Clinical Comparison of THA With a Standard-length or Short Femoral Component

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abstract

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The purposes of this 2-part study were to determine whether reduced distal femoral component geometry allows for routinely larger component sizes to be used and whether clinical or radiographic outcomes differ between total hip arthroplasty (THA) patients treated with either standard-length or short femoral components. Femoral component size and ongrowth surface area were retrospectively compared in a group of bilateral THA patients that had both a standard-length component and a contralateral short component. Then, clinical and radiographic outcomes were compared between matched groups of THA patients that had either a standard-length or short femoral component. The use of the short component resulted in a significantly larger femoral component size being used ($P=.01$), and the potential ongrowth surface area was significantly larger for the short component than for the standard component (median, 36.69 vs 35.55 cm$^2$; $P=.02$). In the matched-pairs analysis, no group differences were noted in modified Harris Hip Scores ($P=.43$) or femoral component subsidence ($P=.35$), but there was a significantly greater prevalence of radiolucent lines in Gruen zone B with the short component ($P=.008$). The use of a short femoral component was associated with consistently larger component sizes being used, which corresponded with a larger potential ongrowth surface area. Short-term clinical and radiographic outcomes did not differ between standard-length and short femoral components. Studies are necessary to determine whether the increased proximal ongrowth surface area may result in improved long-term fixation or, on the contrary, may increase the risk of periprosthetic fracture.

Figure: Anteroposterior radiographs showing a Vancouver type B2 periprosthetic fracture 8 days after primary total hip arthroplasty with a short femoral component (A) and femoral revision with a modular long-stem femoral component with cerclage (B).
Short femoral components are becoming increasingly popular due to a perception of improved ease of implantation with minimally invasive surgical approaches, such as the direct anterior approach. Theoretically, by not contacting the proximal diaphyseal cortices, a short femoral component may allow for a larger component size to be used, potentially increasing proximal fit and fill. In the authors’ experience, this effect has been even more pronounced in patients with a champagne flute femur (Dorr type A). Depending on the implant design, this may then result in a larger potential surface area for bony ongrowth as well as a reduced risk of stress shielding when compared with a standard-length femoral component.1-4 Greater proximal fit and fill and improved metaphyseal fixation have been theorized to result in improved long-term survivorship4-5; however, there may also be a risk of increased subsidence with a short femoral component if metaphyseal fixation is not successfully achieved.6

The purposes of this 2-part retrospective study were to (1) determine whether the size and associated potential ongrowth surface area differed between patients treated with a standard-length femoral component on 1 side and a short component on the contralateral side, and (2) compare early radiographic and clinical outcomes between matched groups of patients treated with either a standard-length or short femoral component. The authors hypothesized that the use of the short component would result in a significantly larger femoral component being implanted (thus a larger potential ongrowth surface area) and that the use of the short component would result in similar clinical and radiographic outcomes over the first postoperative year when compared with a standard-length component.

Materials and Methods

All radiographic and clinical data were collected as part of the authors’ institutional review board–approved outcomes registry, and all procedures were performed by a single board-certified, fellowship-trained orthopedic surgeon (C.P.C.).

Size Comparison

Between June 2007 and October 2012, twenty-three patients (13 women and 10 men; mean age, 61.5±15.0 years; mean body mass index [BMI], 28.7±5.6 kg/m²) underwent staged bilateral cementless total hip arthroplasty (THA). For all patients, the first THA was performed with a standard-length, wedge-shaped femoral component (Taperloc and Taperloc Reduced Distal; Biomet, Warsaw, Indiana), and the more recent contralateral THA was performed with a short version of the same component reduced 35 mm distally (Taperloc Microplasty; Biomet) (Figure 1). The size of the femoral component was recorded at the time of surgery for each patient. The manufacturer provided the surface area of the implant that was porous coated for each size of femoral component, which was then used as an estimate of the potential bony ongrowth surface area.

Matched Pairs Comparison of Clinical and Radiographic Outcomes

To determine an appropriate sample size, an a priori power analysis was performed. With an alpha level of 0.05 and an estimated pooled standard deviation of 1.24 mm,7 a sample size of 50 THA per group (100 total THA) would be 80% powered to detect mean group differences in femoral component subsidence greater than 0.6 mm. Fifty consecutive THA performed with a short femoral component with a minimum 1-year follow-up were identified from a prospective outcomes database. A similar group of 50 THA performed with a standard-length femoral component was then identified. Patients were matched by sex, age (±2.5 years), and BMI (±2 kg/m²) to control for age and sex-related differences in the shape of the proximal femur.8-10 Each patient with a short component was matched with the most recent patient with a standard-length component who met all matching criteria. The canal flare index, which is a method to quantify proximal femoral geometry, was also calculated using each patient’s preoperative anteroposterior (AP) radiograph to ensure that the 2 groups were appropriately matched. The canal flare index is the ratio of the intracortical width of the femur 20 mm proximal to the most medial point on the lesser trochanter to intracortical width at the isthmus.8 All canal flare index measurements were made by a single evaluator (C.A.J.), and all radiographs were collected with a computed radiography system (Centricity PACS-IW version 3.7.3.7; GE Healthcare, Waukesha, Wisconsin).

Modified Harris Hip Scores collected at each patient’s 1-year follow-up visit were used for comparison. The size and location of radiolucent lines were recorded from supine AP and lateral digital radiographs by the senior author (C.P.C.), and radiolucent lines were considered to be present if they were larger than 1.0 mm and occupied more than 50% of the interface in each of the Gruen zones.11 Femoral component subsidence occurring between each patient’s 6-week and 1-year postoperative follow-up were recorded using a previously published technique.7 The distance between the most proximal point of the greater trochanter and the lateral

Figure 1: Anteroposterior radiograph of a patient with standard-length and contralateral short cementless femoral components.
The shoulder of the femoral component were recorded from each patient’s supine AP digital radiograph at 6-week and 1-year follow-up, and the change in distance between these 2 time points was defined as femoral component subsidence. All subsidence measurements were performed by a single evaluator using TraumaCad digital templating and measurement software (Voyant Health, Petach-Tikva, Israel).

Anteroposterior radiographs were calibrated for measurement using the femoral head of the involved THA, and measurements were taken with each image magnified 200%.

**Statistical Analyses**

For part 1 of the study, the implanted sizes and ongrowth surface areas were compared between the standard-length and short femoral components using the Wilcoxon signed rank test. For part 2, patient age, BMI, canal flare index, femoral component subsidence, modified Harris Hip Scores, and pain and function scores were compared using the independent t test. The prevalence of radiolucent lines and/or osteolytic lesions was compared between the 2 groups using Fisher’s exact tests. For all analyses, a P value less than .05 was considered statistically significant. All analyses were performed with SPSS version 20 statistical software (IBM, Armonk, New York).

**RESULTS**

**Size Comparison**

Overall, the use of the short femoral component resulted in a significantly larger size of femoral component being used (P=.01). Median component size was 10 (range, 6-18) for the short components and 9 (range, 6-16) for the standard-length components (Figure 2). As such, the potential ongrowth surface area was significantly larger (P=.02) for the short component (median, 36.69 cm² [range, 30.73-48.17 cm²]) compared with the standard-length component (median, 35.55 cm² [range, 30.73-51.06 cm²]).

**Matched Pairs Comparison of Clinical and Radiographic Outcomes**

The authors’ matching process was successful because the 2 groups did not differ in sex, age, BMI, or canal flare index (Table 1). Standard-length components were placed via a posterior approach in 48 hips and via a direct anterior approach in 2 hips. Conversely, 46 of the short components were placed via a direct anterior approach and 4 via a posterior approach. At a mean 1.3-year follow-up (range, 0.8-5 years), no group differences were noted in modified Harris Hip Scores (P=.43), pain scores (P=.34), or femoral component subsidence (P=.35); however, patients in the short component group had significantly greater function scores (P=.004) (Table 2). A significantly greater prevalence of radio-

<table>
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<th>Short</th>
<th>P</th>
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<td>44 (20/24)</td>
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<td>&gt;.99</td>
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<td>.89</td>
</tr>
<tr>
<td>Mean canal flare index</td>
<td>4.3±0.8</td>
<td>4.5±0.8</td>
<td>.16</td>
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</table>

Abbreviations: BMI, body mass index; THA, total hip arthroplasty.
lucent lines existed in Gruen zone 8 with the short component (10/50; 20%) than with the standard-length component (1/50; 2%) \((P=.008)\). No other statistical differences were noted in the other Gruen zones \((P>.23)\) (Table 3). To date, no patient in the short component group has required reoperation, but 1 patient (1 THA) treated with a standard-length component was revised at 21 months for aseptic femoral loosening.

### Discussion

The purposes of this retrospective study were to (1) determine whether the size and associated potential ongrowth surface area differed between patients who received a standard-length femoral component on 1 side and a short component on the contralateral side, and (2) compare early radiographic and clinical outcomes between matched groups of patients treated with either a standard-length or short femoral component. The hypotheses that the use of the short component would result in a significantly larger femoral component being implanted and that the use of the short component would result in similar clinical and radiographic outcomes over the first postoperative year were supported by the study results.

This study’s results were similar to other recent studies evaluating clinical outcomes and implant position of short femoral components. In a recent randomized trial using radiostereometric analysis, McCalden et al\(^\text{12}\) reported no differences in subsidence between short and standard-length femoral components, as well as no differences in Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores, Short Form (SF)-12 scores, or Harris Hip Scores.\(^\text{12}\) Rohrl et al\(^\text{3}\) also reported small amounts of subsidence of a short component when evaluating implant migration with radiostereometric analysis, and Schmidutz at al\(^\text{13}\) reported 0.7 mm of subsidence with a short component at 2.7 years using Ein Bild Roentgen Analyse femoral component analysis (EBRA-FCA). Furthermore, the subsidence results of the short (0.2 mm) and standard-length (0.3 mm) components in the current study were similar to those previously reported between 6 weeks and 1 year for standard-length tapered cementless femoral components (0.5 and 0.6 mm, respectively).\(^\text{7,14}\)

Significantly greater function scores were demonstrated in the short femoral component group than in the standard-length group. However, these results are more likely due to differences in the surgical approach than the length of the femoral component. The vast majority of procedures (46 of 50 THA) in the short component group were performed with a direct anterior surgical approach compared with 48 of 50 THA in the standard-length group performed via a posterior approach. In a randomized study, Mayr et al\(^\text{15}\) reported significant improvement in a larger number of gait parameters with a direct anterior approach than a posterior approach during the first postoperative year. On the contrary, Maffiuletti et al\(^\text{16}\) reported no differences in gait parameters, SF-12 scores, and WOMAC pain and function scores between patients treated with either a direct anterior or posterior approach, but they noted significantly better WOMAC stiffness scores for patients treated with an anterior approach \((P<.05)\).

A significantly greater prevalence of radiolucent lines was noted in Gruen zone 8 (lateral to the proximal aspect of the
implant on lateral radiographs) (Figure 3) of the THA performed with short components (20%) than with standard-length components (2%) (P = .008). As with the group differences in function scores, this may be related more to surgical approach than implant design. The authors suspect that these radiolucencies are due to subtle rotational bone loss that may have occurred during femoral preparation with the direct anterior approach because the surgeon’s eye is not in direct line with the femoral shaft as with the posterior approach. However, the long-term implications of these lucencies are not yet understood.

The potential benefits of using a short femoral component include the opportunity for greater proximal fit and fill and improved metaphyseal fixation.4,5 This may then result in a larger potential surface area for bony ongrowth as well as a reduced risk of stress shielding when compared with a standard-length femoral component.1-4 On the contrary, there are potential negatives associated with oversizing the proximal femur. The ability to upsize the femoral component with the use of a short stem may result in less proximal femoral bone stock present at the time of revision. Furthermore, oversizing the femoral component may increase the risk of a periprosthetic fracture.

To date, short femoral components have been used in 384 primary THA in the authors’ institution. Following completion of the current study, 3 (0.8%) of 384 THA placed via a direct anterior approach sustained Vancouver type B217,18 periprosthetic fractures. The patients included 2 women (aged 73 and 82 years, with a BMI of 38 and 27 kg/m², respectively) and 1 man (aged 74 years, with a BMI of 31 kg/m²). All 3 fractures occurred with uncontrolled weight bearing with the hip in a flexed position, with the women sustaining fractures on postoperative days 4 and 8, respectively, and the man on postoperative day 26. The 2 women both slipped, catching themselves with their operative limbs, and both described feeling a pop. The man fell after stumbling over a step. The fracture patterns were similar in these cases, with an avulsion of the medial aspect of the femur from the lesser trochanter to approximately 25 to 40 mm distal to the lesser trochanter (Figure 4A). All 3 patients were revised with a modular long-stem component with cerclage (Figure 4B). It is unclear whether the increased lucencies in Gruen zone 8 and/or the fracture pattern may be related to the short femoral component design or potential differences arising from the use of the direct anterior approach. As such, the authors have begun work on a prospective, randomized study comparing short and standard-length femoral components when placed via a direct anterior approach.

The current study had some limitations, including the limitations inherent to all retrospective designs and a short duration of follow-up. Furthermore, due to a lack of previously published data related to potential increases in size with short vs standard-length components, the authors were unable to perform an a priori power analysis for part 1 of this study. However, the significant differences demonstrate that the study was adequately powered. Ideally, both parts of this retrospective study would have been conducted with a single group of patients. However, the authors did not have adequate follow-up on a large enough sample of patients who had been treated with a standard-length component and a contralateral short component to perform a well-powered comparison of clinical and radiographic outcomes. As such, they chose to use groups matched by sex, age, and BMI for that analysis. Unfortunately, differences in surgical approach were unable to be controlled in this study because the use of the short femoral component most often corresponded with the use of the direct anterior approach, whereas the standard-length components were most often placed via a posterior approach. The routine subsidence measurements were made on computed radiography images as part of a prospective outcomes registry, whereas a more advanced imaging technique such as radiostereo-
metric analysis would have been the most accurate technique for that evaluation. In addition, the use of dual-energy x-ray absorptiometry (DEXA) scans may have allowed direct measures of proximal bony ongrowth instead of using femoral component subsidence as a surrogate to verify proximal fixation. However, because data collection for this study was part of a prospective outcomes registry, routine DEXA scans were not feasible.

**Conclusion**

Short-term clinical and radiographic outcomes do not appear to differ between standard-length and short tapered cementless femoral components. The use of a short femoral component consistently resulted in the ability to place a larger-sized component, and long-term follow-up is necessary to determine whether the greater proximal fit and fill with the short component improves long-term results. On the other hand, some concern exists that short femoral stem consistently results in the ability to place a larger-sized component subsidence instead of using femoral component subsidence as a surrogate to verify proximal fixation. However, because data collection for this study was part of a prospective outcomes registry, routine DEXA scans were not feasible.

**References**


