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Revision Total Hip Arthroplasty with Retained Acetabular Component

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Background: Aseptic loosening and osteolysis commonly limit the survivorship of total hip prostheses. Retention of a well-fixed acetabular component, rather than full acetabular revision, has multiple advantages, but questions have lingered regarding the clinical success and prosthetic survivorship following this procedure. We examined the impact of acetabular component position, polyethylene type, liner insertion technique, femoral head size, and simultaneous revision of the entire femoral component (as opposed to head and liner exchange) or bone-grafting on mid-term to long-term prosthetic survival following such limited revisions.

Methods: One hundred hips in 100 patients with osteolysis, polyethylene wear, or femoral component loosening underwent revision total hip arthroplasty with retention of the acetabular component. Acetabular component inclination and anteversion were measured on prerevision radiographs and were categorized according to predetermined positional safe zones (inclination of 35° to 55° and anteversion of 5° to 25°). Operative reports were reviewed for femoral head size, polyethylene liner type (conventional or highly cross-linked), liner insertion technique (use of the existing locking mechanism or cementation), whether the patient had revision of the entire femoral component, and use of bone graft. Outcomes of interest included the Harris hip score, University of California at Los Angeles (UCLA) activity score, episodes of instability, and need for repeat revision.

Results: At an average of 6.6 years (range, two to fourteen years) postoperatively, the Harris hip and UCLA activity scores were both significantly improved compared with the preoperative scores ($p < 0.0001$ and $p < 0.01$, respectively). Overall, the failure rate was 13%. In addition, 6% of the patients had postoperative instability. Hips in which the acetabular component was outside of the safe zone for inclination had a higher rate of failure ($p = 0.048$). Use of conventional, rather than highly cross-linked, polyethylene at the time of revision was also associated with an increased rate of repeat revision ($p = 0.025$).

Conclusions: Revision total hip arthroplasty with retention of the acetabular component is associated with good outcomes in hips with an appropriately positioned, well-fixed acetabular component. Acetabular components outside the safe zone for inclination were at a higher risk for failure, as was use of conventional polyethylene.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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Although total hip arthroplasty is one of the most successful surgical interventions, the results can be compromised by infection, component malposition, and aseptic loosening. The major cause of aseptic failure is loosening, often secondary to osteolysis[1]. In patients with osteolysis detected prior to acetabular component loosening, retention of the acetabular component has multiple advantages, including decreased morbidity and preservation of pelvic bone stock[2-4]. Structurally stable lytic defects can be addressed with bone-grafting through screw holes or around the periphery of a well-fixed acetabular component[5]. Aggressive debridement and curettage of these lesions in combination with exchange of the

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TABLE I Postrevision Instability

Acetabular Inclination *(deg)*	Acetabular Anteversion *(deg)*	Femoral Head Size *(mm)*	Stem Revision	Rerevision	Failure: Reason	Failure: Time After Revision *(mo)*
46	22	22	No	No	Not applic.	Not applic.
48	37	36	Yes	No	Not applic.	Not applic.
35	3	28	No	No	Not applic.	Not applic.
35	40	26	No	Yes	Instability	1
53	8	36	Yes	Yes	Instability	3
62	33	32	No	Yes	Instability	13

polyethylene liner to a highly cross-linked polyethylene liner may be sufficient to halt the lytic process[5-7]. Proponents of this approach reserve full acetabular revision for patients with a loose or malpositioned acetabular component. Others, however, recommend full acetabular revision despite adequate component position and stability, citing higher rates of dislocation and rerevision with retention of the acetabular component[8-11].

The purpose of the current study was to determine the mid-term to long-term outcomes and prosthetic survivorship after revision total hip arthroplasty with retention of a well-fixed acetabular component in patients with pelvic osteolysis and/or polyethylene wear. We aimed to determine whether acetabular component position, polyethylene type, liner insertion technique, femoral head size, and simultaneous revision of the entire femoral component (as opposed to head and liner exchange) or bone-grafting are potential risk factors for failure.

Materials and Methods

Following approval by our institutional review board, our institution's joint replacement registry was reviewed for all cases of revision total hip arthroplasty performed from 1996 to 2008. Only those with a preoperative diagnosis of pelvic osteolysis, polyethylene wear, or aseptic loosening associated with osteolysis and/or substantial wear were included. Cases in which the acetabular component had been revised or acetabular component loosening had been documented were excluded. Patients were followed for a minimum of two years, or until rerevision or

TABLE II Review of Failures

Acetabular Inclination *(deg)*	Acetabular Anteversion *(deg)*	Polyethylene Type	Femoral Head Size *(mm)*	Stem Revision	Cemented Liner	Bone-Grafting	Failure: Reason	Failure: Time After Revision *(mo)*
35	40	Conventional	26	No	No	Yes	Instability	1
53	8	Highly cross-linked	36	Yes	Yes	No	Instability	3
62	33	Conventional	32	No	No	Yes	Instability	13
34	30	Conventional	26	No	No	Yes	Acetabular loosening	76
32	38	Conventional	28	No	No	Yes	Acetabular loosening	91
56	34	Highly cross-linked	28	No	Yes	No	Fractured liner	22
48	27	Conventional	28	No	No	Yes	Osteolysis	115
34	30	Conventional	28	Yes	No	Yes	Infection	40
38	24	Conventional	36	Yes	No	No	Femoral loosening	65
40	21	Conventional	28	No	No	Yes	Acetabular loosening	38
64	22	Conventional	36	No	No	Yes	Osteolysis	88
51	−3	Conventional	28	No	No	Yes	Acetabular loosening	61
41	3	Conventional	32	No	No	Yes	Osteolysis	168

TABLE III Patient Outcomes

	Points		
	Preoperative	Postoperative	P Value
Harris hip score			
Overall score	60.1	77.7	<0.0001
Pain subscore	22.0	36.6	<0.0001
UCLA activity score	4.4	5.3	<0.01

death. Surviving patients who had not undergone rerevision and had not been evaluated within the six months preceding the study were contacted by telephone to update the Harris hip and University of California at Los Angeles (UCLA) activity scores and to inquire about interim episodes of instability or reoperations.

Of the 143 hips that were revised because of pelvic osteolysis, polyethylene wear, or femoral loosening during the period of study, twenty-three (16%) in twenty-three patients were lost to follow-up less than two years postoperatively and four (3%) in four patients were followed for two or more years but could not be reached by telephone for a clinical update. Fifteen patients (sixteen hips; 11%) died prior to the two-year follow-up. Thus, 100 hips (70% of the 143) in 100 patients remained for analysis. Of these 100 hips, eighty-seven in eighty-seven patients had at least two years of clinical follow-up; seventy-nine of these patients were examined in person less than six months before the study and eight were reached by telephone for a clinical update. The remaining thirteen hips in thirteen patients had undergone rerevision.

Operative reports were reviewed for details of the procedure, including surgical approach, femoral head size, polyethylene liner type (conventional or highly cross-linked polyethylene), liner insertion technique (use of the existing locking mechanism or cementation), whether the patient had a simultaneous femoral revision, and use of bone graft around the acetabular and/or femoral component. Clinical charts were examined for demographic information and the prevalence of postoperative complications, specifically dislocations and the need for additional revision. Clinical outcomes were measured with the Harris hip score and UCLA activity score obtained at the time of the most recent follow-up. Repeat revisions, performed for any reason, were defined as failures in this study.

This cohort included fifty-four women and forty-six men. The average age at the time of revision was sixty years (range, twenty-two to eighty-nine years). The index revisions were predominantly performed for osteolysis (59%: acetabular osteolysis only in 39%, femoral only in 11%, and both in 9%) and aseptic loosening of the femoral component (33%). There were sixty-two isolated head and liner exchanges and thirty-eight femoral component revisions for loosening due to osteolysis. All femoral component revisions also included exchange of the femoral head and polyethylene liner. All procedures were performed through a posterior surgical approach. All acetabular components were well fixed at the time of surgery.

Preoperative anteroposterior pelvic radiographs as well as preoperative anteroposterior and cross-table lateral radiographs of the affected hip were reviewed for all patients for whom they were available. If they were unavailable, radiographs from the first post-procedure follow-up visit were measured. Since all acetabular components were well fixed and retained, we assumed that there was no important change in acetabular component position between the preoperative and immediate postoperative periods. Inclination and anteversion of the acetabular component were measured on the anteroposterior pelvic and cross-table lateral radiographs, respectively, as previously described[12,13]. On the anteroposterior pelvic radiograph, a line was drawn across the ischial tuberosities to estimate the orientation of the pelvis. The angle between this line and a line along the opening of the acetabular component represents inclination of the acetabular component[13]. The radiographic safe zone for inclination for this study was defined as 35° to 55°[14]. On the cross-table lateral radiograph, acetabular component anteversion was measured as the angle between the long axis of the acetabular opening and a line perpendicular to the long axis of the body[12]. The anteversion safe zone for this study was defined as 5° to 25°[15].

All radiographs were measured by the same blinded reviewer (M.A.A.). A second blinded observer (N.A.M.) reviewed the radiographs of a random subset of twenty-five patients (25%) in this cohort, and interrater reliability was determined by calculating the intraclass correlation coefficient (ICC) with use of a two-way mixed-effects model. The agreement between the reviewers was excellent, with an ICC of 0.93 for the anteversion assessment (95% confidence interval [CI], 0.86 to 0.96; $p < 0.001$) and an ICC of 0.90 (95% CI, 0.82 to 0.95; $p < 0.001$) for the inclination assessment.

Patient outcomes were determined by comparing the prerevision and postrevision Harris hip and UCLA activity scores. Mean outcome scores were calculated, and a two-tailed t test was utilized to assess differences between prerevision and postrevision scores. We examined several risk factors for failure requiring additional surgery: (1) acetabular component inclination and anteversion, (2) femoral head size, (3) polyethylene liner type (conventional or highly cross-linked polyethylene), (4) liner insertion technique (use of the existing locking mechanism or cementation of a new liner), (5) whether the patient had revision of the entire femoral component, and (6) use of bone graft for any pelvic or femoral osteolytic defects. These variables were recorded for each patient and analyzed for association with failure in a multiple logistic regression analysis. All p values of <0.05 were considered significant. Statistical analyses were performed with use of SPSS for Windows, version 20 (IBM, Armonk, New York).

Source of Funding

There were no external sources of funding for this study.

Results

Six patients (6%) had postoperative instability; one sensed subluxation without any true dislocation, and five had one or more dislocations requiring closed reduction (Table I). Four of the six had acetabular anteversion that was outside of the safe

TABLE IV Risk Factors for Failure

Risk Factor	Odds Ratio (95% CI)	P Value
Acetabular component inclination	4.6 (1.01-20.8)	0.048
Acetabular component anteversion	4.562 (0.98-21.25)	0.053
Conventional polyethylene	14.8 (1.41-155.45)	0.025
Liner insertion technique	1.52 (0.12-19.16)	0.75
Femoral head size	3.52 (0.58-21.29)	0.17
Complete femoral component revision	3.32 (0.62-17.86)	0.16
Bone-grafting	0.75 (0.144-3.93)	0.74

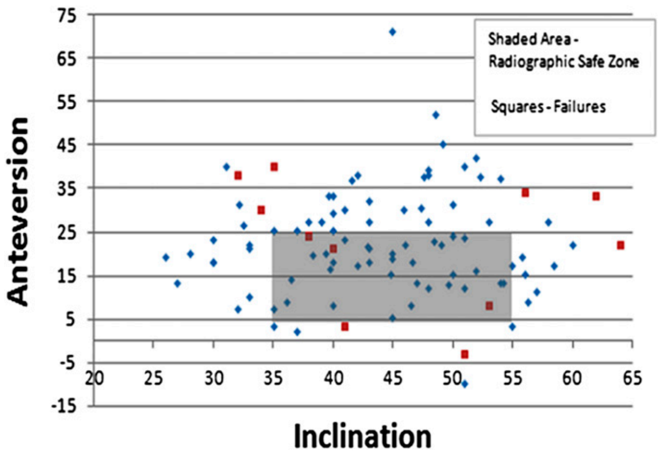

Fig. 1
Thirty-nine percent of the acetabular components fell within the radiographic safe zone for anteversion and inclination (shaded area).

range. One of the six had greater than acceptable acetabular inclination. One of the six had a femoral head that was <28 mm.

Thirteen hips (13%) required another revision: five because of loosening (acetabular loosening in four and femoral loosening in one) at an average of sixty-six months after revision, three because of recurrent instability at an average of 5.6 months postoperatively, three because of progressive osteolysis around a fixed acetabular component at an average of 123 months, one because of a fractured liner at twenty-two months, and one because of infection at forty months (Table II). Of the twelve patients with repeat revision for noninfectious causes, eight underwent full acetabular component revision, two underwent full femoral component revision, and two had a repeat head-liner exchange.

Eighty-seven hips (87%) in the cohort had not required rerevision at the time of follow-up, at an average of 6.6 years (range, two to fourteen years).

The Harris hip scores before revision averaged 60.1 points (range, 28 to 100 points), with significant improvement to an average of 77.7 points (range, 20 to 100 points) postoperatively ($p < 0.0001$). The pain subscore of the Harris hip score also improved significantly, from 22.0 to 36.6 points ($p < 0.0001$). The average UCLA score before revision was 4.4 points (range, 2 to 10 points), which improved to an average of 5.3 points (range, 2 to 10 points) postoperatively ($p < 0.01$) (Table III).

The mean acetabular component inclination for all hips was 44.2° (range, 26° to 65.5°; standard deviation [SD], 8.9°) and the mean anteversion was 22.6° (range, −10° to 71°; SD, 12.4°). Seventy-three hips (73%) were inside the inclination safe zone (35° to 55°). Fifty-six hips (56%) were inside the anteversion safe zone (5° to 25°). Thirty-nine hips (39%) were inside the safe zone for both parameters (Fig. 1). Acetabular components outside of the inclination safe zone were 4.6 times more likely to fail than were those within the safe zone (95% CI, 1.01 to 20.8; $p = 0.048$). However, there was no significant association between acetabular anteversion and failure ($p = 0.053$) (Table IV).

A highly cross-linked polyethylene liner was used in 56% of the revisions in this study. Eleven of the thirteen hips requiring repeat revision had been initially revised with a conventional polyethylene liner. The risk of failure in the patients who received a conventional polyethylene liner at the time of the initial revision was 14.8 times higher than that in the patients who received a highly cross-linked polyethylene liner (95% CI, 1.4 to 155.4; $p = 0.025$). The reasons for failure following the use of conventional polyethylene were acetabular loosening in four hips, osteolysis around a fixed acetabular component in three, instability in two, femoral loosening in one, and infection in one.

The existing locking mechanism was intact and utilized for liner insertion in sixty-two cases. In the remaining thirty-eight cases, the locking mechanism was damaged or had a poor track record and therefore a new liner was cemented into the existing acetabular component. The method of liner insertion was not associated with repeat revision ($p = 0.75$). The femoral head utilized at the time of revision was ≤32 mm in seventy-eight hips and >32 mm in twenty-two hips. Femoral head size was not associated with failure ($p = 0.17$). Bone-grafting of periprosthetic lytic lesions was performed in sixty-eight cases; forty hips had acetabular grafting alone, sixteen had femoral grafting alone, and twelve had grafting at both sites. Bone-grafting was not associated with failure ($p = 0.74$).

Thirty-eight hips underwent revision of the entire femoral component with a polyethylene liner exchange. The average postoperative Harris hip score for those with a femoral revision was 72.3 points compared with 81.3 points for those with a head-liner exchange alone ($p = 0.03$). The two groups had similar Harris hip pain subscores (34.4 and 38.3 points, $p = 0.07$) and similar UCLA activity scores (4.9 and 5.6 points, $p = 0.15$). Femoral component revision was not associated with instability or failure ($p = 0.80$ and $p = 0.16$, respectively).

Discussion

This study demonstrated a 13% failure rate following revision total hip arthroplasty with retention of a well-fixed acetabular component, with a 3% rate of rerevision for instability. In a previous study of 318 hips treated with isolated head and liner exchange, the rate of repeat revision was 16%, with a 5% rate of repeat revision for instability; however, component position was not reported[9]. Another recent study without data on component position identified a 13% rate of repeat revision, with a 5% prevalence of instability requiring revision, in a group of 187 isolated polyethylene exchange procedures followed for an average of 4.2 years[16]. Other previous studies have demonstrated substantially higher rates of instability (range, 15.5% to 29%[4,8,10]) and failure (25%[10]) following polyethylene liner exchange. This variability in outcomes may be due to differences in patient populations, surgical techniques, and postoperative rehabilitation. Some studies, including ours, limited their cohorts to patient who underwent revision because of osteolysis or polyethylene wear[4,8,16], while others included patients who underwent revision for other reasons, including instability[10]. Also, differences in polyethylene may explain higher failure rates, as the use of highly cross-linked polyethylene was not specifically mentioned in the previous studies[4,8-10].

Despite the variability in previous studies, the failure rate in our cohort is comparable with previously reported failure rates following full acetabular revision. Lie et al. reported an 11.8% rerevision rate following complete revision of a fixed acetabular component[9]; Talmo et al. reported a 15% rate[10]. Other authors have demonstrated similar failure rates following liner exchange and complete acetabular revision[17,18]. Restrepo et al. compared thirty-six patients who had undergone polyethylene exchange with thirty-one patients who had had revision of a fixed acetabular component and found similar rerevision rates (8% compared with 3%, $p = 0.62$)[17]. Koh et al. also found comparable rerevision rates between these two cohorts (2.9% compared with 2.2%)[18].

Aside from instability and failure, complications are rarely reported following revision with or without exchange of the acetabular component. Our study had an overall complication rate of 9%, which included five dislocations, two hematomas, one intraoperative fracture, and one infection. Koh et al. reported similar complication rates following head-liner exchange and complete acetabular revision (26.7% compared with 22.8%)[18]. They did demonstrate, however, that blood loss following head-liner exchange was significantly lower than that after acetabular revision (680.0 mL compared with 944.3 mL, $p = 0.017$) and the length of hospital stay was significantly shorter (9.6 days compared with 12.1 days, $p < 0.001$).

Some authors have stated that the best candidates for acetabular component retention with liner exchange are patients with a well-fixed, well-positioned acetabular component[2,3,17,18]; however, there is not a large amount of data supporting this. Two studies showed no difference in acetabular inclination or anteversion between hips that dislocated following head-liner exchange and those that remained stable, but the authors did not evaluate the impact of acetabular component position on prosthetic survivorship[8,10]. To our knowledge, our study is the first to demonstrate an effect of acetabular component position on prosthetic survivorship in the revision setting. Our findings affirm that component position, which is known to limit the survivorship of primary total hip prostheses, also limits the survivorship of revision total hip prostheses with a retained acetabular component.

The current study demonstrated an increased risk of failure with use of conventional polyethylene. Highly cross-linked polyethylene was not commercially available or readily used at our institution until September 2000. Prior to that, all revisions were performed with conventional polyethylene. Following that date, conventional polyethylene liners were used only if the locking mechanism on the retained acetabular component was salvageable and the manufacturer did not make a highly cross-linked polyethylene option for implantation. Older implants may not allow for implantation of highly cross-linked polyethylene with the existing locking mechanism. Our results support cementing a highly cross-linked polyethylene liner into those acetabular components rather than implanting a corresponding conventional polyethylene liner into a well-positioned, well-fixed acetabular component. Cementation of a liner was not associated with an increased risk of failure, a finding consistent with those of other studies[19-22]. Given the demonstrated benefits of highly cross-linked polyethylene, including the potential to halt osteolysis[23], it is preferable to cement a highly cross-linked polyethylene liner if there is no commercially available highly cross-linked option for the existing, well-fixed acetabular component.

Both the Harris hip scores and the UCLA activity scores improved significantly in our study. The Harris hip scores associated with complete femoral revision were lower than those following isolated head-liner exchange. One other study showed a significant improvement in the Harris hip scores following head-liner exchange (from 64.1 points preoperatively to 92.7 points postoperatively), which was comparable with the improvement after acetabular revision (from 66.6 points to 92.1 points)[18]. The Harris hip scores in our study did not improve as impressively as they did in the study by Koh et al.[18], which may be related to our inclusion of femoral revisions, but our clinical outcomes compare favorably with those in studies of different types of revision hip arthroplasty[22-30] (see Appendix). Comparison is somewhat limited by differences in procedures and patient populations; however, these data demonstrate that outcomes are not likely limited by retention of the acetabular component[8-10]. Preoperative Harris hip scores in the current study were slightly higher than those in some studies of other types of revision[24,25], although some patients in our study underwent revision for asymptomatic, extensive osteolysis with a high risk of impending failure and probably had higher preoperative scores due to limited pain or dysfunction.

As this was a retrospective study, we could not control treatment variables, most notably implant selection. A second limitation is that this study included patients in whom a clearly malpositioned acetabular component was retained. Acetabular components outside the safe zones for anteversion and inclination were assessed on an individual basis by the operating surgeon, whose treatment decisions were based on the risks of bone loss during revision of a well-fixed acetabular component and subsequent instability or wear from a malpositioned component. Another limitation is the lack of analysis of femoral anteversion, as previous reports have suggested that obtaining a combined femoral and acetabular anteversion of 25° to 50° may be more important for stability than acetabular anteversion alone[31,32].

In conclusion, this study demonstrated that patient outcomes improved significantly, with a low prevalence of failure requiring repeat revision, at mid-term to long-term follow-up after revision total hip arthroplasty with a retained acetabular component. This procedure can be safely used in patients with a well-fixed, adequately aligned acetabular component. However, it should be performed with caution when the acetabular component position falls outside of the safe zone for inclination. Highly cross-linked polyethylene is better than conventional polyethylene, so cementing in a highly cross-linked polyethylene liner should be considered if no such liner is commercially available for the existing acetabular component. Longer follow-up is necessary to determine whether retention of a well-fixed acetabular component is a good long-term solution.

Appendix

eA A table showing a review of the literature on revision total hip arthroplasty outcomes is available with the online version of this article as a data supplement at jbjs.org. ■

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