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Reduced Incidence of Intraoperative Femur Fracture With a Second-Generation Tapered Wedge Stem

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Background: Intraoperative fractures during total hip arthroplasty (THA) are more common when using cementless stems. The purpose of this study was to investigate the impact of a new shorter second-generation cementless, tapered wedge stem with improved proximal femoral fit in reducing the incidence of intraoperative fracture.

Methods: A retrospective study was conducted on primary THA cases performed at a single institution using a first-generation or second-generation cementless stem from 2006-2016. All intraoperative femur fractures were identified, as well as early 30-day postoperative periprosthetic femur fractures, which could represent nondisplaced intraoperative fractures that were initially missed. Risk for intraoperative femur fracture was analyzed using logistic regression, accounting for demographic covariates and surgeon.

Results: Of 6473 primary THA performed with a cementless, tapered wedge stem during the study period, 3126 used a first-generation stem and 3347 used a second-generation stem. The incidence of intraoperative fracture was 1.79% for first-generation stems and 0.24% for second-generation stems, representing a 7.5-fold reduction of risk for fracture. After accounting for covariates, the odds of intraoperative fracture were 0.33 using the second-generation stem relative to the first-generation stem ($P = .01$). However, there was no significant difference in the odds of early 30-day postoperative fractures using the second-generation stem (odds ratio 0.93, $P = .56$).

Conclusion: A new second-generation cementless stem resulted in a 7.5-fold decrease in the incidence of intraoperative femur fracture compared with the preceding stem.

Cementless, tapered wedge stems for total hip arthroplasty (THA) have grown in popularity, in large part, because of their relative ease and efficiency of implantation. However, intraoperative femur fractures are more common with cementless THA compared with cemented THA, occurring in 1%-4% of cases during broaching or final impaction, as surgeons attempt to obtain a tight press-fit [1–5]. In addition to cementless fixation, female gender, advanced age, and small stem size have all been found to be predisposing risk factors for intraoperative fractures [3,6].

Although satisfactory outcomes may be achieved by treating intraoperative fractures with cerclage wiring, fractures not identified and treated intraoperatively can later become displaced and present as early postoperative periprosthetic fractures [7]. It has also been suggested that as many as 40% of fractures may be missed by surgeons intraoperatively [8]. Furthermore, intraoperative fracture may have detrimental long-term implications on THA outcomes [4,6,9,10]. Thus, minimizing the risk for intraoperative fracture should be considered a best surgical practice.

Although first-generation cementless, tapered wedge stems demonstrated excellent midterm to long-term outcomes, they have also been associated with a higher rate of femur fracture [11–15]. However, shorter cementless stems with a reduced femoral geometry have been previously shown to decrease fracture risk [16,17]. Therefore, a specific second-generation tapered stem was designed to provide a medial curvature that was more size-specific based on 556 computed tomography scans taken from a diverse

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Table 1
Modifications for Second-Generation Tapered Stem [18–21].

- Size-specific medial curvature conforming to native geometry
- Improved proximal femoral fit and fill
- Larger proximal relative to distal stem size to reduce distal only engagement
- Shorter stem design without loss of initial stability
- Distal lateral relief to reduce stem insertion length

group of patients (Table 1) [18]. The result was an implant that more closely approximated femoral geometry, with improved implant fit and initial stability [18,19]. With enhanced proximal fixation, the stem length of the second-generation stem was shortened without compromising stability, and a lateral relief was implemented distally to ease stem insertion and potentially reduce the likelihood of fracture [20,21].

With regard to second-generation tapered femoral stems, the impact of the aforementioned design changes on the risk for intraoperative femur fracture has not been previously investigated. Therefore, the purpose of this study was to compare the incidence of intraoperative femur fracture between first-generation and second-generation cementless, tapered wedge stems, including fractures identified and addressed intraoperatively and fractures occurring in the early 30-day postoperative period that could represent nondisplaced intraoperative fractures that were not immediately identified.

Materials and Methods

A retrospective study was conducted on primary THA cases performed at a single institution from 2006-2016. Patients were identified as those who received either a first-generation (Accolade TMZF, Stryker Orthopaedics, Mahwah, NJ) or second-generation (Accolade II, Stryker Orthopaedics, Mahwah, NJ) cementless, proximally coated, double tapered wedge femoral stem. The second-generation stem is shorter than the first-generation stem and was designed using a large computed tomography database and bone measurement system to potentially have a better femur fit. Improved fit compared with the same first-generation stem used in this study was demonstrated in a previous radiographic study [19]. First-generation stems were implanted from 2006-2011, and second-generation stems were implanted from 2011-2016. Patients undergoing THA for hip fracture or conversion THA with removal of previously implanted hardware were excluded. All THAs were performed by 1 of 7 fellowship-trained arthroplasty surgeons using either a direct lateral (modified Hardinge) [22], direct anterior (modified Smith-Peterson) [23], or anterolateral (Watson-Jones) [24] approach from a supine position. The surgical approach was surgeon dependent. All cases were performed using cementless acetabular and femoral components, and the femur was prepared by reaming followed by step-wise broaching. Patients were permitted to weight bear as tolerated immediately after surgery.

Both intraoperative femur fractures and early postoperative periprosthetic femur fractures occurring within the first 30 days postoperatively were identified. All cases requiring intraoperative cerclage (Dall-Miles Cable System, Stryker Orthopaedics, Mahwah, NJ) or immediate conversion from a short, tapered wedge femoral stem to a long revision stem based on operating room utilization reports were reviewed to identify intraoperative femur fractures. Neither intraoperative cerclage cables nor long revision stems would typically be used in uncomplicated primary THA at our institution. All patients requiring early reoperation, revision THA and/or open reduction and internal fixation, or coded as having a diagnosis of periprosthetic fracture or mechanical failure (ICD-9/10 codes: 996.40, 996.43, 996.44, 996.47, T84.498A, T84.019A, T84.049A, T84.099A) within the first 30 days after primary THA were manually reviewed to identify early postoperative fractures.

Statistical Analysis

All bivariate analyses were performed using a Mann-Whitney *U* test for continuous variables and Fisher exact test for categorical variables. Risk for intraoperative femur fracture was analyzed using a logistic regression, accounting for demographic covariates (age, gender, body mass index [BMI], and Charlson comorbidity index) and surgeon. Regression analysis was not performed for early postoperative fractures because of the low number of such events. All analyses were performed using R Statistical Computing Environment version 3.3.2 (R Foundation, Vienna, Austria).

Results

Of 12,351 primary THAs performed during the study period, 6473 cases were identified that used a specific first-generation (n = 3126) or second-generation (n = 3347) femoral stem and met study inclusion criteria. Although patient demographics were similar between groups, there were statistically significant differences, as patients who received a second-generation stem were older and had lower BMIs (Table 2). There were also differences in perioperative characteristics. Patients with second-generation stems were more likely to undergo THA from a direct anterior approach and undergo simultaneous, bilateral THA compared with those receiving first-generation stems. In addition, both operative duration and length of hospitalization decreased for patients who received second-generation stems.

The incidence of intraoperative femur fracture was 1.79% (95% confidence interval [CI] 1.36%-2.32%; 56 of 3126 cases) for first-generation stems and 0.24% (95% CI 0.10%-0.47%; 8 of 3347 cases) for second-generation stems (Fig. 1). After accounting for covariates, the adjusted incidence of intraoperative fracture was 1.64% (95% CI 1.02%-2.50%) for first-generation stems and 0.53% (95% CI 0.22%-1.09%) for second-generation stems (Table 3). The odds of intraoperative femur fracture were considerably lower using the second-generation stem, both unadjusted (odds ratio [OR] 0.13; 95% CI 0.05-0.28; $P < .0001$) and after accounting for covariates (OR 0.33; 95% CI 0.13-0.71; $P = .01$). In addition to the second-generation stem, male gender (OR 0.45; 95% CI 0.26-0.76) and younger age (OR 0.68; 95% CI 0.55-0.83) significantly reduced the risk for intraoperative fracture (Table 4). The risk of fracture by surgeon varied from an OR of 0.10-2.70 relative to the median fracture rate among surgeons (Fig. 2). The relative decrease in the incidence of intraoperative fracture using the second-generation stem compared with the first-generation stem was similar for both men (adjusted; 1.05% vs 0.34%,

Table 2
Comparison of Baseline Patient Demographics and Perioperative Characteristics.

Variable	First Generation (n = 3126)	Second Generation (n = 3347)	*P* Value
Age, y	62.6 (12.4)	63.5 (10.6)	.01[a]
Male gender, %	47.6%	49.7%	.08
BMI, kg/m^2	28.5 (5.6)	28.0 (4.6)	.04[a]
CCI	0.31 (0.79)	0.31 (0.79)	.65
Simultaneous, bilateral, %	10.4%	17.6%	<.0001[a]
Operative time, min	69.6 (30.8)	64.4 (34.5)	<.0001[a]
DA approach, %	21.6%	64.6%	<.0001[a]
LOS, d	3.2 (2.3)	1.4 (1.2)	<.0001[a]

Continuous variables reported as mean (standard deviation).
BMI, body mass index; CCI, Charlson comorbidity index; DA, direct anterior; LOS, length of hospital stay.
[a] Statistically significant.