CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 000, pp. 000–000

Favorable Midterm Results of Total Hip Arthroplasties with a Lateral Flare Uncemented Stem

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Uncemented stems have been advocated for primary total hip arthroplasties in the young active population. We evaluated the clinical and radiographic results of total hip arthroplasties with a customized lateral flare cementless femoral stem in a prospective, consecutive series of 35 patients (40 hips) younger than 55 years at the time of surgery and who were followed up for an average of 9.2 years (range, 5.7–12.2 years). The study group comprised 20 men and 15 women with an average age of 45.2 years (range, 30–55 years). One patient had aseptic loosening of the stem and one patient had a deep infection. The mean preoperative Harris hip score was 47 and at the latest followup it was 97. The mean axial migration was 0.51 mm. Femoral osteolysis was found to be circumscribed to the proximal femur in Gruen Zones 1 (15%) and 7 (8%) in patients with accelerated polyethylene wear. Radiographic changes consistent with new bone apposition under the lateral flare of the stem in Zones 2, 6, and 7 were found in 73% of the cases. Our data suggest a custom lateral flare stem for primary arthroplasties in the younger patient population achieves excellent clinical results with a low rate of aseptic loosening.

Level of Evidence: Therapeutic study, Level IV (case series). See the Guidelines for Authors for a complete description of levels of evidence.

Cemented total hip arthroplasty (THA) performed in the young, active population has been associated with high rates of mechanical failure.[8,9,14,33] Callaghan et al[5] reported a revision rate for aseptic loosening of the Charnley low friction arthroplasty of 29% with an impending failure rate of 8% after 20 to 25 years in patients younger than 50 years, whereas Dorr et al[14] reported a revision rate of 33% in young patients followed up for an average of 9.2 years with an impending failure rate of 56%. The reported high rate of radiographic loosening coupled with misinformation regarding the so-called cement disease,[31] resulted in the introduction of cementless fixation in the acetabulum and in the femur, which today is one of the most common forms of fixation in the younger population.[18]

The first-generation uncemented stems for THA were not devoid of problems and were associated with high rates of thigh pain, aseptic loosening, and stress shielding.[3,4,16,17,22,28,29] To minimize these problems, a high metaphyseal loading femoral stem incorporating a lateral flare in the proximal body was designed and initially was available as a custom implant.

We sought to answer two questions. Will primary uncemented fixation using a hydroxyapatite (HA)-coated custom stem provide favorable and consistent clinical and radiographic results in young, active individuals having THAs? What, if any, are the visible radiographic changes after implanting a stem that includes a lateral flare to engage the lateral metaphyseal area of the femur?

MATERIALS AND METHODS

We prospectively followed 40 consecutive, nonselected patients (47 hips) younger than 55 years who had primary THAs between June 1992 and November 1997 using a customized lateral flare stem. The patients were followed up for a minimum of 5 years or until death or revision surgery. The customized lateral flare stem was the only type of femoral component the senior author (JF) used during the study period. Three patients were excluded; two patients were lost to followup after 4 and 5 years. Two of these patients had intact reconstructions and one patient had incomplete followup studies. Two patients died of unrelated causes 5 and 9 years after the initial surgery with well-fixed components. The remaining 40 hips in 35 patients (20 men and 15 women) with an average age of 45.2 years at the time of surgery (range, 30–55 years) were followed up for an average of

Received: April 11, 2005
Revised: October 5, 2005; January 10, 2006
Accepted: February 9, 2006
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The institution of the authors has received research funding from Encore Medical Corporation, Austin, TX.
Each author certifies that his or her institution has approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
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DOI: 10.1097/01.blo.0000214410.60722.b1

9.5 years (range, 5.7–12.2 years). The preoperative diagnoses included primary osteoarthritis in nine patients, avascular necrosis in 16 patients, congenital hip dysplasia in seven patients, and secondary osteoarthritis related to a slipped capital femoral epiphysis in three patients.

The senior author (JFF) performed all surgeries through a standard posterolateral approach, which included splitting the gluteus maximus, detaching the short rotators, and a doing a T-shaped capsulotomy. The acetabular component used was a Harris-Galante II uncemented cup (Zimmer Inc, Warsaw, IN). The insertion technique involved line-to-line reaming and augmentation of the fixation with one or more screws. The polyethylene liner accommodated a 28-mm cobalt-chromium femoral head. The femur was prepared by straight reaming and progressive broaching until the custom implant-matched broach size was reached. To minimize distal contact, the canal was over-reamed in every case to 0.5 mm greater than the diameter of the distal stem. Using a small curette, the cancellous bone adjacent to the greater trochanter was removed, ensuring sufficient mediolateral space to accommodate seating of the lateral flare of the implant. Femoral and acetabular components were implanted without cement.

The computer-aided design and computer-assisted manufacture (CAD-CAM) implants were manufactured using a Hip Design Workstation[30,42] and were made of titanium alloy (Ti6Al4V). The design features of the stem included three longitudinal 1-mm to 2-mm macrogrooves in the proximal ⅓ and an HA coating to a level 15 mm below the grooves. The distal stem was polished and had three 5-mm macrogrooves in the anterior, medial, and posterior surfaces to limit the bone-stem contact. Ten degrees anteversion was built into the neck of the stem. The taper of the stem is 12/14 optimized for a 28-mm cobalt-chromium head (Fig 1).

After insertion of the components, the capsule and the external rotators were reapproximated using heavy nonabsorbable sutures through drill holes on the greater trochanter.[37] The patients were allowed full weightbearing immediately after surgery. Clinical evaluations were performed before surgery, 3, 6, and 12 months after surgery, and yearly thereafter using the Harris hip score (HHS).[27] Anteroposterior (AP) and lateral films of the involved hips and AP views of the pelvis were assessed along with clinical followups.

The immediate postoperative and the last followup radiographs were evaluated and rated by a qualified orthopaedic surgeon (AGDV, not an author) from another academic institution who was blinded to the clinical results. The stems were rated stable (evidence of osseointegration with the absence of radiolucent lines) or unstable (change in the position, continuous or progressive radiolucent line, or evidence of migration). The presence of pelvic or femoral osteolysis, progressive radiolucent lines, stress shielding, bone resorption, cancellous or cortical thickening, and visible periprosthetic bone density changes were recorded according to the zones described by DeLee and Charnley[13] and Gruen et al.[26] Perioperative and postoperative fractures were noted. Radiolucencies with a scalloped or cystic appearance and greater than 2 mm wide were documented as osteolysis.

To avoid interobserver inconsistencies or errors, axial migration of the stem was measured by one observer (AL) using a previously described method,[41] which included digitization of the radiographs and measurement of the distance from the tip of the greater trochanter to a reference point in the stem. These were made from the outermost tip of the lateral flare of the prosthesis to a reproducible bony landmark in the greater trochanter present on both films. We then calculated the vertical distance between the two points on each film, and the difference was considered a measure of the subsidence of the prosthesis. Three different sets of readings were made on each digitized film. The measurements were taken every 2 weeks. The reported subsidence represents the average value of each set of measurements. The intraobserver error was calculated to be 0.32 mm.

The changes in hip scores were evaluated with the Student's t test and statistical significance was set at $p < 0.05$.

Fig 1. The custom-manufactured titanium lateral flare femoral stem is shown; the proximal ⅓ has a circumferential grit-blasted HA-coated surface. The prominent lateral expansion captures the lateral cortex. The distal stem is polished and has macrogrooves to limit bone contact.

RESULTS

The custom lateral flare stem yielded favorable, consistent clinical results and radiographic fixation in the population studied. The Harris hip score increased from an average of 47.5 (range, 24–58; SD, 7.7; 95% confidence interval [CI], 45.3–49.7) preoperatively to an average of 97.7 (range, 81–100; SD, 3.7; 95% CI, 96.6–98.8) at the last examination. None of the patients with stable stems reported thigh pain. One patient with thigh pain had multiple osteolytic lesions associated with accelerated polyethylene wear. The stem had migrated 1.13 mm at the time of revision surgery. Two periprosthetic fractures occurred during the followup period; one was an intraoperative nondisplaced fracture (Type B1 Vancouver classification[15]), which was repaired with cable fixation with an uneventful evolution, and the second was an oblique spiral diaphyseal fracture at the level of the stem (Type B1 Vancouver classification), which occurred 9.5 years after surgery with a well-fixed stem treated with open reduction and internal fixation. One revision surgery was done for late septic loosening of the femoral component 7 years after implantation and one revision was done because of aseptic loosening in a patient who with trauma after a fall resulting in bilateral calcanei fractures 4 years after the index surgery. This patient subsequently had aseptic loosening and thigh pain develop requiring revision surgery 5 years after the initial surgery. Eleven patients required acetabular revisions because of accelerated polyethylene wear (nine patients) (Fig 2), dislodgement of the liner (one patient) (Fig 3) and septic loosening (one patient). The 10 patients with aseptic joints had well-fixed femoral stems.

This stem design showed consistent radiographic fixation. Thirty-eight stems (95%) were stable at the latest followup with bone ingrowth in the metaphyseal area accompanied by minimal axial migration (less than 1 mm) (Fig 4). One hip was classified as unstable with femoral osteolytic lesions in Zones 2, 3, 5, and 7 and was revised as mentioned above. Endosteal bone apposition was evident radiographically in 29 patients (73%) particularly below the lateral flare of the stem (lower part of Gruen Zone 1 and Gruen Zone 2) and Zones 6 and 7. Calcar remodeling was visible in 11 patients (28%) and manifested as slight rounding of the most medial femoral cortex at the neck cut level in nine patients and more pronounced remodeling changes at the same level in two patients. Six patients (15%) evidenced distal pedestal formation. These patients did not have thigh pain or increased axial migration. The average subsidence in this subset of patients was 0.59 mm (range, 0.22–1.22 mm; SD, 0.37; 95% CI, 0.29–0.89).

Pelvic osteolysis in Zone 1 was seen in three hips (8%), in Zone 2 in seven hips (18%) and in Zone 3 (5%) in two hips. Femoral radiolucencies were seen in Gruen Zone 1 in six hips (15%), in Zone 7 in three hips (8%), and in Zones 2, 3, and 6 in one hip (0.3%) respectively (Fig 5). Four stems had no measurable subsidence. The average subsidence in the 36 stems at the latest followup was 0.6 mm (range, 0.2–1.5; SD, 0.4; 95% CI, 0.5–0.7). The mean linear wear of the polyethylene liner of the acetabular component was 0.28 mm/year (range, 0.01–0.86; SD, 0.21; 95% CI, 0.23–0.35).

DISCUSSION

We report the intermediate to long-term results of a lateral flare customized femoral stem for THA in a younger active population.

The limitations of our analysis include the lack of a control group with stems with different fixation modes or different shape (diaphyseal versus metaphyseal), and the lack of longer-term followup. The radiographs were mea-

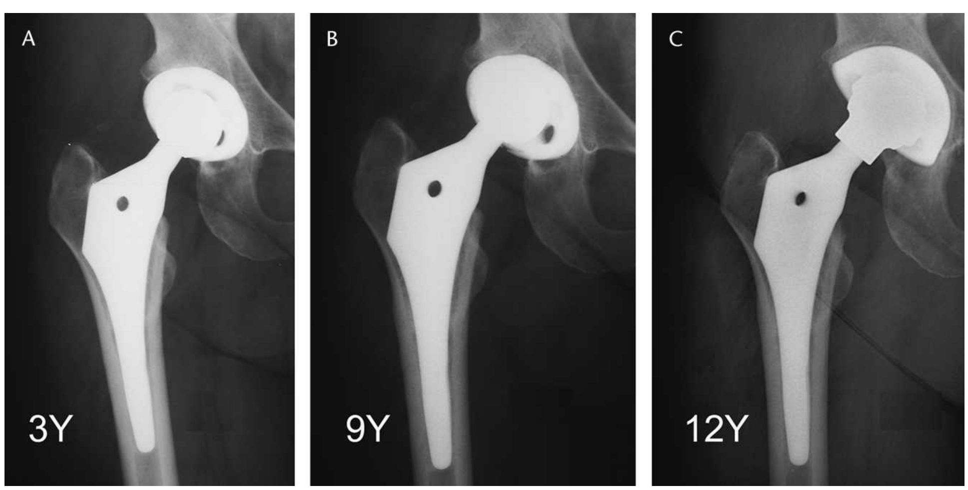

Fig 2A–C. Anteroposterior radiographs of a 55-year-old woman who had osteoarthrosis of the right hip are shown. (A) The 3-year followup film shows the extended proximal shape of the stem allowing for a broader base of support in the metaphysis. (B) The 9-year followup radiograph shows marked eccentricity of the prosthetic femoral head in the acetabular component suggesting polyethylene wear. (C) The patient had revision of the acetabular cup to a metal-on-metal articulation; the distal femur was free of osteolysis and remained solidly fixed in the canal as can be seen on the 12-year followup radiograph.

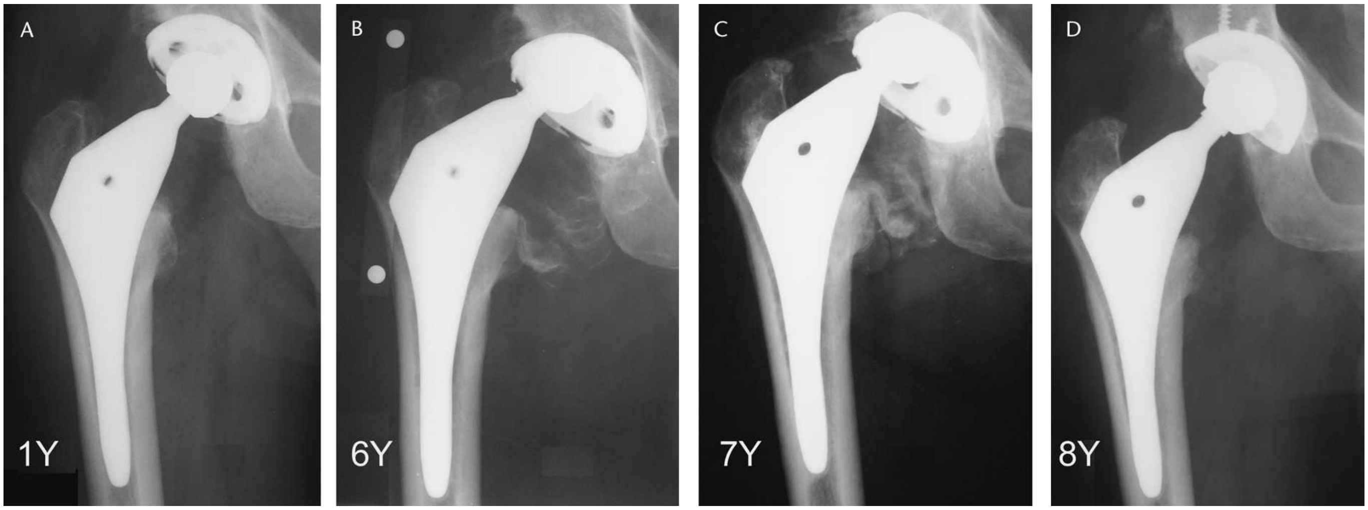

Fig 3A–D. Anteroposterior radiographs of a 46-year-old man with avascular necrosis of the right hip are shown. (A) The 1-year followup AP film shows a custom lateral flare total hip replacement. (B) The 6-year followup radiograph shows accelerated polyethylene wear (0.56 mm/year) and dislodgement of the liner. (C) The 7-year followup radiograph at the time of revision surgery shows the prosthetic femoral head had penetrated through the acetabular shell. (D) The articulation was revised to a metal-on-metal cup. The osteolysis was confined to the proximal femur above the lateral flare of the prosthesis, which remained fixed.

sured for subsidence by one observer, which, although eliminating interobserver variability, can introduce systematic bias. However, we think the materials presented allow us to respond to our two research questions.

The low rate of aseptic loosening of the lateral flare stem in the younger patient population along with preservation of the distal femur when there is accelerated polyethylene wear and proximal osteolysis suggest this stem provides a circumferential proximal seal restricting particle migration from the articulating space to the femoral canal. Moreover, during the 10 acetabular revisions, the stems were solidly fixed in nine patients. Only one patient

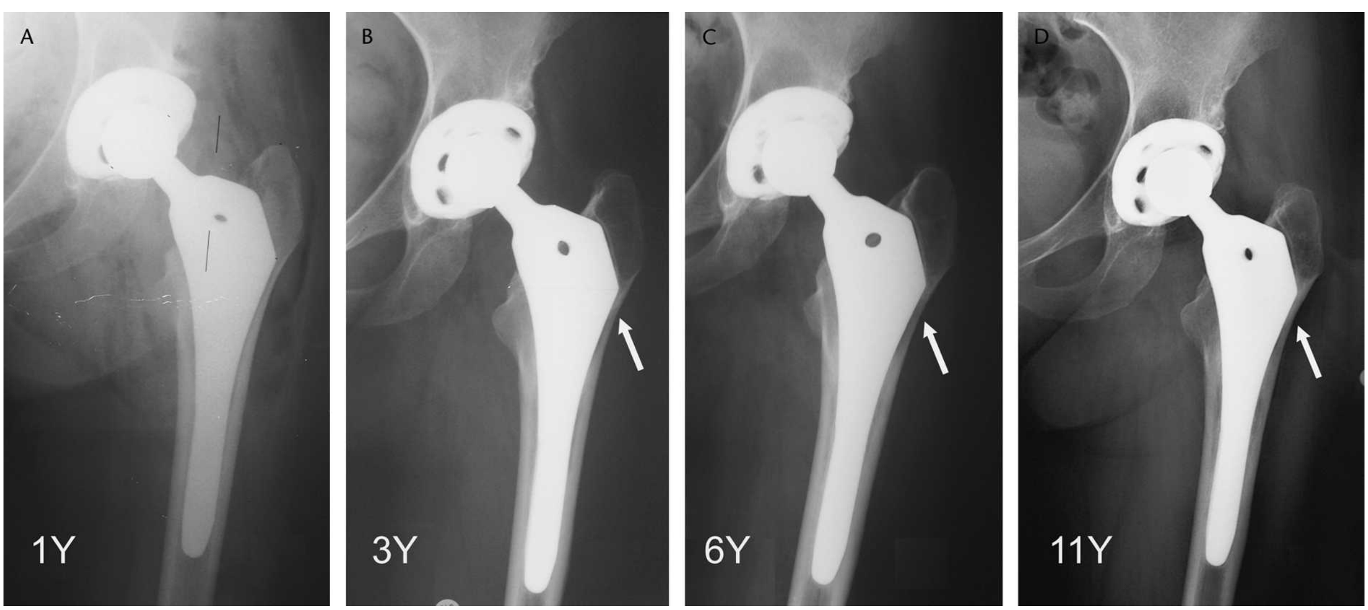

Fig 4A–D. Anteroposterior films of a 44-year-old woman with osteoarthrosis of the left hip secondary to congenital dislocation are shown. (A) The 1-year followup radiograph is shown. (B) Three years after the index surgery, some bone apposition can be seen in the lateral metaphysis. (C) Six years after the surgery, a stable stem with osseointegration can be seen. (D) The 11-year followup radiograph shows some retroacetabular and proximal femoral osteolysis with an intact distal femur. The bone response elicited by the loads below the flare of the prosthesis (white arrows) can be seen.

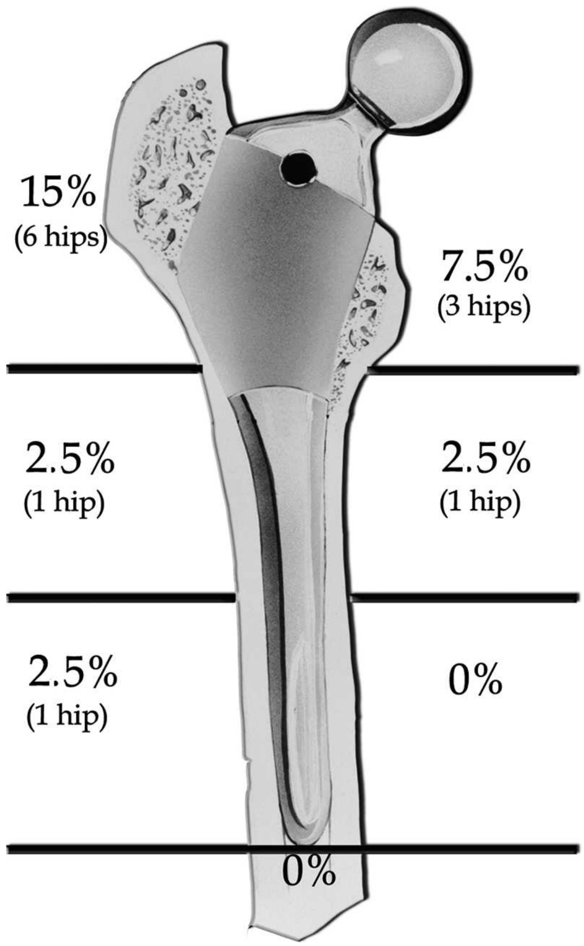

Fig 5. The distribution of radiographic osteolytic lesions in the femur divided by Gruen zones is shown. Most of the osteolysis was confined to the proximal Zones 1 and 7. There was one patient who presented with multiple distal osteolysis who was subsequently had revision surgery.

with accelerated polyethylene wear (0.48 mm/year) and aseptic loosening of the stem had osteolytic lesions develop in Zones 2, 3, 6, and 7 after a followup of 4 years.

The lateral flare design is based on the theory that the lateral aspect of the femur is loaded in compression during the single-stance phase of gait.[19,20] In addition to the load transfer from the femoral head to the medial femoral cortex, particular attention has been placed on the compressive forces experienced at the base of the greater trochanter. It has been proposed that to reproduce the endosteal compressive forces between the femoral head and the proximal lateral femur, a femoral stem needs to engage this region by means of a lateral expansion or flare.[19]

Intraoperative fractures of the proximal femur are a well-known complication of uncemented stem fixation, particularly those requiring a tight metaphyseal fit.[7,12,39] Although the lateral flare stem has a prominent proximal body, insertion of the lateral flare requires minimal reaming and gentle scooping with a curette of the cancellous bone above the lateral cortex at the level of the base of the greater trochanter. The flare of the stem rests at or above the intersecting point of the midneck axis and the lateral endosteal bone in a straight path from the femoral cut. In our consecutive series, there was one minor oblique diaphyseal periprosthetic fracture 2 days after surgery, which was repaired with cable fixation without additional clinical consequences.

The low axial migration values we found reflect the high degree of proximal fit and fill and the close endosteal contact (four of 40 stems had no measurable migration). It may be argued that the addition of an HA coating contributes to enhancing early fixation,[23,24] providing proximal stress transfer,[38] and limiting subsidence;[32] however, we previously reported comparable low subsidence values less than 1 mm at 4 years followup in porous-coated and grit-blasted stems with the same proximal shape.[35]

Primary stability is a fundamental factor in achieving bony ingrowth.[1,2] Our radiographic data suggest there was bone apposition in 73% of the cases. A partial pedestal was found adjacent to the tip of the stem in six hips (15%) with no apparent influence on the stability of the stem, as the average subsidence in this subgroup remained less than 1 mm.

We previously investigated changes in periprosthetic bone density using dual xray absorptiometry in patients with revision HA-coated and primary porous-coated lateral flare reconstructions.[34,40] With primary porous-coated lateral flare reconstructions, bone mass was maintained at 12 months, with an average in all seven Gruen zones of 102% and 108% in the support area of the stem underneath the lateral flare when compared to baseline values.[34]

For revision arthroplasties with custom HA lateral flare stems, Walker et al[40] reported maintenance of bone density in all regions within 12% of the immediate postoperative values at 4 years. The radiographic correlation is fairly constant; aligned trabecular bone can be observed streaming from the lower part of the greater trochanter to the lateral flare of the stem in 29 of our patients.

Some authors have reported encouraging clinical results in young, active patients using contemporary uncemented femoral stems designed for proximal loading. McLaughlin and Lee[36] reported similar femoral survivorship using the flat, tapered Taperloc (Biomet Inc., Warsaw, IN) stem in 100 hip replacements performed in patients younger than 50 years after a mean followup of 10.2 years. Capello et al[6] and D'Antonio et al[11] also reported similar results in the younger population using the Omnifit-HA (Osteonics, Allendale, NJ) stem after an average of 6.4 and 6.8 years followup, respectively. The distinctive feature of the stem we used, however, is the presence of a lateral flare designed to provide a high metaphyseal fit and sturdy initial stability.

The midterm to long-term clinical results of the lateral flare stem for THAs in patients younger than 55 years at the time of surgery showed a low rate of aseptic loosening of the stem and a low rate of distal femoral osteolysis despite high surface wear of the articulating surface. The main cause of revision surgery were mechanical failure and biologic failure of the acetabular component associated with high rate of polyethylene wear.[10,24] We continue to prospectively follow this cohort of patients to assess maintenance of these favorable clinical and radiographic results.

Acknowledgments

We thank Dr. Alejandro Gonzalez Della Valle, who evaluated the preoperative and postoperative radiographs.

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