Revision of a Cemented Acetabular Component to a Cementless Acetabular Component : A Ten to Fourteen-Year Follow-up Study

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J Bone Joint Surg Am. 2001;83:1706-1711.

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A Ten to Fourteen-Year Follow-up Study

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Background: Although cementless acetabular components are routinely used in revision hip surgery, few investigators have evaluated the retention and efficacy of these components in the long term. In the current study, the clinical and radiographic outcomes of a series of arthroplasties performed by one surgeon with a cementless acetabular component were assessed at a minimum of ten years.

Methods: From 1986 through 1988, sixty-one consecutive revision total hip arthroplasties were performed in fifty-five patients because of aseptic failure of one or both components of a prosthesis in which both components had been cemented. Twenty-eight patients (thirty-two hips) were alive at a mean of 12.9 years (range, 11.5 to 14.3 years) after the operation. In all of the patients, the acetabular component was revised to a porous-coated Harris-Galante component inserted without cement, and the femoral component was revised to an Iowa component affixed with contemporary cementing techniques. The hips were evaluated clinically and radiographically at a minimum of ten years subsequent to the index revision. No hips were lost to follow-up.

Results: None of the acetabular components required revision because of aseptic loosening. Two hips (3%) demonstrated radiographic evidence of aseptic loosening of the acetabular component. The polyethylene liner was exchanged during the follow-up period in eight hips.

Conclusion: After a minimum of ten years of follow-up, cementless acetabular fixation in revision hip arthroplasty had produced durable results that were markedly better than those reported for acetabular fixation with cement.

Cementless acetabular fixation became popular because of concern about the longevity of cemented acetabular components. Although intermediate-term studies (those with five or more years of follow-up) have demonstrated reductions in the prevalences of acetabular osteolysis and mechanical failure with the use of cementless acetabular components[1-14], long-term data (after ten or more years of follow-up) on cementless acetabular fixation in primary and revision total hip arthroplasties are only now becoming available[15,16].

The purpose of the current study was to update the data on a consecutive series of revision total hip arthroplasties with cementless acetabular fixation, performed by the senior author (R.C.J.), that had been previously reported on at a minimum of five years[13]. We hoped to answer the following question: Is cementless acetabular fixation more durable than fixation with cement in revision hip surgery?

Materials and Methods

Between January 22, 1986, and November 17, 1988, the senior author performed seventy consecutive so-called hybrid revision total hip arthroplasties in sixty-four patients at Methodist Hospital in Des Moines, Iowa. The criteria for inclusion in the study was a revision of both components secondary to mechanical failure of a cemented total hip prosthesis. Nine patients (nine hips) who had undergone conversion of a surface replacement or a bipolar hemiarthroplasty to a total hip arthroplasty or who had had revision of only one component because of aseptic loosening were therefore excluded from the study. Thus, fifty-five patients with sixty-one involved hips formed the study population.

All acetabular components were replaced with a porous-coated Harris-Galante-I hemispherical acetabular cup (Zimmer, Warsaw, Indiana), inserted without cement and with supplemental fixation by two or three 5.1-mm titanium screws through the dome. The acetabular component was impacted into a reamed bed of the same diameter (line-to-line fit). It was impacted into viable bone even if it required placing the component in a high-hip-center position (that is, with the hip center >30 mm proximal to the interteardrop line). Fourteen (23%) of the sixty-one components were placed in this high-hip-center position. No structural bone grafts were used, and only autograft bone produced by the reaming was

used to fill cavitary defects. All femoral components were replaced with an Iowa precoated, grit-blasted femoral component (Zimmer, Warsaw, Indiana), inserted with use of contemporary cementing techniques (that is, a distal cement plug and a cement gun delivery system).

At the time of the index revision, the study population included thirty-one men (56%) and twenty-four women (44%) who were, on the average, 67.6 years of age (range, thirty-nine to eighty-nine years of age). The average height was 168 cm (range, 150 to 185 cm), and the average weight was 80 kg (range, 40 to 109 kg).

Thirty-one index revisions (51%) were performed on the right hip and thirty (49%), on the left. The indication for the revision was aseptic loosening in fifty-six hips (92%), fracture of the femoral stem in three (5%), and recurrent dislocation in two (3%). The index procedure was the first revision in forty-nine hips (80%), the second in ten (16%), and the third in two (3%).

Of the original fifty-five patients (sixty-one hips), twenty-eight (thirty-two hips) were alive at the time of the current study and twenty-seven (twenty-nine hips) had died from causes unrelated to the index revision.

The living cohort included fourteen men (50%) and fourteen women, whose average age at the revision was 64.2 years (range, thirty-nine to seventy-six years). Their average height was 166 cm (range, 140 to 185 cm), and their average weight was 74 kg (range, 49 to 102 kg). Thirty (94%) of the thirty-two hips were revised because of aseptic loosening, and two (6%) were revised because of a fracture of the femoral component. Prior to the index revision, twenty-eight hips (88%) had not been revised previously, three (9%) had been revised once, and one (3%) had been revised twice.

Clinical Evaluation

Clinical results regarding pain, function, and satisfaction were reported for the twenty-eight living patients (thirty-two hips), all of whom had been followed for at least ten years (average, 12.9 years; range, 11.5 to 14.3 years). Clinical outcomes were assessed with use of telephone interviews, conducted by one individual with a questionnaire employing standard terminology[17]. All patients, some with help from their family, were able to answer the questionnaire.

Clinical results regarding complications and repeat revisions were reported for all fifty-five patients (sixty-one hips) in the study group. Relatives of twelve patients (fourteen hips) who had died subsequent to the minimum five-year follow-up interval were interviewed by telephone, and this information was used to identify complications and repeat revisions.

Radiographic Evaluation

Current radiographs were available for thirty hips in twenty-seven living patients, who were followed for an average of 12.8 years (range, 10.2 to 14.2 years) subsequent to the index revision. One living patient (two hips) declined radiographic evaluation; his most recent radiograph, made at five years, demonstrated maintenance of the fixation of the acetabular and femoral components. None of the thirty acetabular components that were examined radiographically had been revised subsequent to the index procedure.

Two of us examined the most recent of the available anteroposterior radiographs of the pelvis. For each patient in the study, these radiographs were compared with the corresponding preoperative and serial postoperative radiographs, with particular attention given to the immediate postoperative radiograph.

Preoperative radiographs of all of the patients were evaluated for osseous deficiencies of the acetabulum with use of a modification of the system developed by the American Academy of Orthopaedic Surgeons[18]. Segmental, cavitary, and combined defects of the acetabular bone stock exceeding 2 cm in width were recorded.

Pelvic osteolysis of >5 mm^2 and radiolucency at the bone-prosthesis interface were evaluated with respect to the three zones of the acetabulum described by DeLee and Charnley[19].

The technique proposed by Massin et al.[20] was used to determine the placement of the hip center in relation to the interteardrop line and to measure migration of the acetabular component. Migration of the acetabular component was defined as a change in the vertical or horizontal position of the hip center of >5 mm. A coefficient, the ratio of the actual and measured widths of the femoral head, was calculated for each radiograph of interest and was used to adjust all measurements for magnification.

Digital edge-detection measurement, described by Shaver et al.[21], was used to calculate linear and volumetric acetabular wear. Linear acetabular wear was defined as penetration of the femoral head into the acetabular liner or shell. All hips with a minimum of two years of radiographic follow-up were included in this analysis.

The femoral cementing technique was graded in accordance with the criteria of Barrack et al.[22]. Femoral osteolysis of >5 mm^2 and radiolucency at the bone-cement interface of the femoral component were localized with respect to the seven zones described by Gruen et al.[23]. Radiographic loosening of the femoral component was classified according to the system of Harris and McGann[24]. The greater trochanter was noted to be united, ununited and stable, or ununited and migrated. Heterotopic ossification was classified with the scheme of Brooker et al.[25].

Subsidence of the femoral component, defined by Loudon and Charnley[26], was noted when an increase of ≥ 5 mm in the vertical distance from the tip of the femoral stem to the drill-hole for the trochanteric reattachment wire in the lateral cortex was observed.

Debonding was noted when any separation of the femoral stem from the surrounding cement mantle was seen.

Data Analysis

The Wilcoxon rank-sum test was used to test the correlation of acetabular wear (linear and volumetric) with gender, preoperative femoral osteolysis, and preoperative acetabular osteolysis. The Spearman correlation was used to assess wear as a

function of age at the index revision. The Fisher exact test (two-tailed) was used for all other comparisons. The prescribed level of significance was $\alpha = 0.05$ for all statistical tests.

Kaplan-Meier survivorship analysis[27] was used to estimate the probability of component retention as a function of time since the index revision. Survivorship analyses were performed for the following end points: (1) repeat revision of the acetabular component because of aseptic loosening; (2) radiographic evidence of probable or definite aseptic loosening of the acetabular component, including that precipitating repeat revision; and (3) removal or repeat revision of the acetabular or femoral component for any reason. Survivorship statistics were reported with corresponding measurements of standard error.

Results

Clinical Results

At the latest follow-up evaluation, fifteen (47%) of the thirty-two hips were pain-free, ten (31%) were occasionally mildly painful, and seven (22%) were moderately painful, requiring the patient to modify or avoid certain activities. The study group reported a mean pain index of 2.7 (range, 0 to 8) on an analog scale of 0 to 10, with 0 indicating a complete absence of pain and 10 indicating extreme pain. Eighteen patients (twenty hips; 63%) used medication to alleviate hip pain. Of these patients, sixteen (seventeen hips; 85%) experienced substantial relief as a result of the medication, one (two hips; 10%) experienced only minimal relief, and one (one hip; 5%) did not specify whether pain was relieved. Ten patients (twelve hips; 38%) did not use analgesics specifically for the treatment of hip pain. Overall, twenty-six patients (thirty hips; 94%) stated that their pain and dependence on analgesics had decreased as a result of the index hybrid revision.

Of the twenty-five patients (twenty-nine hips) who responded to questions about the ability to walk, thirteen patients (fifteen hips; 52%) could walk without support for an unlimited amount of time, two patients (three hips; 10%) could walk for eleven to thirty minutes before experiencing major pain, five patients (five hips; 17%) could walk for two to ten minutes, two patients (two hips; 7%) could walk for less than two minutes or indoors only, and three patients (four hips; 14%) could not walk for any duration in the absence of support. Three patients (three hips) did not comment on their ability to walk. At the most recent follow-up evaluation, fourteen patients (sixteen hips; 50%) did not require ambulatory support, four patients (five hips; 16%) used a cane on long walks only, nine patients (ten hips; 31%) needed full-time support, and one patient (one hip; 3%) was bedridden.

Overall, of the twenty-seven patients (thirty hips) responding to questions regarding function, who were followed clinically for an average of 12.9 years, twenty-six patients (twenty-nine hips; 97%) stated that the index hybrid revision had increased their level of function and twenty-six patients (twenty-nine hips) were satisfied with the result of the operation. One patient (one hip; 3%), an eighty-one-year-old woman with a pain index of 8, was dissatisfied with the result of the revision. One patient with bilateral revision did not comment.

Radiographic Results

Of the thirty hips (twenty-seven patients) with complete radiographic follow-up, seventeen (57%) had had osseous deficiencies of >2 cm on preoperative radiographs. Eleven acetabula (37%) demonstrated cavitary defects; five (17%), segmental defects; and one (3%), combined segmental and cavitary defects. Osseous deficiencies were absent or unremarkable in thirteen acetabula (43%).

Immediate postoperative radiographs revealed acetabular radiolucencies in twenty-four hips (80%). The radiolucencies involved one zone in seven hips (23%), two zones in ten (33%), and three zones in seven (23%). At the time of the review, acetabular radiolucencies were present in twenty-five hips (83%) and involved one zone in four hips (13%), two zones in eleven (37%), and three zones in ten (33%). Twenty-one hips (70%) demonstrated persistent radiolucencies (that is, present on the immediate and most recent postoperative radiographs), seventeen hips (57%) had new radiolucencies, and sixteen hips (53%) had both. No hip demonstrated global acetabular radiolucencies that included the area of the screws.

Comparison of the placement of the hip center on the immediate postoperative and most recent radiographs demonstrated migration and definite loosening of one acetabular component (3%). It should be noted, however, that this patient reported no functional deficit, pain, or other complications in association with the index revision. One other patient, who had died, had had migration of the acetabular component at three months with no additional migration during the 9.8 remaining years of her life.

The most recent radiographs demonstrated osteolysis in four acetabula (13%). The osteolysis involved one zone in three hips (10%) and three zones in one (3%).

Definite aseptic loosening of the femoral component was observed in two hips (7%); probable loosening, in no hips; possible loosening, in one (3%); and no loosening, in twenty-two (73%). Five hips (17%) had been revised after the index revision for aseptic femoral loosening. Thus, including those five hips and the two unrevised hips with evidence of definite loosening, the overall rate of femoral loosening in living patients was 23%.

Repeat Revisions

At the time of the review, repeat revision had been performed in thirteen (21%) of the sixty-one hips in the original cohort. Of these thirteen hips, six were revised because of aseptic loosening of the femoral component. During three of these femoral revisions the polyethylene liner was also exchanged, and during one the constrained liner was cemented into the intact acetabular shell. Four hips had revision of the femoral component because of recurrent dislocation; the acetabular liner was exchanged during two of these procedures, and the

constrained liner was cemented into the intact acetabular shell during the other two. One of these hips was revised again because of dissociation of the constrained acetabular liner, and the repeat revision involved cementing of an elevated liner into the intact acetabular shell. Hence, overall five liners were exchanged and three constrained polyethylene liners were cemented into intact acetabular shells. In one additional hip, a lateral lip polyethylene augmentation was added to the existing liner because of recurrent dislocation. Two Girdlestone procedures were performed. One, performed because of recurrent dislocation, entailed removal of the femoral head only; the acetabular component and the femoral stem were secure and were left in place. Septic loosening of both components was the indication for the second Girdlestone procedure. The time until repeat revision (of any kind) averaged 5.0 years (range, three months to 12.0 years), and the time until repeat revision of a loose femoral component averaged 6.8 years (range, 1.1 to 10.3 years).

Statistical Analyses

Correlates of Linear and Volumetric Acetabular Wear

The mean rate of linear acetabular wear was 0.145 mm/yr (range, 0.000 to 0.392 mm/yr) and the mean rate of volumetric wear was 48.1 mm^3/yr (range, 0.000 to 148.7 mm^3/yr) for

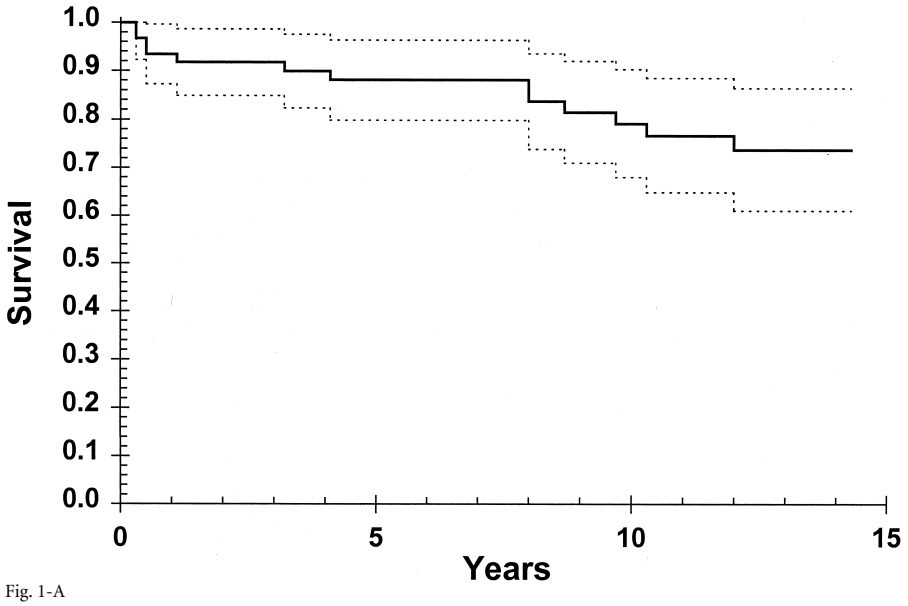

Fig. 1-A

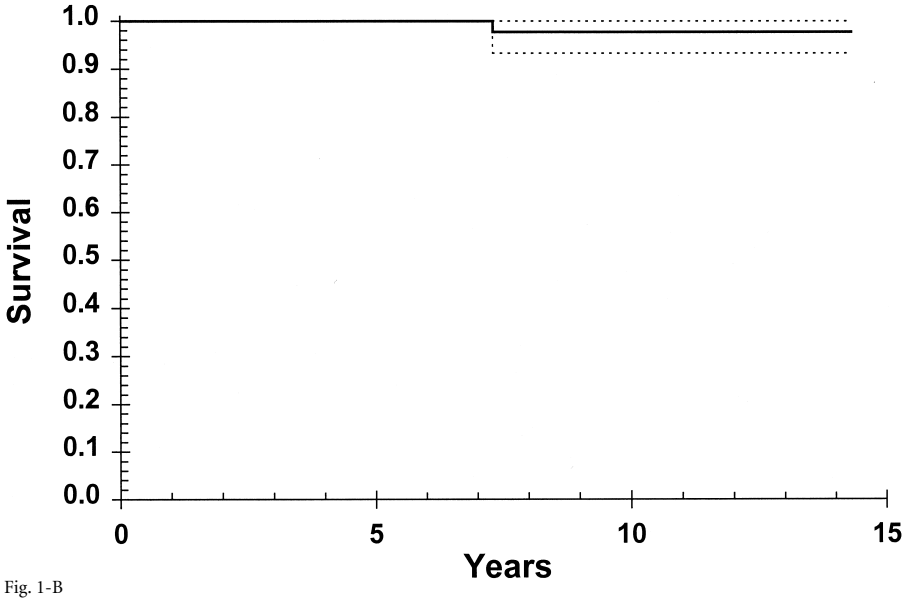

Fig. 1-B

Survivorship curves as determined with the Kaplan-Meier method[27] with revision of either component for any reason (Fig. 1-A) and definite or probable acetabular loosening (Fig. 1-B) as the end points.

the thirty-seven hips (twenty-seven in living patients and ten in patients who had died) that had been followed radiographically for a minimum of two years. The acetabular components in male patients demonstrated significantly greater rates of linear wear ($p = 0.005$) and volumetric wear ($p = 0.006$) than did the acetabular components in female patients. Furthermore, the rates of linear ($p = 0.031$) and volumetric ($p = 0.019$) wear were significantly greater in hips exhibiting femoral osteolysis but were not significantly different in hips exhibiting acetabular osteolysis ($p = 0.791$). There was no significant correlation between age and either the linear wear rate ($r = 0.15$; $p = 0.384$) or the volumetric wear rate ($r = 0.21$; $p = 0.238$).

Survivorship Analysis

Overall survival, with removal or repeat revision of either component for any reason as the end point, was 79.2% ± 5.7% at ten years (Fig. 1-A). With failure defined as repeat revision of the acetabular component because of aseptic loosening, the rate of survival was 100% at ten years after the index revision. With an end point of definite or probable loosening of the acetabular component, the probability of survival at ten years was 97.7 ± 2.3% (Fig. 1-B).

Discussion

Although cementless acetabular fixation has been utilized in revision hip surgery for more than a decade, there is a paucity of ten-year follow-up studies[16]. Hence, the objective of the present study was to evaluate the durability of cementless acetabular fixation used in revision hip surgery and followed for a minimum of ten years. The present study is unique in that all of the index revisions were performed by the same surgeon, the femoral components were also revised, and the femoral and acetabular component designs were uniform across the study populations. Weaknesses of the study include the potential for intraobserver and interobserver variability in the interpretation of radiographs and the fact that the femoral component design (the grit-blasted 80-microinch Ra Iowa femoral component) had a relatively high failure rate[11].

After a minimum ten-year follow-up interval, none of the acetabular shells had been revised because of aseptic loosening. Two acetabular shells (3%) were noted to have migrated. One of these components migrated in the first three postoperative months, stabilized, and did not migrate further during the remainder of the patient's lifetime (9.8 years). The migration of the other component was detected only through the course of radiographic measurement; this component had stabilized subsequent to migration, and the patient was able to function without pain or other complications at twelve years. These results are comparable with those reported by Leopold et al., who followed a series of the same Harris-Galante-I devices for 10.5 years[16]. In the present series, despite a well-fixed acetabular shell, nine patients (nine hips) underwent additional procedures on the acetabulum: five underwent a liner exchange; three, cementing of a constrained liner; and one, lateral augmentation of the liner. One of the patients required an additional liner exchange because of dissociation of the constrained liner. Osteolysis was noted in four acetabula (13%), all of which were in living patients with at least ten years of radiographic follow-up. This prevalence of pelvic osteolysis is comparable with that reported by Leopold et al. (17%) in a series of 138 hips followed radiographically for an average of 10.5 years[16]. Linear acetabular wear (femoral head penetration) averaged 0.145 mm/yr in the present series.

These results represent a marked improvement compared with the results of the same surgeon using acetabular fixation with cement. As we previously reported[28], at a minimum of ten years after eighty-one acetabular revisions performed with cement by the senior author, eleven (14%) of the acetabular components were revised because of aseptic loosening and twenty-seven (33%) (including the revised cases) were loose radiographically. In the only other minimum ten-year follow-up study of cemented acetabular fixation of which we are aware, Estok and Harris reported rerevision of seven (22%) of thirty-two acetabular components and radiographic loosening in an additional six hips, for a total prevalence of loosening of 41% (thirteen of thirty-two)[29].

The results of cemented femoral fixation in our study group were not as encouraging, however, as 10% (six) of sixty-one femoral components were revised because of aseptic loosening and the total prevalence of femoral loosening was 15% (nine of sixty-one). These results did not represent an improvement compared with those in the senior author's previous series, in which 5% (four) of seventy-three femoral components were revised because of aseptic loosening and the total prevalence of femoral loosening was 16% (twelve of seventy-three)[28]. On the basis of these findings, additional investigation of cementless femoral components and impaction allografting with cement in revision surgery is warranted.

The findings of this study strongly support the continued use of cementless acetabular fixation in revision total hip arthroplasty as the durability of the fixation was better, after a minimum of ten years of follow-up, than that in series in which cemented acetabular fixation was utilized. The high polyethylene linear wear rate (0.145 mm/yr) and the relatively high prevalence of acetabular osteolysis (13% in living patients) will require further follow-up to determine their importance in terms of component durability. ■

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In support of their research or preparation of this manuscript, one or more of the authors received grants or outside funding (National Institutes of Health Grant AR43314). In addition, one or more of the authors

received payments or other benefits or a commitment or agreement to provide such benefits from commercial entities (Zimmer and DePuy). Also, commercial entities (Zimmer and DePuy) paid or directed, or agreed to pay or direct, benefits to a research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

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