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Polished, Collarless, Tapered, Cemented Stems for Primary Hip Arthroplasty May Exhibit High Rate of Periprosthetic Fracture at Short-Term Follow-Up

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ABSTRACT

Background: Cemented stems are designed to follow 1 of 2 principles of fixation: composite beams or slide taper. Stems in the latter category have a collarless, polished, tapered (CPT) design and subside into the cement mantle, creating hoop stresses. We compared the rate of periprosthetic fracture (PPF) of stem designed with these 2 principles of fixation. In addition, we examined radiographic factors that may predispose to the development of PPF.

Methods: We retrospectively reviewed all patients who underwent primary THA by a single surgeon using highly polished cemented stems. PPF rates were compared between CPT stems (follow-up, 21 months; standard deviation [SD], 22) and composite beam stems (follow-up, 21.7 months; SD, 26). Demographic data were compared between patients with and without a PPF. Three preoperative radiographic parameters (canal bone ratio [CBR], canal-calcar ratio, and canal flare index), stem alignment, and cement mantle were compared in match-paired patients with and without a PPF (1:34).

Results: Seven of 1460 THA patients developed a PPF (0.479%); 4 hips of 185 with a CPT stem (2.2%); and 3 of 1275 hips with a composite beam stem (0.23%; $P = .0064$). Three of the 4 PPFs in the CPT group and none in the composite beam group were classified as Vancouver B2. The CBR in patients with a PPF was 0.50 (SD, 0.07) and 0.43 (SD, 0.07) in the match cohort of hips without PPF ($P = .013$).

Conclusion: CPT stems may be associated with a higher risk of PPF that often require reoperation. An increased CBR may be a risk factor for postoperative PPF.

Total hip arthroplasty (THA) has been a remarkably successful surgery for the treatment of hip pain in the setting of degenerative changes. As a result, the number of THAs performed in the United States has been increasing and the indications have been expanded [1].

With the increase in utilization and surgical volume, there has been a concomitant rise in the number of revisions including those for periprosthetic fractures (PPF) [1].

Cemented femoral fixation has been traditionally associated with a lower PPF risk than cementless fixation [2,3]. Cemented stems are designed to follow 1 of 2 principles of fixation: those adhering to the "composite beam" principle are designed with geometry and/or surface finish that deters motion at the cement-bone interface. These stems are often collared. The stems adhering to the "loaded taper" or "shape-closed" principle are designed to subside into the cement mantle as acrylic creeps. These stems are collarless, tapered, and have a highly polished surface finish to minimize cement and metal abrasion with naturally occurring micromotion [2,4]. They are also known as collarless, polished, tapered (CPT) stems [4,5].

With the reduction in the use of cemented fixation in the United States, PPFs occurring in cemented stems are difficult to study. Demographic and morphologic risk factors for PPF in patients receiving cemented stems are not well elucidated [6–8]. However, data on independent risk factors for PPF in cemented stems are emerging and some investigators have reported a potential relationship with stem design [9,10].

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The purpose of this study is to compare the rate of PPFs in THAs performed by a single surgeon using highly polished stems that rely on 1 of the 2 philosophies of cement fixation, specifically the CPT design and a composite beam collared design. As a secondary goal, an attempt was made to identify preoperative radiographic characteristics that may predispose patients to develop PPF after cemented femoral fixation.

Materials and Methods

The study has been institutional review board approved. This study is a retrospective cohort review of prospectively collected data. All hybrid primary, elective THAs performed by the senior author (AGDV) using a cemented stem with a highly polished surface finish from January 2005 to September 2016 were considered for the study. This group represents 71% of primary elective THAs performed by the senior author during the study period. Four patients (4 hips) were excluded: 3 patients (3 hips) had a follow-up of less than 30 days and 1 patient died of congestive heart failure 29 days postoperatively. The remaining 1262 patients with 1460 THAs and with a minimum follow-up of 30 days were included in the study. A composite beam-type stem with a collar was used in 1275 THAs (VerSys Heritage; Zimmer, Warsaw, IN). A CPT stem was used in the remaining 185 THAs: CPCS (Smith and Nephew, Memphis, TN) in 143 hips, and Exeter (Stryker, Mahwah, NJ) in 42 hips. The senior author (AGDV) took an interest in CPT stems during the study period and implanted them intermittently with no strict selection criteria.

All surgeries were performed using a posterolateral approach [11]. Patients were allowed to bear weight as tolerated postoperatively.

Age at the time of surgery, gender, height, weight, body mass index (BMI), diagnosis, and follow-up were recorded for patients with CPT and composite beam stems. Age, BMI, diagnosis, and follow-up were similar in patients with CPT and composite beam stems. Female patients were over-represented in the composite beam group (Table 1). Patients in the CPT group were followed for an average of 21 months (range, 1 to 89; standard deviation [SD], 22). Patients in the composite beam group were followed for an average of 21.7 months (range, 1 to 135; SD, 25.9). No attempt was made to contact the patients to obtain additional follow-up. The number of patients followed for 3 or more years, 1 to 2 years, and less than a year was 49, 53, and 83, respectively, in the CPT group, and 308, 402, and 565, respectively, in the composite beam group.

The patients' institutional and office records and the surgeon's registry were reviewed to identify intraoperative or postoperative PPFs. Operatively and nonoperatively treated PPFs were analyzed. Fractures were grouped using the Vancouver classification based on analysis of radiographs, and the description in the operative note of fractures that occurred intraoperatively or that required subsequent surgery [12]. There was complete agreement between the senior author (AGDV) and the reviewer (AS, PW) as to the Vancouver classification. The cause and timing of PPFs and the type of treatment were recorded.

PPF rates were calculated for the entire cohort and for patients who received CPT and composite beam stems. Comparison in PPF rates between CPT and composite beam stems was performed.

In order to compare bone quality and the technical quality of the reconstruction between patients with and without PPF while controlling for the effects of known potential confounding variables, an analysis of preoperative radiographs and those obtained 6 weeks postoperatively was performed in a matched cohort analysis: every THA with PPF was matched with 34 THAs in patients without a fracture based on age ± 8 years, sex, BMI ± 9, preoperative diagnosis, and length of implantation ± 6 years. Preoperative radiographs calibrated for magnification were used to calculate 3 parameters indicative of proximal femoral morphology and bone quality [13,14] on the preoperative radiographs (Fig. 1). First, the canal bone ratio (CBR), which was calculated by dividing the endosteal diameter by the outer bone

Table 1
Demographic and Preoperative Characteristics in CPT and Composite Beam Stems.

Group	Stem Design	N	Age (y), Mean (SD)	Gender, F, M—N (%)	BMI, Mean (SD)	Follow-Up (mo), Mean (SD)	Diagnosis, N (%)	Laterality, N (%)
Composite beam	VerSys Heritage	1275	64.9 (12.0)	905 (71.0%) 370 (29.1%)	28.58 (6.36)	21.7 ± 25.9	OA 1155 (90.6%) RA 12 (0.9%) AVN 75 (5.9%) DDH 18 (1.4%) Fr nonunion 7 (0.5%) Other 8 (0.6%)	Right: 686 (53.8%) Left: 552 (43.3%) Bilateral: 37 (2.9%)
CPT	CPCS	143	66.1 (10.7)	83 (58.04%) 60 (41.9%)	28.6 (5.6)	20.26 ± 21.26	OA 137 (95.8%) RA 2 (1.3%) AVN 2 (1.3%) DDH 1 (0.6%) Fr nonunion 0 (0.0%) SCFE 1 (0.6%)	Right: 78 (54.5%) Left: 60 (41.9%) Bilateral: 5 (3.5%)
	Exeter	42	65.4 (12.3)	6 (13.9%) 36 (83.7%)	30.7 (5.2)	23.4 ± 24.07	OA 38 (88.4%) RA 0 (0.0%) AVN 2 (4.8%) DDH 1 (2.3%) Fr nonunion 1 (2.3%)	Right: 18 (42.9%) Left: 23 (54.8%) Bilateral: 1 (2.4%)
	Total	185	65.9 (11.3)	89 (48.1%) 96 (51.9%)	29.08 (5.59)	20.98 ± 21.97	OA 175 (94.6%) RA 2 (1.1%) AVN 4 (2.1%) DDH 2 (0.5%) Fr nonunion 1 (0.5%) SCFE 1 (0.5%)	Right: 96 (51.9%) Left: 83 (44.9%) Bilateral: 6 (3.2%)
P^*			.361	<.0001	.0194	.3954	.4122	.6528
P^{**}			.177	<.0001	.1258	.4192	.4668	.8755

CPT, collarless, polished, tapered; N, number of cases; SD, standard deviation; F, female; M, male; BMI, body mass index; OA, osteoarthritis; RA, rheumatoid arthritis; AVN, avascular necrosis; DDH, developmental dysplasia of the hip; Fr nonunion, fracture nonunion; SCFE, slipped capital femoral epiphysis.
P^*: P value compares all 3 groups using the omnibus test.
P^{**}: P value compares the composite beam group to the CPT group.