Second-generation Modular Acetabular Components Provide Fixation at 10 to 16 Years

Paul F. Lachiewicz MD, Elizabeth S. Soileau BSN

Published online: 21 June 2011

© The Association of Bone and Joint Surgeons® 2011

Abstract

Background First-generation modular titanium fiber-metal-coated acetabular components had high rates of wear, pelvic osteolysis, and liner dissociation. Second-generation components were designed to reduce the incidence of these problems but it is unclear whether the changes achieved these goals.

Questions/purposes We asked the following questions: (1) Is the risk of revision surgery for loosening, wear, or liner dissociation low with the second-generation acetabular component? (2) Is the rate of pelvic osteolysis low? (3) Can the liner be exchanged without bone cement?

Methods We retrospectively reviewed prospectively collected data from 99 patients (118 hips) undergoing THAs with one second-generation modular titanium acetabular component with routine screw fixation and conventional polyethylene. The minimum followup was 10 years (mean, 12 years; range, 10–16 years). We obtained Harris hip scores and examined radiographs for loosening and osteolysis.

Results At last followup, all acetabular components were well fixed and no titanium shell had been revised or removed. No liner had dissociation. At most recent

followup, the mean Harris hip score was 89. We observed pelvic osteolysis in eight hips (7%). There were three reoperations for dislocation (head-liner exchange only) and three loose femoral components revised. Two liners (at 11 and 14 years) were exchanged for wear-pelvic osteolysis.

Conclusions This second-generation modular titanium fiber-metal-coated acetabular component with screw fixation had no loosening, no liner dissociation, and a low rate of pelvic osteolysis at 10 to 16 years. Liner exchange is practical without use of cement. We continue to use this component with highly crosslinked polyethylene liners.

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

Introduction

The first and second versions of an uncemented titanium fiber-metal-coated acetabular component (HGP-I and HGP-II; both Zimmer, Warsaw, IN) with screw fixation had a locking mechanism composed of three (HGP-I) or three to five (HGP-II) sets of thin metal “tines” that were bent to hold the polyethylene liner [1, 5, 11, 12, 20, 25–27]. This so-called polyethylene locking mechanism was a major factor implicated in backside wear of the liner, pelvic osteolysis in 17% to 23%, broken “tines,” and catastrophic liner dislodgement with inability to safely replace the liner (without shell removal) without bone cement [7, 28, 31]. The HGP-II component did not have a polished inner surface, had a locking mechanism of three to five sets (dependent on shell size) of metal “tines” fabricated of pure titanium (not titanium alloy), and was thicker to permit 6.5-mm screws that had a bulbous head.

One of the authors (PFL) is a member of the speakers' bureau of Zimmer, and his institution received research support from Zimmer for a different study.

Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

P. F. Lachiewicz (✉), E. S. Soileau
Chapel Hill Orthopedics Surgery and Sports Medicine,
101 Conner Drive, Suite 200, Chapel Hill, NC 27514, USA
e-mail: paul.lachiewicz@gmail.com

The so-called “second-generation” titanium fiber-metal-coated acetabular component (Trilogy; Zimmer) was introduced in 1994 with several notable modifications from the earlier versions [19]. The polyethylene locking mechanism was redesigned to include a locking ring that grasped the entire periphery of the liner, two metal antirotation tabs to match cutouts on the liner, and a polar inset for the polar tab of the polyethylene liner. This design was intended to permit liner exchange without the use of bone cement. The inner surface of the component was also highly polished titanium and was designed for improved polyethylene liner congruity. These changes were introduced to minimize rotation of the polyethylene liner in the metal shell, decrease or eliminate backside wear, and prevent liner dislodgement. It was hoped that these design features would result in a clinically low incidence of acetabular component revision for loosening or wear, radiographic pelvic osteolysis, and eliminate liner dislodgement at followup times greater than 10 years. Two studies with this acetabular component [8, 9] at minimum 4 years to mean 5.7 years followup reported only one loose component and one case of osteolysis. We previously reported this device in 93 patients (112 hips) at 7 to 13 years followup (mean, 9.5 years) and found no loosening or dissociation and only two cases of pelvic osteolysis [19].

We asked the following questions: (1) Is the rate of revision surgery for loosening, wear osteolysis, or liner dissociation low at longer followup? (2) Is the rate of pelvic osteolysis low at 10 to 16 years with this component and conventional polyethylene liners? (3) Can the polyethylene liner be exchanged without bone cement?

Patients and Methods

We retrospectively reviewed prospectively collected data from all 219 patients having 250 primary THAs between March 1994 and December 1999. All patients had the second-generation titanium fiber-metal acetabular component (Trilogy, multihole; Zimmer), and no other acetabular component was implanted during this time. Ninety-three of these 219 patients were previously reported [19]. No other acetabular component was used during the study period. Also during this time, 14 of these patients (14 hips) were included in a prospective, randomized study comparing the rate of dislocation between a 28-mm and 22-mm head size [18]. Of the original 219 patients, 87 patients (97 hips) had died and 33 patients (35 hips) were lost before 10 years followup. Telephone contact only was made with 10 patients (11 hips) of the “lost” group and they had not had any additional surgery on the hip. These exclusions left 99 patients (118 hips) with a minimum followup of 10 years

(mean, 12 years; range, 10–16 years). There were 56 female patients (66 hips) and 43 male patients (52 hips) with a mean age of 59.3 years (range, 22–81 years). The mean patient weight was 77 kg (range, 44–115 kg), the mean height was 170 cm (range, 150–188 cm), and the mean body mass index 26.7 kg/m^2 (range, $16.5\text{--}38.6 \text{ kg/m}^2$). The preoperative diagnosis was osteoarthritis in 75 hips, osteonecrosis in 19, rheumatoid arthritis in 13, and other diagnoses in nine.

All surgery was performed by one surgeon (PFL) using previously reported techniques [19]. The femoral component was cemented in 73 hips and uncemented in 45 hips with the decision based on patient age and bone quality. The femoral head size was 28 mm in 83 hips, 22 mm in 18 hips, 26 mm in 16 hips, and 32 mm in one hip. The decision on head size was based on both the outer diameter of the acetabular component [18] and a desired minimum polyethylene thickness of 7 mm. The conventional polyethylene liners [19] had a mean thickness of 9.4 mm (range, 7.2–13.3 mm).

Patients were mobilized on the first or second postoperative day, either full (cemented femur) or partial (uncemented femur) weightbearing, with a walker or crutches for 6 weeks. No formal physiotherapy was prescribed.

Patients were routinely examined and had radiographs at 6 weeks, 6 months, 1 year, and annually (or biannually) in two outpatient facilities. The patients were clinically prospectively followed using the Harris hip score [15] preoperatively and at routine postoperative intervals by one clinical research nurse (ESS). AP pelvis radiographs and true lateral radiographs were routinely obtained in the recovery room. Standardized supine AP radiographs centered over the pubis and frog-lateral radiographs were performed at each followup visit with technicians specifically trained for these radiographs with similar patient and tube positioning [19]. The radiographs were reviewed (by both authors at the same time) for pelvic osteolysis, acetabular radiolucent lines, and component shift or migration using the method described by Massin et al. [24]. The acetabular abduction angle, measured on the 6-week postoperative pelvic radiograph, was a mean 42.8° (range, $30^\circ\text{--}55^\circ$). Acetabular radiolucent line thickness and location were described using the method of DeLee and Charnley [6]. Pelvic osteolysis was described using the method of Maloney et al. [22]. Oblique pelvic radiographs and computerized axial tomography were not performed. Survivorship analysis of the entire cohort was performed at 10 and 15 years with three end points or definitions of failure: shell removal, reoperation only for wear or osteolysis, and revision of the hip arthroplasty for any reason (including femoral loosening, recurrent dislocation, and wear osteolysis).

Results

There were no reoperations for acetabular component loosening, migration, or polyethylene liner dissociation. No acetabular titanium shell has been removed for any reason. There were no apparent insertional fractures of the acetabulum intraoperatively. The mean preoperative Harris hip score for the entire cohort was 53.2 points (range, 21–81 points) and the mean postoperative hip score was 89.3 points (range, 57–100 points).

We observed pelvic osteolysis in eight hips (7%), and these included the two patients who had revision for osteolysis. In six hips, a lesion was noted in one acetabular zone and in two hips, a lytic lesion was noted in two zones. In one patient, the pelvic osteolytic lesion was noted on the 8-year followup radiograph, whereas in the other seven hips, the lesion was first noted on the 10- to 15-year followup radiograph. Acetabular radiolucent lines were seen in 15 hips (15 patients). In 14 hips, it was in one zone only, in Zone 1 or Zone 3, and less than 1 mm in thickness. In one hip, there were radiolucent lines less than 1 mm thick in two zones.

Eight patients (7%) had a reoperation. Three patients with cemented femoral components were revised for aseptic loosening. The polyethylene liner was routinely exchanged at the time of femoral component revision. Three patients had reoperations for recurrent posterior dislocations (one each with a 28-mm, 26-mm, and 22-mm femoral head). These patients had exchange of the polyethylene liner with increase in size of the femoral head.

Two of these patients had no additional dislocations at 11 and 6 years, respectively. One patient had an increase of the femoral head from 28 to 36 mm at 11 years but has had two anterior dislocations in the 3 years after the liner-head exchange. There were two reoperations (1.7%) for symptomatic pelvic osteolysis-polyethylene wear. These two patients had mild groin pain, presumably as a result of hip synovitis. One patient had liner exchange with grafting of osteolysis by another surgeon at 11 years and one patient had liner exchange without grafting at 14 years. Both patients had relief of symptoms at 2 years postoperatively. The 10- and 15-year survival for the acetabular shell was 100%. With failure defined as reoperation for wear or osteolysis, the 10-year survival rate was 100% and the 15-year survival rate was 93.4% (95% confidence interval, 72.36% to 98.75%) (Fig. 1). With failure defined as any reoperation, the 10-year survival rate was 94.33% (95% confidence interval, 90.13% to 96.77%) and the 15-year survival rate was 88.15% (95% confidence interval, 69.47% to 95.20%) (Fig 2).

Discussion

The results of uncemented acetabular components at followup times of 10 years and longer are dependent on a number of implant factors, including fixation ingrowth surface, adjuvant fixation, polyethylene fabrication, and polyethylene liner locking mechanism. This second-generation

Fig. 1 Survivorship curve with the end point of revision (liner exchange only) for wear or osteolysis.

Fig. 2 Survivorship curve with the end point of revision for any reason (femoral component loosening, recurrent dislocation, and wear osteolysis).

titanium fiber-metal-coated acetabular component had a new unique polyethylene locking mechanism and a polished, more congruent inner surface. In our previous report of 111 hips at 7 to 13 years, we noted no loosening or dissociation, no revisions for wear, and only two cases of pelvic osteolysis [19]. We asked the following questions: (1) Is the risk of revision surgery for loosening, wear, or liner dissociation low with the second-generation acetabular component? (2) Is the rate of pelvic osteolysis low? (3) Can the liner be exchanged without bone cement?

This study has several limitations. First, we had no control group comparing these patients with the second-generation component with those having the first two versions of the first-generation titanium fiber-metal acetabular component. Second, 87 patients (39%) had died and 33 patients (15%) were lost to followup before 10 years. However, this is to be expected in a 10-year followup study. Third, we did not perform oblique pelvic radiographs or computerized axial tomography and the rate of pelvic osteolysis might be underestimated. Fourth, polyethylene wear measurements [21] using digital techniques with computerized edge detection [2, 16, 23, 29] were not performed, because we did not have digital radiography. In our previous study [19], we reported a difference in the rate of polyethylene wear between the two types of standard polyethylene (irradiated in air and irradiated in nitrogen gas) used with this component, and we did not repeat the analysis for this study. Fifth, we had a single observer for our radiographic findings and had no way to assess the

reliability of our findings. A final limitation is that we did not measure the size of the osteolytic lesions on the plain radiographs, because we believe this would be unreliable.

A number of studies reported 10-year results of first-generation uncemented acetabular components [1, 3, 4, 10, 13, 14, 17, 30] (Table 1). It is difficult to directly compare the results of those studies with the present study as a result of the lack of consistency in defining the cohorts, differences in followup time, and lack of survivorship data using the three end points defined in this study. In addition, none of the reported components is considered a second-generation component, and most, if not all, are not in use any more. Thus, the question of whether the design changes solved the problems can only be inferred by generally comparing the rates of shell revision and osteolysis. Our findings are similar to the two short-term followup studies of this second-generation component. Della Valle et al. reported the minimum 4-year results of 308 acetabular components (77% without screws) [9]. Only one component was revised for aseptic loosening and pelvic osteolysis was seen in 12 hips (5%). The mean age of the patients in that study (64 years) was greater than the patients in the present study. In a subgroup of the same cohort study, 65 hips followed for a mean of 5.7 years, Della Valle et al. reported one case of pelvic osteolysis [8]. In our study of 118 hips with the second-generation titanium fiber-metal acetabular component with a mean followup time of 12 years (range, 10–16 years), there were only two hips (1.8%) revised for symptomatic polyethylene wear and osteolysis and there were eight hips (7%) with pelvic osteolysis.

Table 1. Uncemented acetabular component survival

Author	Acetabular component	Original cohort (number of hips)	Died/lost (number of hips excluded)	Cohort followed (number of hips)	Followup (years) range (average)	Survival (%) Revision Any reason	Survival (%) Revision Shell loose	Survival (%) Revision Shell loose or liner	Revision Shell	Acetabular lysis Number (%)
Kawamura et al. [17]	PCA	311	124	187	10–14 (12)	90	92.7	NS	8	51 (33)
Udomkiat et al. [30]	APR	132	22	110	7–11.9 (10.2)	NS	NS	79.6%	30 (27%)	4 (4)
Della Valle et al. [10]	HG-I	204	97	107	15–18 (NS)	NS	99	93	10 (9.3)	27 (25)
Archibeck et al. [1]	HG-II	92	14	78	8–11 (10)	91.9	96.4	NS	2 (2.6)	12 (16)
Garcia-Rey et al. [13]	Duraloc 500	125	14	111	12–15 (13.4)	94.4	NS	NS	0	1 (0.9)
Grobler et al. [14]	Duraloc 300	100	27	73	minimum 10 (NS)	NS	100	95.4	0	3 (4.1)
Claus et al. [4]	AML	NS	NS	126	minimum 10 (13.7)	NS	NS	NS	5 (NS)	60 (47.6)
	Arthropor	NS	NS	112	minimum 10 (12)	NS	NS	NS	5 (NS)	53 (47.6)
Bojescul et al. [3]	PCA	100	36	64	15–17 (15.6)	76	83	83	17 (17)	19 (30)
Lachiewicz (current study)	Trilogy	250	132	118	10–16 (12)	94.3 (10 years)	100 (10 years)	100 (10 years)	0	8 (7)
						88.2 (15 years)	100 (15 years)	93.4 (15 years)		

HG-I = Harris-Galante I; HG-II = Harris-Galante II; Trilogy, all Zimmer, Warsaw, IN; PCA = porous-coated anatomic, Howmedica Osteonics, Rutherford, NJ; AML = anatomic medullary locking; Duraloc 300, Duraloc 500, all DePuy, Warsaw, IN; Arthropor, Joint Medical Products, Stamford, CT; APR = anatomic porous replacement, Sulzer Orthopaedics, Austin, TX; NS = not stated in article.

Liner exchange for wear, recurrent dislocation, or at the time of femoral revision was effectively performed without cement in eight hips of this cohort. While we again note the difficulty of comparing the various series (Table 1), these rates appear improved from the historical results with the first two versions of the titanium fiber-metal acetabular component.

Based on our observations, we question the need for new acetabular components with more expensive coatings, different polyethylene locking mechanisms, or monoblock (nonmodular) designs. Loosening did not occur with this titanium-fiber metal-coated component fixed with screws. Pelvic osteolysis was still seen with this acetabular component but at a very low rate at 10 to 16 years. However, this cohort used “conventional” polyethylene liners. The author continues to use this acetabular component for primary THAs but now uses highly crosslinked polyethylene liners in all patients.

Acknowledgments We thank Dr John Hubbard for assistance with radiographic measurements, Mr Rich Sloane for performing the survival analysis, and Mr Stephen Perlman for assistance with the literature search.

References

1. Archibeck MJ, Berger RA, Jacobs JJ, Quigley LR, Gitelis S, Rosenberg AG, Galante JO. Second-generation cementless total hip arthroplasty. Eight to eleven-year results. *J Bone Joint Surg Am.* 2001;83:1666–1673.
2. Barrack RL, Lavernia C, Szuszczewicz ES, Sawhney J. Radiographic wear measurements in a cementless metal-backed modular cobalt-chrome acetabular component. *J Arthroplasty.* 2001;16:820–828.
3. Bojescul JA, Xenos JS, Callaghan JJ, Savory CG. Results of porous-coated anatomic total hip arthroplasty without cement at fifteen years. A concise follow-up of a previous report. *J Bone Joint Surg Am.* 2003;85:1079–1083.
4. Claus AM, Sychterz CJ, Hopper RH, Engh CA (2001) Pattern of osteolysis around two different cementless metal-backed cups Retrospective, radiographic analysis at minimum 10-year follow-up. *J Arthroplasty* 16(1):177–182.
5. Crowther JD, Lachiewicz PF. Survival and polyethylene wear of porous-coated acetabular components in patients less than fifty years old: results at nine to fourteen years. *J Bone Joint Surg Am.* 2002;84:729–735.
6. DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. *Clin Orthop Relat Res.* 1976;121:20–32.
7. Della Valle AG, Ruzo PS, Li S, Pellicci P, Sculco TP, Salvati EA. Dislodgement of polyethylene liners in first and second generation Harris-Galante acetabular components. *J Bone Joint Surg Am.* 2001; 83:553–559.
8. Della Valle AG, Su E, Zoppi A, Sculco TP, Salvati EA. Wear and periprosthetic osteolysis in a match-paired study of modular and nonmodular uncemented acetabular cups. *J Arthroplasty.* 2004; 19:972–977.
9. Della Valle AG, Zoppi A, Peterson MG, Salvati EA. Clinical and radiographic results associated with a modern cementless modular cup design in total hip arthroplasty. *J Bone Joint Surg Am.* 2004;86:1998–2004.
10. Della Valle CJ, Berger RA, Shott S, Rosenberg AG, Jacobs JJ, Quigley L, Galante JO. Primary total hip arthroplasty with a porous-coated acetabular component. A concise follow-up of a previous report. *J Bone Joint Surg Am.* 2004;86:1217–1222.
11. Firestone DE, Callaghan JJ, Liu SS, Goetz DD, Sullivan PM, Vittetoe DA, Johnston RC. Total hip arthroplasty with a cemented, collared femoral stem and a cementless acetabular component. *J Bone Joint Surg Am.* 2007;89:126–132.
12. Gaffey JL, Callaghan JJ, Pederson DR, Goetz DD, Sullivan PM, Johnston RC. Cementless acetabular fixation at fifteen years. A comparison with the same surgeon's results following acetabular fixation with cement. *J Bone Joint Surg Am.* 2004;86:257–261.
13. Garcia-Rey E, Garcia-Cimbrelo E, Cordero-Ampuero J. Outcome of a hemispherical porous-coated acetabular component with a proximally hydroxyapatite-coated anatomical femoral component. A 12- to 15-year follow-up study. *J Bone Joint Surg Br.* 2009;91:327–332.
14. Grobler GP, Learmonth ID, Bernstein BP, Dower BJ. Ten-year results of a press-fit, porous-coated acetabular component. *J Bone Joint Surg Br.* 2005;87:786–789.
15. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end result study using a new method of result evaluation. *J Bone Joint Surg Am.* 1969;51:737–755.
16. Hui AJ, McCalden RW, Martell JM, MacDonald SJ, Bourne RB, Rorabeck CH. Validation of two and three-dimensional radiographic techniques for measuring wear after total hip arthroplasty. *J Bone Joint Surg Am.* 2003; 85:505–511.
17. Kawamura H, Dunbar MJ, Murray P, Bourne RB, Rorabeck CH. The porous coated anatomic total hip replacement. A ten to fourteen-year follow-up study of a cementless total hip arthroplasty. *J Bone Joint Surg Am.* 2001;83:1333–1338.
18. Kelley SS, Lachiewicz PF, Hickman JM, Paterno SM. Relationship of femoral head and acetabular size to the prevalence of dislocation. *Clin Orthop Relat Res.* 1998;355:163–170.
19. Lachiewicz PF, Hubbard JB, Soileau ES. Polyethylene wear and osteolysis with a new modular titanium acetabular component. Results at 7 to 13 years. *J Arthroplasty.* 2008;23:971–976.
20. Latimer HA, Lachiewicz PF. Porous-coated acetabular components with screw fixation. Five to ten-year results. *J Bone Joint Surg Am.* 1996;78:975–981.
21. Livermore J, Ilstrup D, Morrey B. Effect of femoral head size on wear of the polyethylene acetabular component. *J Bone Joint Surg Am.* 1990;72:518–528.
22. Maloney WJ, Herzwurm P, Paprosky W, Rubash HE, Engh CA. Treatment of pelvic osteolysis associated with a stable acetabular component inserted without cement as part of a total hip replacement. *J Bone Joint Surg Am.* 1997;79:1628–1634.
23. Martell JM, Berkson E, Berger R, Jacobs J. Comparison of two and three-dimensional wear analysis after total hip arthroplasty. *J Bone Joint Surg Am.* 2003;85:1111–1117.
24. Massin P, Schmidt L, Engh CA. Evaluation of cementless acetabular component migration. An experimental study. *J Arthroplasty.* 1989;4:245–251.
25. Min BW, Song KS, Kang CH, Won YY, Koo KH. Polyethylene liner failure in second-generation Harris-Galante acetabular components. *J Arthroplasty.* 2005;20:717–722.
26. Parvizi J, Sullivan T, Duffy G, Cabanela ME. Fifteen-year clinical survivorship of Harris-Galante total hip arthroplasty. *J Arthroplasty.* 2004;19:672–677.
27. Rohrl SM, Nivbrant B, Snorrason F, Karrholm J, Nilsson KG. Porous-coated cups fixed with screws. A 12-year clinical and radiostereometric follow-up study of 50 hips. *Acta Orthop.* 2006;77:393–401.

28. Soto MO, Rodriguez JA, Ranawat CS. Clinical and radiographic of the Harris-Galante cup. Incidence of wear and osteolysis at 7 to 9 years follow-up. *J Arthroplasty*. 2000;15:139–145.
29. Sychterz CJ, Yang AM, McAuley JP, Engh CA. Two-dimensional versus three-dimensional radiographic measurements of polyethylene wear. *Clin Orthop Relat Res*. 1999;365:117–123.
30. Udomkiat P, Dorr LD, Wan Z. Cementless hemispheric porous-coated sockets implanted with press-fit technique without screws: average ten-year follow-up. *J Bone Joint Surg Am*. 2002;84:1195–1200.
31. Werle J, Goodman S, Schurman D, Lannin J. Polyethylene liner dissociation in Harris-Galante acetabular components. A report of 7 cases. *J Arthroplasty*. 2002;17:78–81.