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.

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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.
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%)  
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, postopera-
tively, 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, 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.

**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 Papsky 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 survival 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).

**Table 1. Femoral Components Used in Combined Revisions**

<table>
<thead>
<tr>
<th>Component</th>
<th>Cemented n</th>
<th>Total n</th>
</tr>
</thead>
<tbody>
<tr>
<td>AML Fullcoat ≥8° *</td>
<td>31</td>
<td>14</td>
</tr>
<tr>
<td>Versys Fullcoat 28°*</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Versys Fullcoat 6°*</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>AML Fullcoat 6°†</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Versys Midcoat†</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>ZMR Modular</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Allograft-prosthetic component</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Calcar replacing§</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>24</td>
</tr>
</tbody>
</table>

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

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...
Cementless Acetabular Revision

That is further evidence of improved results of cementless surgery. 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 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.

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.
the acetabular and femoral components, but acetabular failure rates that appear higher than those of series using the earlier-generation implants.

References


