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Revision of the Acetabulum With a Contemporary Cementless Component

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Abstract: We evaluated the performance of a contemporary cementless acetabular component at a minimum of 5 years postoperatively. One hundred eighty-seven consecutive acetabular component revisions were performed using a hemispherical porous-coated component. Patients were followed prospectively with radiographs and Harris hip scores. Twenty patients died, leaving 158 patients (166 hips) available for follow-up at a mean of 91 months. No patients were lost. Eleven acetabular components (7%) required repeated revision, including 4 (2%) for aseptic loosening. Seven of the 145 unrevised acetabular components with radiographic follow-up (5%) were loose. The results of acetabular revision with this contemporary acetabular component were good but inferior to those of earlier-generation implants. This difference is likely multifactorial. **Keywords:** acetabular revision, cementless fixation, outcome.

Acetabular component revision using a cementless acetabular component has been demonstrated to have excellent durability in both intermediate [1-8] and long-term [9-16] outcome studies, with lower rates of failure than have been observed when a cemented acetabular component was used [17-21]. The implants studied in prior reports, however, are largely no longer in use. As implant design and surgical techniques evolve, these changes can be met with unexpected deleterious effects.

The Trilogy acetabular component (Zimmer, Warsaw, IN) is a third-generation implant in the line of cementless components that began with the Harris-Galante (HG)–I component upon which most of the previous large series in the literature are based [3,4,6,8,10,16,22,23]. In comparison with its predecessors, the Trilogy component has a more secure locking mechanism, a smoother inner surface, and an increased thickness of the metal shell itself. The purpose of this study was to report midterm outcome data on a large series of revision hip arthroplasties using a single modern cementless acetabular component to determine the longevity of a commonly used implant.

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Materials and Methods

Sample

We prospectively followed a consecutive series of revision hip arthroplasties performed between May 1994 and December 2000 by 4 surgeons at a single center using a cementless acetabular implant coated with porous titanium mesh (Trilogy, Zimmer). One hundred seventy-eight patients who underwent 187 acetabular revisions were included in the study. There were 107 women (60%) and 71 men (40%) in the cohort, who at the time of the index revision had a mean age of 62.0 years (range, 27-89 years). The mean body mass index was 27.6 (range, 18.5-49.4).

An isolated acetabular component revision was performed in 60 hips (32%), and the remaining patients underwent revision of both components. The index revision was the first in 155 hips (83%), the second in 29 hips (16%), and the third in 3 hips (2%). The reasons for index revision included aseptic loosening of both components in 72 (39%), aseptic loosening of the acetabular component only in 58 (31%), failed hemiarthroplasty in 23 (12%), acetabular osteolysis/wear in 17 (9%), instability with component malposition in 7 (4%), failed surface arthroplasty in 5 (3%), second-stage reimplantation after infection in 2 (1%), and 1 each (<1%) for acetabular implant breakage, acetabular loosening with femoral periprosthetic fracture, and pain. The acetabular component being revised had been cemented in 79 hips (42%) and cementless in 108 hips (58%). Preoperative radiographs were classified using the system of Paprosky et al [24]. There were 23 (12%) type I defects, 61 (33%) type IIA defects, 48 (26%) type IIB defects, 17 (9%) type IIC defects, 30 (16%) type IIIA defects, and 4 (2%) type IIIB defects. Preoperative radiographs were not available for review in 4 hips.

In the 127 combined acetabular and femoral revisions, cementless femoral components were used in 103 hips (81%) and cemented components in 24 hips (19%, Table 1). In the 60 isolated acetabular revisions, cementless stems were retained in 46 hips (77%) and cemented stems in 14 hips (23%). An extended trochanteric osteotomy was used in 56 (44%) of the 127 revisions that included revision of the femoral component.

Surgical Technique/Materials

The surgical technique included underreaming of the acetabulum by 2 mm and the use of a mean of 2.9 screws for adjunctive fixation (range, 0-6 screws). The mean acetabular shell size was 61 mm (range, 50-80 mm). The head sizes used were 28 mm in 88%, 32 mm in 11%, and 22 mm in 1%. The acetabular liners consisted of standard ultra high molecular weight polyethylene that was compression molded with 1050 resin, machined, and gamma-irradiated in nitrogen. These were neutral in 54%, 20° lipped in 25%, 10° lipped in 17%, and 7° lipped in 2%. Structural femoral head allograft was used in 1 hip, and morselized cancellous allograft was used in 105 hips (56%) to fill cavitary defects. No autograft was used.

Patient Evaluation

Patients were evaluated preoperatively, postoperatively, and during yearly follow-up visits. The Harris hip score was used to assess pain and overall function [25]. Scores were considered excellent if greater than 90, good if 80 to 89, fair if 70 to 79, and poor if less than 70. Standard radiographs consisted of an anteroposterior pelvis film, as well as anteroposterior and true lateral films of the proximal femur. Radiographs were evaluated by 2 orthopedic surgeons who were not directly involved with the original operative procedures. The 6-week postoperative anteroposterior pelvis radiograph was considered the reference radiograph for acetabular evaluation, to which all subsequent radiographs were compared. The system used for assessing the acetabulum in follow-up radiographs has been previously described [26,27] using a variation of the zones of DeLee and Charnley [28]. Briefly, 5 zones of the acetabulum were identified: A1, A2, B1, B2, and C. Implants were considered loose if there was 2 mm of component migration, a change in component position of 2° or more, or broken screws. Cementless femoral component loosening was defined according to the criteria of Engh et al [29]; and cemented femoral component loosening, according to the criteria of Harris and McGann [30]. As previously described by Archibeck et al [31], *osteolysis* was defined as a nonlinear radiolucency in any zone around the acetabulum or about a fixation screw and classified as small (<1 cm diameter in its largest dimension) or large (>1 cm diameter in any dimension) and by location.

Table 1. Femoral Components Used in Combined Revisions

Cementless	n	Cemented	n
AML Fullcoat ≥8″ *	31	Harris Precoat *	14
Versys Fullcoat ≥8″ *	25	Anatomic *	3
Versys Fullcoat 6″ *	21	Impaction grafting	3
AML Fullcoat 6″ †	15	Central line	2
Versys Midcoat †	4	Omnifit ‡	1
ZMR Modular	4	Calcar replacing §	1
Allograft-prosthetic component	2		
Calcar replacing §	1		
Total	103	Total	24

* Zimmer, Warsaw, IN.
† DePuy, Warsaw, IN.
‡ Osteonics, Stryker Howmedica, Mahwah, NJ.
§ Manufacturer unknown.

Statistical Methods

SPSS for Windows (Version 15; SPSS, Chicago, Ill) was used for data management and statistical analysis. The log-rank test was performed to compare independent groups with respect to time to radiographic acetabular loosening without revision or acetabular revision for aseptic failure and time to radiographic stem loosening without revision or stem revision for aseptic failure. Cox proportional hazards regression was carried out to investigate relationships between these variables and clinical and demographic variables. These included preoperative Paprosky acetabular deficiency, sex, age at surgery, body mass index, number of previous hip arthroplasties, previously cemented as opposed to a cementless acetabular implant, number of screws, type of bone grafting, cemented as opposed to cementless femoral component, and isolated acetabular as opposed to a revision of both components. The Friedman test was performed to compare the preoperative and most recent Harris hip scores. To avoid violations of the assumption of statistical independence, all statistical tests were carried out using only 1 hip per patient. For each patient with bilateral revisions, the first hip revised was used in the analysis, with the exception of 1 patient for whom the second hip was selected because the revision for this hip failed. A .05 significance level was used for all statistical tests. No 1-sided tests were done.

Kaplan-Meier survivorship analysis [32] was performed with the following end points: (1) repeated revision for aseptic loosening, (2) repeated revision for aseptic loosening or radiographic evidence of definite loosening, (3) repeated revision for any reasons. Patients were censored at the time of death, at the time of final follow-up, and at the time of revision for reasons other than the ones included in the end point. All hips were included in the Kaplan-Meier curves because these did not involve any statistical tests or confidence intervals (which would have required independent data).

Results

At a minimum of 5 years postoperatively, 20 patients (21 hips) had died; and 11 hips in 10 patients underwent repeated revision. This left 148 patients (155 hips) remaining in the study for follow-up at a mean of 91 months (range, 60-141 months); no hips were lost to follow-up. Clinical and radiographic follow-up was available on 139 patients (145 hips). Clinical follow-up only was available on 10 patients (ten hips) who were unable or unwilling to obtain radiographs.

Clinical Results

The mean Harris hip score of the hips that remained in the study improved from 57 points (range, 21-93) to 85 points (range, 25-100) at the time of final follow-up ($P < .001$). Of the 155 hips, 120 (77%) had good or excellent results, 14 had fair results (9%), and 21 (14%) had poor results. Of the 21 with poor Harris hip scores, 8 identified their affected hip as the main cause of their disability. The remaining 13 were limited by either other orthopedic conditions or medical comorbidities. Of these 13, 6 described their hip as not painful, 2 as slightly painful, 4 as mildly painful, and 1 as moderately painful. Of the 8 whose hip was the main source or disability, 4 were still satisfied with their hip arthroplasty.

Reoperations

Thirty-one of the 187 hips underwent a reoperation (16%), 11 of which (6%) were repeated acetabular revisions. Four of the repeated revisions (2%) were for aseptic loosening, 4 (2%) were for infection, and 1 each was performed for instability (secondary to component malpositioning), osteolysis, and a periprosthetic fracture of the pelvis. These last 3 components were all found to be well fixed at the time of reoperation. The acetabular revisions for aseptic loosening were performed at 22, 26, 50, and 86 months after the index revision.

Eleven (6%) of the femoral stems required repeated revision. Seven of these (4%) were revised for aseptic loosening and 4 (2%) for infection. The femoral revisions for aseptic loosening took place at a mean of 64 months postoperatively (range, 12-124 months).

In addition to these revisions, there were 17 reoperations in 13 hips (11%) in which the acetabular and femoral components were retained. These reoperations included 5 (3%) revisions to constrained liners for recurrent instability, 3 (2%) trochanteric hardware removals, 3 (2%) soft tissue releases, 2 (1%) irrigation and debridements for superficial infection, and 1 each of irrigation and debridement of postoperative hematoma, trochanteric reattachment, heterotopic bone resection, and grafting for pelvic osteolysis.

Radiographic Analysis

Of the 145 acetabular components that remained in the study and were available for radiographic follow-up, 123 (95%) were stable and 7 (5%) were loose (Fig. 1). Of the 7 classified as loose, all 7 showed evidence of component migration and thus failed to ingrow after the index procedure. Radiolucent lines were common, with 99 of 145 hips (68%) having a line present.

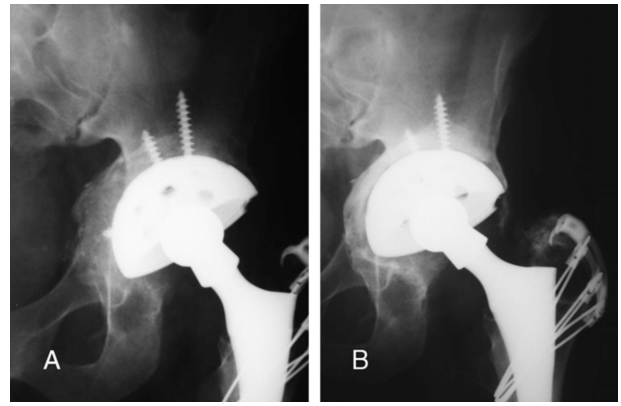

Fig. 1. Anteroposterior radiographs at (A) 6 weeks and (B) 60 months postoperatively demonstrating definite radiographic loosening of the acetabular component with a complete radiolucent line and component migration.

Pelvic osteolysis was detected in 14 (10%) of the 145 hips. This included 6 (4%) large retroacetabular, 3 (2%) large peripheral, 2 (2%) small retroacetabular, and 3 (2%) small peripheral osteolytic lesions. For the femoral components, 143 (99%) were stable and 2 (1%) were loose. Of the 9 stems that either were revised for aseptic loosening or were radiographically loose, 4 were cemented stems placed at the time of index revision, 4 were cementless stems placed at the time of index revision, and 1 was a cemented stem from the original total hip arthroplasty that was retained at index revision.

Survivorship Analysis

With failure defined as radiographic loosening or component revision secondary to aseptic loosening, Kaplan-Meier survivorship was 92.5% for the acetabular (Fig. 2) and 95.7% for the femoral components at 8 years. The survivorship of the revision total hip arthroplasty with the end point defined as revision of the acetabular or femoral component for any reason was 89.4% at 8 years.

Regression Analysis

The only variable that was found to be predictive of failure of the acetabular component secondary to loosening using backward elimination was the number of prior revisions ($P = .001$). The Paprosky classification was statistically significant if used as the only independent variable in a Cox regression model ($P = .015$). When the same variables were used to predict femoral component failure, none of the variables were statistically significant in the final Cox regression model obtained by backward elimination.

Discussion

Several series have demonstrated excellent survivorship of first-generation cementless acetabular implants

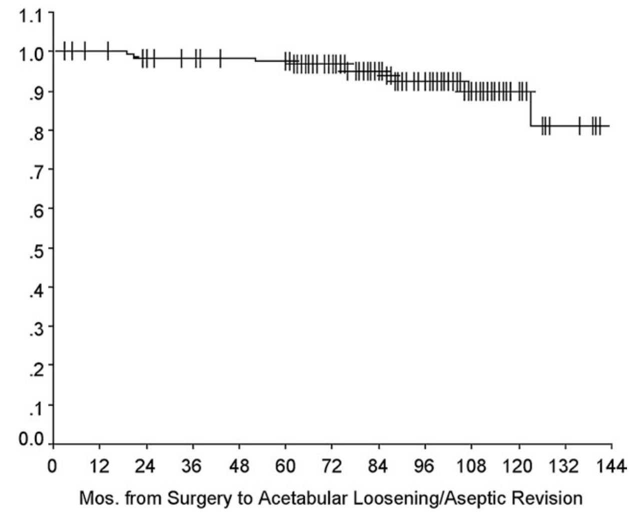

Fig. 2. Kaplan-Meier curve for acetabular component survivorship with revision for aseptic loosening or definite radiographic loosening as the end point. Survivorship was 92.5% at 96 months.

when used to revise a failed acetabular component after similar follow-up periods as this study. Silverton et al [6], as a follow-up on the original series of Padgett et al [4], reported on 115 HG-1 prostheses at a mean of 100 months and reported no cases of revision for aseptic loosening or definite radiographic loosening. Della Valle et al [10] reported a minimum of 15-year follow-up on this cohort, with 97% survivorship at 15 years when revision for loosening or radiographic evidence of loosening was used as the end point. Weber et al [8] in a series of 61 revision hips using the HG-1 component at a mean of 74 months reported no acetabular revisions for aseptic loosening and 1 radiographically loose acetabular component (2%). In a follow-up on this same cohort by Templeton et al [16] at a mean of 12 years, there had been no acetabular revisions for aseptic loosening, with a 3% rate of definite radiographic loosening.

Lachiewicz and Poon [3] reported on 57 revision hips using the HG acetabular component at a mean of 7 years, including 11 cases in which bulk structural allograft was required. At the time of latest follow-up, there had been no revisions for aseptic loosening; and none of the components were radiographically loose. The cohort reported on by Tanzer et al [23] and Hallstrom et al [12] showed somewhat higher rates of failure using HG acetabular implants at long-term follow-up. The first report followed 132 patients for a mean of 41 months and had 2 acetabular failures (1%) for aseptic loosening; both failures were associated with a pelvic discontinuity. The follow-up report of Hallstrom et al at a mean of 12 years revealed a 4% revision rate for aseptic loosening and a 7% rate of definite radiographic loosening; thus, the total aseptic failure rate was 11%.

The present report demonstrates acetabular survivorship that is further evidence of improved results of cementless vs cemented fixation in the setting of acetabular revision surgery [3,4,8,17-21,23]. However, our results are inferior to those using earlier-generation implants. The 4 large series above followed nearly 350 patients at midterm follow-up length similar to this series, with only 2 cases of revision for aseptic loosening (0.6%) and 1% definite radiographic loosening, compared with 2% and 5%, respectively, in our series.

Our study demonstrates increased failure with increased case complexity (both the number of prior revisions and the Paprosky classification were predictive of failure); and thus, increased case complexity could explain these findings. However, differences in the implant design and the surgical technique may also be responsible for the observed differences with prior reports. The Trilogy component has a thicker wall to accommodate a more secure locking mechanism when compared with the HG-1 acetabular component. The increased stiffness of the component could have led to increased stress shielding and decreased stress transfer to host bone with resultant deleterious effects on bone remodeling and ingrowth. The surgical technique used was also different than has been reported for prior series, with underreaming of acetabulum by 2 mm as opposed to line-to-line insertion of the metal shell. Although underreaming increases initial press-fit stability, it may prevent full seating of the component at the acetabular dome, with a resultant decrease in contact between the ingrowth surface and host bone. Finally, fresh frozen cancellous allograft bone was used to fill contained defects in the present series, whereas autograft was used in prior reported series [3,4,8,23]. It is possible that the increased osteoinductivity of autograft bone could have led to the higher rates of successful bone ingrowth in prior series.

Although not the main focus of this study, the femoral components used in this study showed excellent initial component fixation and intermediate-term durability, with 95.7% survivorship at 8 years. Although there was variation in the components used, cementless extensively porous-coated stems with distal fixation were used in 92 (72%) of the combined acetabular and femoral revisions; and only 3 of these cementless components (3%) required repeated revision for loosening, and only 1 additional component was radiographically loose. These results are in agreement with previous series [33-36] that have shown greater than 90% survivorship at mid- and long-term outcome for femoral revision using cementless stems with distal fixation.

To our knowledge, this series represents the largest comprehensive series of clinical and radiographic follow-up of cementless revision acetabular arthroplasty in the literature to date; and we believe that, with 100% follow-up, our results are reliable. This is also the only large series investigating specifically a modern, third-generation implant. We demonstrate good survivorship of both the acetabular and femoral components, but acetabular failure rates that appear higher than those of series using the earlier-generation implants.

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