Long-term Results and Bone Remodeling After THA With a Short, Metaphyseal-fitting Anatomic Cementless Stem

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Abstract

Background Long-term results of standard total hip arthroplasty (THA) in young patients were not optimal. There are a number of reported disadvantages to longer cementless stems in THA including thigh pain and proximal stress shielding. However, it is unknown whether a short, metaphyseal-fitting anatomic stem without diaphyseal fixation, which represents a possible alternative, will maintain fixation over the longer term.

Question/purposes We therefore evaluated long-term (1) clinical results using validated scoring instruments; (2) osseointegration and bone remodeling; (3) complications; and (4) rates of revision and osteolysis in patients younger than 65 years who underwent THA with a short, metaphyseal-fitting anatomic cementless stem.

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Methods We reviewed 500 patients (630 hips) younger than 65 years (mean age at surgery, 52.7 years) who underwent THA with the Immediate Postoperative Stability stem (IPS; DePuy, Leeds, UK) by one surgeon (Y-HK) from January 1995 to March 2002. Demographic data, Harris hip score, WOMAC score, UCLA activity score, and radiographic data were recorded. All patients underwent dual-energy x-ray absorptiometry scanning of the acetabulum and proximal femur at 2 weeks after the operation and at final followup to determine stress shielding. Thigh pain was specifically investigated and scored by patients on a visual analog scale. Other complications were recorded. We determined component survival rates at 15 years using revision and aseptic loosening as end points. Minimum followup was 11 years (mean, 15.8 years; range, 11–18 years).

Results The clinical and functional results improved significantly for the Harris hip score, WOMAC, and UCLA activity scores ($p < 0.001$). At latest followup, mean Harris hip, WOMAC, and UCLA activity scores were 94 (range, 71–100), 15 (range, 5–29), and 7.9 (range, 6–9) points, respectively. All hips had osseous integration of the acetabular and femoral components. No patients had thigh pain. Four hips (0.6%) had deep infection and four (0.6%) had a recurrent dislocation. No patients had Grade 3 stress shielding. Fifteen-year survival rates were 98.7% (95% confidence interval [CI], 0.95–1.00) for the acetabular component and 99.4% (95% CI, 0.97–1.00) for the femoral component with revision as the end point and 100% (95% CI, 0.98–1.00) for both components with aseptic loosening as the end point.

Conclusions The short, metaphyseal-fitting anatomic cementless femoral stem provided stable fixation without relying on diaphyseal fixation in younger patients, suggesting metaphyseal fitting alone is sufficient in young

patients who have good bone quality. Because we observed no thigh pain and little stress shielding in our patients, modifying the distal stem design as is done with this implant might be advantageous, but this would need to be determined in future comparative studies.

Level of Evidence Level IV, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Although excellent long-term results have been reported with standard cementless femoral stems in THA [2, 10, 12, 14, 37], proximal stress shielding, thigh pain, polyethylene wear, and osteolysis are the remaining concerns [12, 14, 25]. Considering most cementless implants are used in young patients, it would be advantageous to preserve bone stock and reduce thigh pain and osteolysis when possible. Conservative metaphyseal-fitting anatomic cementless femoral implants with an alternative bearing surface such as an alumina-on-alumina bearing fulfill this requirement. Metaphyseal-engaging short stems provide theoretical benefits compared with conventional cementless stems, including avoiding proximal-distal mismatch, decreasing proximal stress shielding, and limiting perioperative fractures. Several studies show short-stem designs provide short-term fixation [32, 34, 38, 39]. Since 1995, we have investigated the option of a short, metaphyseal-fitting anatomic cementless femoral component. The intention was to reproduce natural load transfer with a short stem while obtaining optimal stability using the morphology of the proximal femur. In this design of the stem, vertical stability was provided by the wedge shape of the prosthesis with the addition of a lateral flare. This increases the load on the proximal femur, medially and laterally, and decreases load transmission to the femoral diaphysis. The transition zone between the loadbearing and nonloadbearing section of the stem is short, avoiding metal-to-bone contact below the metaphysis. The polished distal stem is short and narrow and placed centrally in the femoral canal to avoid distal contact with the femur. The proximal 30% of the stem is porous-coated with sintered titanium beads with a mean pore size of 250 μm to which a hydroxyapatite coating is applied to a thickness of 30 μm . There are nine available sizes, and there are left- and right-sided stems to reflect the asymmetry of the proximal femur (Fig. 1). Although the design rationale of this stem seems sound, to our knowledge, it has not been evaluated clinically in patients who received this implant more than a decade ago. We have previously published our results at 5.6 and 8.8 years, respectively, using this stem in the same cohort of patients [18, 19]; the current series is a followup of the

Fig. 1 A photograph shows the short, metaphyseal-fitting anatomic cementless femoral component with a polished and tapered stem. It has a pronounced lateral flare.

same group at a minimum of 11 years (mean, 15.8 years) to determine longer-term clinical results. We therefore evaluated longer-term (1) clinical results using validated scoring instruments; (2) osseointegration and bone remodeling using plain radiographs; (3) complications; and (4) rates of revision and osteolysis in patients younger than 65 years at minimum 11 years after undergoing THA with a short, metaphyseal-fitting anatomic cementless stem.

Patients and Methods

From January 1995 to March 2002, the senior author (Y-HK) performed 641 primary THAs using a short, metaphyseal-fitting anatomic cementless femoral stem in 509 patients 65 years of age or younger; 132 patients had bilateral THAs under the same anesthetic. This short, metaphyseal-fitting anatomic cementless femoral stem was used in every THA in our institution during the study period. Patients were excluded from the study if they were older than 66 years or had a followup of less than 10 years from the date of operation. Two patients died and seven patients were lost to followup in the interim, meaning that 500 patients (630 hips, 98% of patients) were available for clinical and radiographic evaluation at a mean of 15.8 years (range, 11–18 years).

During the same period, the senior author (Y-HK) performed 30 THAs (25 patients) using other implants in patients 65 years of age or younger; the study group of 509 patients therefore represented 95% of the senior author's THA practice in younger patients. During that period, the general indications for this stem were any patients except those with high dislocation of the femoral head according to developmental dysplastic of the hip, severe osteoporosis, and intertrochanteric fracture of the femur.

The study was approved by the institutional review board, and all patients provided informed consent.

The mean age of the patients at the time of the index arthroplasties was 52.7 years (range, 20–63 years). There were 314 men and 186 women. The mean weight of the patients was 79.2 kg (range, 59–120 kg) and their mean height was 165.9 cm (range, 151–185 cm). The mean body mass index was 28.8 kg/m² (range, 25.7–35.3 kg/m²). The diagnosis was osteonecrosis of the femoral head in 262 patients (52%), osteoarthritis in 160 (32%), osteoarthritis secondary to developmental dysplastic hip in 26 (5%), osteoarthritis secondary to childhood septic arthritis in 25 (5%), ankylosing spondylitis in 16 (3%), traumatic arthritis in 10 (2%), and multiple epiphyseal dysplasia in one (0.2%). All hips with osteonecrosis of the femoral head had Ficat and Arlet Stage III or IV changes [13]. The presumed cause of osteonecrosis was ethanol-associated in 160 patients (61%), idiopathic in 76 (29%), and steroid use in 26 (10%) (Table 1).

The morphology of the proximal femur was Dorr [9] Type A in 510 hips (81%), Type B in 44 hips (7%), and Type C in 76 hips (12%).

All procedures were performed by the senior author through a posterolateral approach. The index operation was performed under epidural anesthesia in 364 patients and general anesthesia in the remaining 136 patients. A cementless Duraloc[®] acetabular component (DePuy Orthopaedics, Inc, Warsaw, IN, USA) was used in all hips. These components were press-fitted after the acetabulum had been underreamed by 2 mm. One or two screws were used for additional fixation in 55 hips (11%); the remainder did not require any screw fixation. A 28-mm alumina ceramic liner (BIOLOX[®]-forte; CeramTec, Plochingen, Germany) was used in all hips regardless of the size of the acetabular component, which ranged from 48 mm to 62 mm. We aimed to fix the acetabular component between 40° and 45° inclination and between 20° and 30° of anteversion.

All patients received an IPS anatomic cementless femoral component with a 28-mm alumina ceramic femoral head (BIOLOX[®]-forte). The femoral component was inserted with a press-fit technique. The proximal femur was prepared with broaches; reamers were never used. The size of the femoral component that matched the size of the

Table 1. Demographic data of patients

Demographic	Number
Number of patients (hips)	500 (630)
Male:female	314:186
Mean age (years)	52.7 (20–63)
Mean weight (kg)	79.2 (59–120)
Mean height (cm)	165.9 (151–185)
Mean body mass index (kg/m ²)	28.8 (25.7–35.3)
Diagnosis (patients)	
Osteonecrosis (Ficat and Arlet Stage III or IV)	262 (52%)
Ethanol-associated	110 (61%)
Idiopathic	76 (29%)
Steroid use	26 (10%)
Osteoarthritis	160 (32%)
Osteoarthritis secondary to developmental dysplastic hip	26 (5%)
Osteoarthritis secondary to childhood septic arthritis	25 (5%)
Ankylosing spondylitis	16 (3%)
Traumatic arthritis	10 (2%)
Multiple epiphyseal dysplasia	1 (0.2%)
Duration of followup (years)	15.8 (11–18)

Ranges or percentages in parentheses.

largest broach used was selected. The size of the femoral component was selected not by a canal fit and fill, but by the torsional stability of the stem dictated by bone quality. The dimension of the real component was 0.5 mm larger than that of the prepared metaphysis. In approximately 94% of cases, the femoral distal stem did not contact the endosteum of the femur because the femoral stem was inserted in a neutral position. In the remaining 6% of cases, the femoral distal stem slightly contacted the medial or lateral endosteum because of varus or valgus implantation of the stem.

The patients were allowed to stand on the second post-operative day and progress to full weightbearing with crutches as tolerated. They were advised to use a pair of crutches for 6 weeks and walk with a cane thereafter if required. All patients were able to stop using the cane in 3 months.

Clinical and radiographic followup was undertaken at 3 months, 1 year, and yearly thereafter. The Harris hip score [16] and the WOMAC score [3] were determined before surgery and at each followup examination. Patients scored thigh pain on a 0- to 10-point visual analog scale (0 = no pain, 10 = severe pain). The level of activity of the patients after THA was assessed using the UCLA activity score [44]. We defined a limp as mild if patients moved their trunk and head 5 cm over the affected hip, moderate if they moved 5 to 10 cm, and severe if they

moved more than 10 cm before the stance phase of gait. Lateral displacement of the patient's head while walking was measured in centimeters for grading purposes from a photograph with a scale marker. The occurrence of any clicking or squeaking sound emanating from the ceramic-on-ceramic bearing was recorded. Patients were asked at each visit whether they experienced squeaking. Also, squeaking was evaluated during ambulation by the surgeon at the followup visit.

The radiographs were analyzed by a research associate (S-ML) who had no knowledge of the patient's identity. A supine AP radiograph of the pelvis with both hips in neutral rotation and no abduction was taken for every patient. A cross-table lateral radiograph was also made of each hip. Anteversion and inclination of the acetabular component was measured as done previously [28]. Definite loosening of the femoral component was defined when there was a progressive axial subsidence of more than 3 mm or a varus or a valgus shift of more than 3° [25]. Subsidence of the femoral component was measured as done previously [25]. The intraobserver error for this measurement was determined by the intraclass correlation coefficient after repeated measurement three times at intervals of 3 days. This was 0.94 (95% confidence interval [CI], 0.93–1.0), indicating excellent reproducibility.

Bone ingrowth into the femoral component was considered to have occurred when there was direct contact between the trabecular bone of the femur and the femoral component. Sites of any osteolysis in the acetabulum were recorded according to the system of DeLee and Charnley [8] and those in the femur by the system of Gruen et al. [15]. For the purpose of this study, osteolysis was defined as being present or absent; its extent was not quantified using special software. We used plain radiographs rather than CT scans to evaluate for osteolysis.

Proximal femoral bone resorption was graded radiographically [12] with Grade 1 indicating atrophy or

rounding off of the calcar; Grade 2, loss of density in the calcar region with loss of the medial cortical wall to the level of the lesser trochanter; and Grade 3, loss of density in the entire medial cortical wall distal to the level of the lesser trochanter.

All patients underwent dual-energy x-ray absorptiometry scanning of the pelvis and proximal femur (Zones 1 and 7) using a Hologic QDR 4500A densitometer (Hologic Inc, Waltham, MA, USA) in the metal removal hip scanning mode 2 weeks after surgery, which served as a baseline of bone mineral density (BMD) for the subsequent scans. Further scans were obtained at final followup [20]. Methods used to acquire the pelvic scan were described in our previous report [20]. Heterotopic ossification, if present, was graded according to the classification of Brooker Z [6].

The changes in Harris hip score were evaluated using a paired t test. WOMAC and UCLA activity scores and bone density results also were evaluated using a paired t test. The chi square test with Yate's correction was used to analyze complication rates and radiographic data. Kaplan-Meier survival analysis [17] was performed with revision for any cause or aseptic loosening as the end point. All statistical analyses were performed using SPSS® Version 14.0 (SPSS Inc, Chicago, IL, USA). Statistical significance was set at p values of < 0.05.

Results

The clinical and functional results improved for the Harris hip score, WOMAC, and UCLA activity scores (Table 2). At final followup, 475 patients (95%) had no detectable limp, and 25 (5%) had a mild limp that was related to leg length discrepancy and weakness in the abductor muscle. The ability to use stairs and public transportation, to put on footwear, and to cut toenails was improved substantially after the operation. The preoperative UCLA activity score

Table 2. Clinical results

Parameter	Preoperative	Followup at 15.8 years	p value (Student's two-tailed t test)
Harris hip score (points)	38 (range, 21–49)	94 (range, 71–100)	< 0.001
Excellent (90–100)	0	445 (89%)	–
Good (80–89)	0	43 (8.6%)	–
Fair (70–79)	75 (15%)	9 (1.8%)	–
Poor (< 70)	425 (85%)	3 (0.6%)	–
WOMAC score (points)	60 ± 11.3 (range, 46–75)	15 ± 6.7 (range, 5–29)	< 0.001
UCLA activity score (points)	2.9 (range, 1–4)	7.9 (range, 6–9)	< 0.001
Thigh pain	–	None	–
Clicking sound	–	45 (9%)	–
Squeaking sound	–	None	–

Fig. 2A–B Radiographs illustrate the case of a 40-year-old male patient who had osteonecrosis of both femoral heads. **(A)** An AP view of both hips before surgery shows Ficat Stage III osteonecrosis of both femoral heads and Dorr Type A femoral bones. **(B)** An AP view of both hips taken 18 years postoperatively reveals the acetabular and femoral components are well fixed in a satisfactory position in both hips without osteolysis. Grade 2 calcar resorption is evident in both hips, but periprosthetic bone stock is well preserved without having stress shielding-related bone osteopenia.

was 2.9 points (range, 1–4 points), which improved to 7.9 points (range, 6–8 points) at final followup. This improvement was statistically significant ($p = 0.031$). No patient had thigh pain at final followup. Of the total 500 patients, 30 (6%) changed from heavy labor work before the operation to sedentary work after the operation. The remaining 470 patients (94%) remained in their previous occupation after the operation. We recommended against participation in high-impact sports.

Oseointegration was seen in all hips (Fig. 2). No hip had a subsidence of more than 1.0 mm. Fifty-five hips (9%) subsided less than 1 mm. Five hundred ninety-two hips (94%) exhibited Grade 1 stress shielding in the calcar region [11]. No hip exhibited Grade 3 stress shielding. No acetabular or femoral osteolysis was identified in any hip (Table 3). Around the femoral component, BMD was significantly reduced in Zone 7 and slightly decreased in Zone 6. The mean BMD in Zones 2 and 3 increased significantly

Table 3. Radiographic results

Parameter	Number
Dorr bone type	
A	510 hips (81%)
B	44 hips (7%)
C	76 hips (12%)
Acetabular component position	
Inclination	44.5° (38°–51°)
Anteversion	23.3° (18°–28°)
Femoral component position	
Neutral	592 hips (94%)
Varus	25 hips (4%)
Valgus	13 (2%)
Center of rotation	
Horizontal (mm)	41.2 (36–48)
Vertical (mm)	15.1 (13–24)
Femoral offset (mm)	42.3 (36–51)
Abductor moment arm (mm)	45.7 (41–85)
Limb-length discrepancy (mm)	0.5 ± 0.6 (–1.3 to 1.3)
Radiolucent line (> 1 mm)	0 hip (0%)
Migration of acetabular or femoral component	0 hip (0%)
Stress shielding	
Grade 1	592 hips (94%)
Grade 2	38 hips (6%)
Osteolysis	0 hip (0%)

Ranges or percentages in parentheses.

by final review. The mean BMD in Zones 1, 4, and 5 increased slightly by final review (Table 4).

Intraoperative linear fractures at the calcar occurred in seven hips (1.1%). These were treated with Dall-Miles cabling (Howmedica, Rutherford, NJ, USA); all healed completely and osseointegration of the prosthesis was achieved. Two hips (0.3%) had an avulsion fracture at the greater trochanter. There was no hip instability and no other problems. Dislocation occurred in five hips (0.8%), one of which was treated successfully with closed reduction and an abduction brace for 3 months. The remaining four hips required revision of the acetabular component. Grade 1 heterotopic ossification occurred in 30 (4.8%) and Grade 2 heterotopic ossification in five (0.8%). No hip had Grade 3 or 4 heterotopic ossification. Forty-five patients (9%) had clicking sounds, but no patient had squeaking sounds. No patient had an alumina head or liner fracture.

No hip required revision of any component for aseptic loosening. Both components were revised in four hips (0.6%) because of deep infection at 6 months and 1 year, respectively. Four acetabular components (0.6%) were revised after recurrent dislocation. Kaplan-Meier survival

Table 4. Bone mineral density (g/cm²) of the acetabulum and proximal femur

Zone	Followup at 1 week	Followup at 15.8 years	Percentage change	p value (Student's two-tailed t test)
Acetabulum				
I	1.016	1.291	+27	< 0.001
II	0.985	0.851	−14	< 0.001
III	0.998	1.021	+2	0.238
Femur				
1	0.963	0.991	+3	0.139
2	1.004	1.081	+8	0.047
3	0.998	1.061	+6	0.035
4	1.013	1.043	+3	0.218
5	0.996	1.041	+5	0.215
6	0.997	0.963	−3	0.131
7	0.956	0.883	−8	< 0.001

analysis, with revision as the end point for failure, revealed 98.7% (95% CI, 0.95–1.00) for the acetabular component and 99.4% (95% CI, 0.97–1.00) for the femoral component at 15 years after the operation. When aseptic loosening was used as the end point for failure, the survival rate of both components was 100% (95% CI, 0.98–1.00) at 15 years postoperatively.

Discussion

Long-term results of standard THA in young patients are not optimal. There are a number of reported disadvantages to longer cementless stems in THA including thigh pain and proximal stress shielding. However, it is unknown whether a short, metaphyseal-fitting anatomic stem without diaphyseal fixation, which represents a possible alternative, will maintain fixation over the long term. We therefore evaluated longer-term (1) clinical results using validated scoring instruments; (2) osseointegration and bone remodeling; (3) complications; and (4) rates of revision and osteolysis in patients younger than 65 years who underwent THA with a short, metaphyseal-fitting anatomic cementless stem. The clinical and functional results improved for the Harris hip score, WOMAC, and UCLA activity scores. Osseointegration was seen in all hips. Four hips (0.6%) had deep infection and four hips (0.6%) had a recurrent dislocation. No hip had osteolysis.

There are several limitations in this study. First, although the data were collected prospectively, the study was retrospective in design, not randomized, and used no control group. Without a control group, it is not possible to draw any direct conclusions on the performance of the implant in question relative to any other. Second, we did

not use radiostereometric analysis to evaluate for migration; radiostereometric analysis is known to be more precise than manual techniques of measurement [4]. Third, there may be selection bias. Twenty-five patients < 65 years old during the 7-year period of this study did not receive this stem, because they had high dislocation of the hip, intertrochanteric fracture, or severe osteoporosis. Finally, this is an older generation prosthesis. Because of the excellent results of this prosthesis without diaphyseal fixation, the distal stem of this prosthesis was removed to introduce an ultrashort metaphyseal-fitting anatomic cementless femoral stem (Proxima; DePuy, Leeds, UK).

Albanese et al. [1] quantified BMD to evaluate changes around the prosthesis and to measure bone stock and bone density redistribution after a THA. They studied Mayo (Zimmer, Warsaw, IN, USA), CFP (Link, Frankfurt, Germany), Alloclassic (Zimmer), and Santori's custom-made short (DePuy, Leeds, UK) stems. Although all of these stems functioned well clinically, BMD was decreased substantially in the calcar region in Mayo, CFP, and Alloclassic stems. Santori's custom-made short metaphyseal-fitting anatomic stem resulted in complete proximal load transfer and produced a more physiological redistribution of BMD. We showed that it is possible to obtain optimal fixation of a short metaphyseal-fitting anatomic cementless stem without diaphyseal fixation in young patients and that there was no thigh pain and little stress shielding with this approach. On the basis of hip scores, this implant seems comparable to others [11, 35–38, 41–43] but without a controlled trial, there is no way to know for sure [1, 2, 7, 18, 19, 21–28]. A potential concern with the use of short, metaphyseal-fitting anatomic cementless femoral components is whether stable fixation can be obtained without diaphyseal fixation. In our study, osseointegration was reliable with a stem of this design. Walker et al. [42] and Leali and Fetto [29] suggested that the femoral stem below the lesser trochanter would be unnecessary for a cementless anatomic femoral stem with a lateral flare and that a short stem would suffice. Several authors reported that firm fixation of a short metaphyseal-fitting femoral stem was obtained [19–22, 26, 31, 36]. Complications in this series were comparable in frequency and severity to other series of cementless femoral stems [18–28, 38]. Of particular note was a lack of thigh pain after 1 year after the operation. We believe this is the result of the lack of interference with the diaphysis. Thigh pain is known to be related to stem design and implant stiffness [5, 7, 14]. The normal modulus of elasticity of cortical bone is less than 20 GPa [7], whereas most conventional metal implants occupying the diaphysis have a modulus of elasticity between 80 and 200 GPa [33, 40]; therefore, a short, tapered, polished intramedullary stem is one way to preserve femoral elasticity and avoid symptoms in this region.

Table 5. Demographic data and implant survivorship for various short-stem and standard-stem designs

Study	Level of evidence	Number of hips	Number of patients	Mean age (years)	Mean followup (years)	Survivorship (%)
Mayo stem						
Morrey [32]	IV	159	146	50.8	6.5	98.2
Lateral flare designs						
Kim et al. [22]	II	144	126	53.9	4.5	100
Kim and Oh [26]	III	70	70	74.9	4.1	100
Kim et al. [27]	IV	256	230	65	5.6	99.6
Santori and Santori [38]	IV	129	109	51	9.8	100
Shortened proximally coated stems						
Patel et al. [34]	III	160	149	75	2.9	100
Stulberg and Dolan [39]	IV	65	65	56	2	100
Kim [19]	IV	604	471	52.7	8.8	100
Standard tapered stems						
Petsatodes et al. [35]	IV	233	220	47.5	17	98.1
Ellison et al. [11]	IV	249	201	34.7	7.6	99
McLaughlin and Lee [31]	IV	145	138	24.5	24.5	99

There are many other theories about what causes thigh pain [12, 14, 41] and that we really do not know which one is right. The prevalence of stress shielding-related bone resorption was between 18% [30] and 50% [41] after THA using tapered cementless femoral stem. Kim et al. [20, 22–24] reported that their short, anatomic cementless femoral stem had mild stress shielding in the calcar region and it was nonprogressive 1 year after surgery. We believe that a short, tapered, polished distal stem minimized stress shielding-related proximal femoral bone resorption.

We have shown in our study that this implant demonstrated no femoral loosening despite our younger patients studied. We believe that circumferential metaphyseal fitting with lateral flare of the stem was responsible for rigid fixation of the stem without diaphyseal fixation.

Survivorship of THA in young patients is poorer than that seen in older cohorts. Young patients may have acquired disease from varied causes, and they tend to have higher activity levels than those of older patients. The majority of patient in our series continued to participate in high-demand activities, including moderate to heavy manual labor. These disease entities and level of activity did not seem to affect the longevity of fixation of the acetabular and femoral components. We believe several factors were responsible for our good results: improved design (the proximal-fitting design of the femoral stem including pronounced lateral flare, AP build-up, and a short and narrow polished distal end of the stem), surgical technique for implantation of the cementless stem, the strong trabecular bone in young patients, and use of ceramic-on-ceramic bearing. Our results are consistent with those from other studies [20, 21, 26, 30, 31, 34] (Table 5).

In conclusion, a short, metaphyseal-fitting anatomic cementless femoral stem provided stable fixation without diaphyseal fixation in younger patients (UCLA activity score, 7.9 points). Clinical and radiographic results support the rationale of this short stem. On the basis of our findings in this series, we believe that new design features (ultra-short metaphyseal fitting with lateral flare and preservation of the femoral neck) without any diaphyseal stem might be the future.

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