replacements: a case report. *Knee Surg Sports Traumatol Arthrosc*. 2008;16:148–151.
5. Delp SL, Kocmond JH, Stern SH. Tradeoffs between motion and stability in posterior substituting knee arthroplasty design. *J Biomech*. 1995;28:1155–1166.
6. Erceg M, Maricevic A. Recurrent posterior dislocation following primary posterior-stabilized total knee arthroplasty. *Croat Med J*. 2000;41:207–209.
7. Galinat BJ, Vernace JV, Booth RE Jr, Rothman RH. Dislocation of the posterior stabilized total knee arthroplasty: a report of two cases. *J Arthroplasty*. 1988;3:363–367.
8. Gidwani S, Langkamer VG. Recurrent dislocation of a posterior-stabilized prosthesis: a series of three cases. *Knee*. 2001;8:317–320.
9. Han HS, Kang SB, Yoon KS. High incidence of loosening of the femoral component in legacy posterior stabilised-flex total knee replacement. *J Bone Joint Surg Br*. 2007;89:1457–1461.
10. Hossain S, Ayeko C, Anwar M, Elsworth CF, McGee H. Dislocation of Insall-Burstein II modified total knee arthroplasty. *J Arthroplasty*. 2001;16:233–235.
11. Innocenti M, Civinini R, Carulli C, Matassi F, Villano M. The 5-year results of an oxidized zirconium femoral component for TKA. *Clin Orthop Relat Res*. 2010;468:1258–1263.
12. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res*. 1989;248:13–14.
13. Jacobs WC, Clement DJ, Wymenga AB. Retention versus sacrifice of the posterior cruciate ligament in total knee replacement for treatment of osteoarthritis and rheumatoid arthritis. *Cochrane Database Syst Rev*. 2005:CD004803.
14. King TV, Scott RD. Femoral component loosening in total knee arthroplasty. *Clin Orthop Relat Res*. 1985;194:285–290.
15. Lombardi AV Jr, Berend KR. Posterior cruciate ligament-retaining, posterior stabilized, and varus/valgus posterior stabilized constrained articulations in total knee arthroplasty. *Instr Course Lect*. 2006;55:419–427.
16. Lombardi AV Jr, Mallory TH, Vaughn BK, Krugel R, Honkala TK, Sorscher M, Kolczun M. Dislocation following primary posterior-stabilized total knee arthroplasty. *J Arthroplasty*. 1993;8:633–639.
17. Lombardi AV Jr, Nett MP, Scott WN, Clarke HD, Berend KR, O'Connor MI. Primary total knee arthroplasty. *J Bone Joint Surg Am*. 2009;91(suppl 5):52–55.
18. Nakayama K, Matsuda S, Miura H, Iwamoto Y, Higaki H, Otsuka K. Contact stress at the post-cam mechanism in posterior-stabilised total knee arthroplasty. *J Bone Joint Surg Br*. 2005;87:483–488.
19. Ng TP, Chiu KY. Recurrent dislocation of total knee arthroplasty: an unusual cause. *J Arthroplasty*. 2003;18:1067–1070.
20. Pereira DS, Jaffe FF, Ortiguera C. Posterior cruciate ligament-sparing versus posterior cruciate ligament-sacrificing arthroplasty. Functional results using the same prosthesis. *J Arthroplasty*. 1998;13:138–144.
21. Scott RD. Prosthetic replacement of the patellofemoral joint. *Orthop Clin North Am*. 1979;10:129–137.
22. Sharkey PF, Hozack WJ, Booth RE Jr, Balderston RA, Rothman RH. Posterior dislocation of total knee arthroplasty. *Clin Orthop Relat Res*. 1992;278:128–133.
23. van den Boom LG, Brouwer RW, van den Akker-Scheek I, Bulstra SK, van Raaij JJ. Retention of the posterior cruciate ligament versus the posterior stabilized design in total knee arthroplasty: a prospective randomized controlled clinical trial. *BMC Musculoskelet Disord*. 2009;10:119.
24. Yamazaki J, Ishigami S, Nagashima M, Yoshino S. Hy-Flex II total knee system and range of motion. *Arch Orthop Trauma Surg*. 2002;122:156–160.