

TEN YEARS EXPERIENCE WITH NONCEMENTED REVISION SOCKETS

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ABSTRACT

A prospective study was completed on 167 noncemented revision sockets. A total of 167 hip replacement cases were followed-up a mean of 4.3 years (2 to 9.8 years). Of the 167 cases, 28 hips had a bulk structural allograft and 139 hips had a rim fit. Of the 139 rim fit acetabular components, 70 hips had slurry bone graft; 69 had no bone graft. Harris hip scores were used for clinical evaluation. Radiographic measurements of radiolucent lines were expressed as socket fixation grades. Harris hip scores at last follow-up averaged 86.4. The pain scores showed absent or slight pain only in 86% of hips. A total of 42.9% of hips with bulk structural allograft had re-revision, while 4.3% of rim fit sockets had re-revision with only 2 of these (1.4%) for loosening. We measured migration in 32.1% of hips with bulk allograft and 2.1% of those with rim fit. A shifting pattern of radiolucent lines was common in the first two years postoperative with 17.4% having a worse grade and 9.4% improved. After two years, fixation was stable with 4% having a progressively worse grade and 2% improved. We had one cup (0.6%) with osteolysis. We could not demonstrate any statistical relationship for improved results by the use of slurry bone graft or evidence of screws. We conclude that a rim fit porous-coated socket fixed with or without screws provides predictable results in revision hip replacement. Bulk structural allograft should be limited to salvage surgery.

INTRODUCTION

Revision hip surgery of the acetabulum performed with cemented components has not been reported to have high success.^{1, 2, 10, 19} Kavanagh et al.⁹ reported that 70% of the revisions of the acetabular component that had been performed with cement in their series were associated with progressive radiolucency. Revision arthroplasty using cemented acetabular components with allograft has not given encouraging results either.^{7, 8} Graft resorption and component loosening were seen in 18% to 32% of cases within five years.

Because of the reported high failure rate with cemented revision sockets, we began in late 1984 to use noncemented porous-coated sockets. We used noncemented sockets even when using bulk structural allograft. We have reported our results with noncemented sockets implanted with bulk structural allograft and we experienced a high failure rate.^{20, 22}

In this study we will report our overall experience with noncemented porous sockets in revision hip arthroplasty. Prior to 1989, we used slurry bone graft and screws in most revision sockets. After 1989, we significantly limited use of support bone graft and, wherever possible, obtained a press fit without adjective screw fixation. The rim fit we obtained in the revision acetabulum was almost always between the anterior acetabulum at the level of the anterior inferior spine and posteriorly at the ischium (Fig. 1). This places the mouth of the cup approximately 1.5cm superior to the position in primary arthroplasty. In primary arthroplasty the cup is placed between the pubis anteriorly and the ischium posteriorly. We determined to demonstrate that rim fit sockets provided clinical results superior to those with bulk allograft in our patients and those with bone cement fixation in the literature.

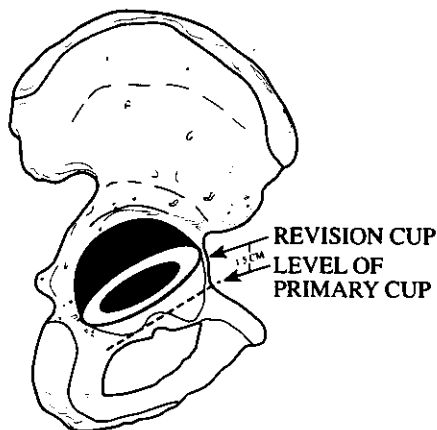


FIGURE 1

The rim fit socket is placed between the anterior acetabulum at the level of the anterior inferior spine and posteriorly at the ischium. This places the mouth of the cup approximately 1.5cm superior to the position in primary arthroplasty.

MATERIALS AND METHODS

We studied all acetabular revisions that had been performed between January 1985 and July 1992. During this time 322 revisions of hips were performed. Of 322 hips, 41 hips had incomplete follow up, but were known to be alive and functioning well without further revision; eight hips were lost to follow up. Thirteen patients with 13 hip implants died with only one of these hips followed over two years and this hip was included in this study; 33 hips had only exchange of the modular insert with or without stem revisions. Thirty-six hips had only stem revision. Twenty-five hips had cemented acetabular components and were excluded. This leaves 167 hips which had socket revisions performed with a noncemented acetabular component with or without femoral revisions. These were studied after a mean of 4.3 years follow up (2 to 9.8 years).

There were 75 men with 80 hip implants and 82 women with 87 hip implants. The average age at the surgery was 57 years old (range 25 to 88 years). The average weight was 157.6 lb (range 84 to 288 lb). Both the femoral and the acetabular component was revised in 137 hips and only the acetabular component was revised in 30 hips. The Anatomic Porous Replacement (APR[®], Intermedics Orthopedics[®], Austin, Texas) acetabular component was used at revision surgery. The APR acetabular component is a hemispherical, porous-coated component of titanium alloy and a porous coating of Cancellous-Structured Titanium[™] (CSTi[™]). The coating has an average pore size of 490 micrometers. The shell wall was 3.5mm thick. The

component could be fixed with 6.5mm cancellous screws that were made of titanium alloy. The reason for revision in the 167 hips was loosening of the acetabular component in 118 hips; hemiarthroplasty and bipolar failure in 22 hips; reimplantation after resection of prosthesis in 5 hips; dislocation in 8 hips; malposition of the acetabular component in 3 hips; a broken acetabular insert in 3 hips; infection in 3 hips; and other cause in 4 hips.

All patients were followed in a prospective manner. Radiographs and clinical data were obtained preoperatively, postoperatively, and then at six months, one year and yearly thereafter. The Harris Hip Scores were used to grade the clinical result at each visit.⁶

Anteroposterior radiographs of the hips and pelvis, centered over the pubis, and frog-leg lateral radiographs of the hip were made for all patients at each visit. The radiographs of the hip were performed in a standardized fashion, with an identical tube angle and distance. No specific device was used for positioning of the patient. The immediate postoperative radiograph was considered the reference radiograph, and all subsequent radiographic measurement for evaluation of migration or a change in the position of the component were compared with the measurements on this radiograph. Both anteroposterior and lateral radiographs were used to assess radiolucencies by Gruen zones and osteolysis. Anteroposterior radiographs were used to measure the migration of sockets and polyethylene wear.

Fixation of the socket was evaluated by a modification of the DeLee and Charnley classification.^{3,12} Fixation Type IA is defined by the absence of radiolucent lines of the socket; Type IB has a radiolucent line in one zone; and Type IC has a radiolucent line in two zones. Type II has a complete radiolucent line in three zones less than 2mm in width. Type III has a complete radiolucent line in all zones (equal to or greater than 2mm), a progressive Zone 3 radiolucent line, or socket migration.²⁰

Magnification of the radiograph was corrected by using a known femoral head size. Migration of the acetabular component was defined as linear (direction of medial, superior or both), or rotational (change in theta angle). Migration was determined by comparing sequential films and measuring the distance between the socket and both Kohler's line and the teardrop (Fig. 2). Kohler's line and the teardrop have been shown to be reliable landmarks in the acetabulum.^{4,15} The measurement of the migration of acetabular components was accomplished as described (Fig. 2).

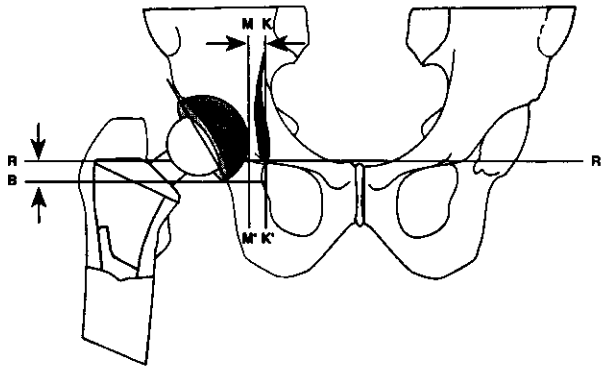


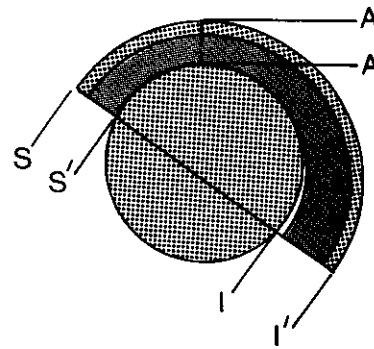
FIGURE 2

A horizontal reference line (R R') was drawn between the inferior margins of the teardrops on the pelvic radiographs. A perpendicular line (K K') of horizontal reference line was drawn through the inferior margin of the teardrops. A line (M M') parallel to K K' line from the most medial part of the acetabular component and a line (B) parallel to R R' line from the inferior margin of the acetabular were drawn. The distance between K K' line and M M', and between (B) line and R R' line were measured.

By comparing the value measured at different follow-up periods we assessed the presence of migration of acetabular component. The lateral opening of the cup was measured with the method described by Callaghan et al. ² A difference in the serial measurements of 3mm or more or a change in the angle of the cup of 3 degrees or more was considered to indicate migration.

Wear of the polyethylene in the cup was measured from the anteroposterior radiograph of the pelvis. A line was drawn from the superior to the inferior edge of the metal acetabular component. The distance from the superior margin of the acetabular component to the femoral head (S S') and from the inferior margin of the acetabular component to the femoral head (I I') were measured (Fig. 3). Linear wear of polyethylene was calculated by the following formula: linear wear = (I I' - S S') / 2. The linear wear measured was composed of real linear wear and creep of polyethylene so that real linear wear may be less than the value measured in the direction of A A'.

When bone stock was not available superiorly to provide support for the cup, a bulk structural allograft was placed superiorly. We divided our patients into two groups. In group A, bulk structural allograft was used in 28 hips (Fig. 4).



$$\text{linear wear} = \frac{I I' - S S'}{2}$$

FIGURE 3

A line is drawn from the superior (S) to the inferior edge (I) of the metal acetabular component. The distance from the superior margin of the acetabular component to the femoral head (S S') and from the inferior margin of the acetabular component to the femoral head (I I') were measured.

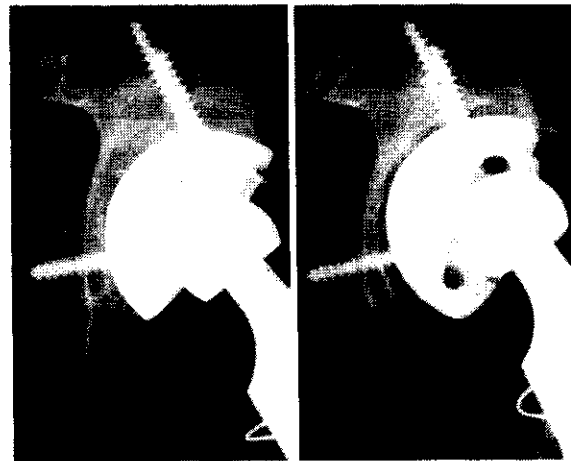


FIGURE 4

Radiographs of sockets with bulk structural allograft. A. Immediately postoperative. B. Three years postoperatively, socket was loose and screw was broken.

In group B, 139 hips had a rim fit acetabular component without bulk structural allograft (Fig. 5). Twenty-six of these hips had the dome of the cup through the medial wall (Fig. 6).

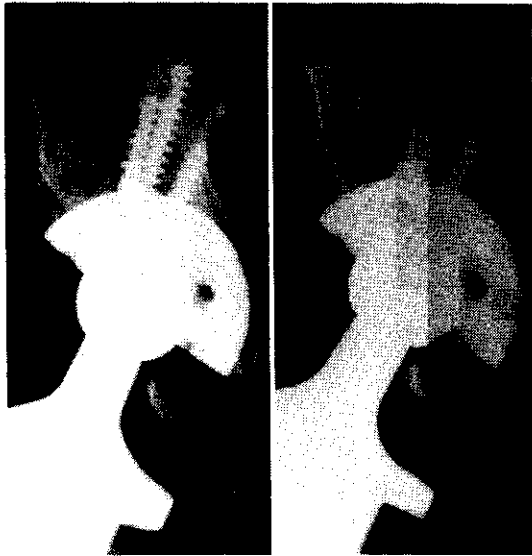


FIGURE 5
Radiographs of sockets with rim fit. A. Immediately postoperative. B. Six years postoperatively, fixation of socket was Type IA.

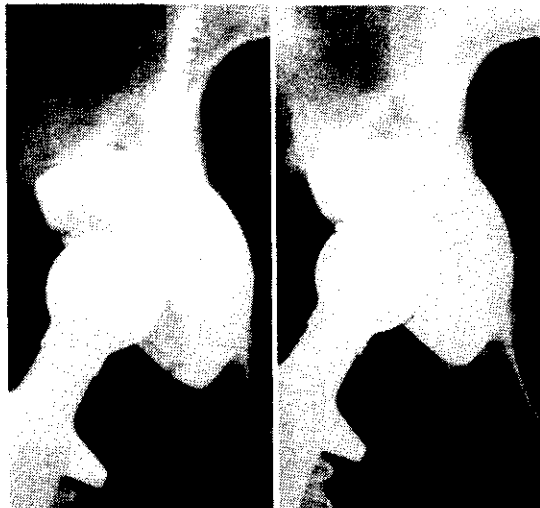


FIGURE 6
Radiographs of sockets with rim fit which had the dome of the cup through the medial wall. A. Immediately postoperative. B. Four years postoperatively, fixation of socket was Type Ia.

Statistics were measured by student T test, Chi square test, analysis of variance and survival analysis were used in this study using SYSTAT statistical software in computer.

RESULTS

Twenty-eight hips had a bulk structural allograft and 12 (42.9%) of these hips required a second revision surgery. Thirteen of these hips had socket fixation type I; 5 had Type II and 10 hips had Type III. Of the 12 hips revised, 9 of these had loosening of the acetabular component of Type III; 2 had Type II fixation and were incidentally revised at surgery necessitated for a loose stem; and one socket with Type II fixation was revised because of dislocation of the hip. One other hip has Type III fixation which has not been reoperated. Nine of 28 hips (32.1%) had migration of the acetabular component. Of these 9 hips with migration of acetabular component, linear migration was in 6 hips; rotational migration in 1 hip and the combination of linear and rotational migration in 2 hips. Eight had a fixation grade of Type III, and 7 of these had a second revision; 3 of these sockets had broken screws. One hip migrated into a stable position and has no radiolucent lines.

Progressive radiolucent lines were present in 16 (57%) of the hips. In the postoperative radiographs, 22 hips had a fixation grade of IA; 2 hips had IB; and 4 hips had IC (Table 1).

Table 1.
Comparison of socket fixation between immediate postoperative and last follow-up (Bulk structural allograft)

Postop	Last Follow-up	No. of sockets
IC	IA	1
IB	IB	1
IA	IA	10
IA	IB	1
IA	II	4
IA	III	7
IB	III	1
IC	II	1
IC	III	2

At final follow-up, fixation grade of 12 (42.9%) sockets was stable or better (radiolucent lines disappeared). The fixation grade of 16 (57%) sockets became worse with either progressive radiolucent line or migration.

One hundred thirty-nine hips had a rim fit, and 6 (4.3%) had a second revision. Two hips (1.4%) had a second revision for loosening of the socket; 2 hips (1.4%) because of dislocation; 1 hip (0.7%) for malposition of the acetabular component; and 1 hip (0.7%), for acetabular fracture (osteoporosis of

acetabulum). Three sockets (2.1%) had migration, 3 hips with linear migration and no rotational migration, but two of these have fixation Type IA and one had type IB; none had Type II or III. Excluding one early revised hip (less than 2 years) at the final follow-up, the fixation grade of these rim fit sockets was 102 (73.9%) with fixation Type IA, 12 (8.7%) Type IB, 7 (5.1%) Type IC, 15 (10.9%) Type II, and 2 (1.4%), Type III. The hips with rim fit had better clinical results as compared by revision than the hips with bulk structural allograft ($P < 0.0005$). Survivorship analysis showed an increased risk of revision for the hips with bulk structural allograft as compared to the hips with rim fit (Fig. 7).

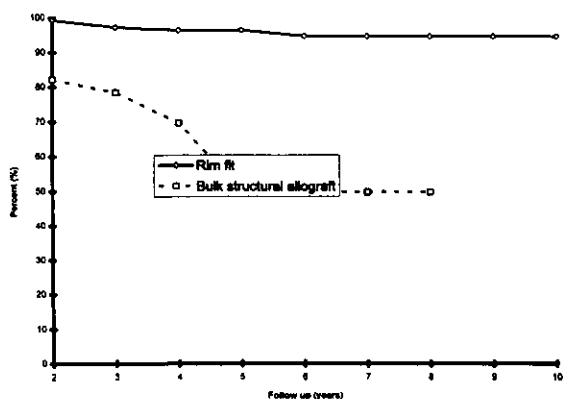


FIGURE 7
Survival analysis to compare rim fit with bulk structural allograft.

Excluding the six hips with a second revision, the mean Harris hip rating at last follow-up was 86.4 (range 40 to 100), 67 (50.4%) were graded excellent, 35 (26.3%) good, 16 (12%) fair, and 15 (11.3%) were poor results. The mean pain score was 40.4 (range 10 to 44). Pain was absent in 83 hips (62.6%), slight in 31 hips (23.3%), mild in 17 hips (12.7%), moderate in 1 hip (0.8%), and severe in 1 hip (0.8%). These pain scores reveal that the 23% fair and poor scores were mostly a result of decreased functional scores caused by factors other than the hip.

In the hips with rim fit the immediate postoperative fixation grade was Type IA in 112 hips; 11 hips had IB; and 15 hips had IC. In the first two years there is a shifting pattern of radiographic fixation. At two years postoperatively 73.2% had not changed fixation grade, 17.4% had a worse fixation, and 9.4% were better (Table 2). After two years postoperative the fixation grade was stable. A total of 94% of sockets did not change fixation grade, while 5 hips (4%) became worse and 3 hips (2%) had better fixation grade (Table 3).

Table 2.
Comparison of socket fixation between immediate postoperative and at 2 years follow-up (Rim fit)

Postop	2 years	No. of sockets
IB	IA	5
IC	IA	7
IC	IB	1
IA	IA	92
IB	IB	5
IC	IC	4
IA	IB	5
IA	IC	5
IA	II	8
IA	III	2
IC	II	3
IB	II	1

Table 3
Comparison of socket fixation between 2 years and last follow-up (Rim fit)

2 years	Last Follow-up	No. of sockets
IC	IA	2
IC	IB	1
IA	IA	100
IB	IB	10
IC	IC	4
II	II	14
III	III	2
IA	IB	1
IA	IC	1
IB	II	1
IC	II	2

The two hips with Type III fixation had this fixation grade by the two year follow-up and were revised. At final follow-up, hips with bulk structural allograft had more hips with progressive

radiolucent lines and migration as compared to hips with rim fit ($p < 0.0005$). Rim fit with dome of cup through medial wall had more migration than rim fit without dome of cup through medial wall, and this was statistically different ($p = 0.057$).

The influence of technique can be evaluated by comparing our results prior to and after January 1989. Technique for bone preparation of the socket was changed in 1989. Subsequent to 1989 the acetabulum was under-reamed and an intrinsic press fit of the socket was obtained. Prior to 1989 fixation of the socket was not always intrinsically stable and screws were commonly used to obtain secure fixation of the socket. Prior to 1989, besides the use of screws, we used slurry graft (ground cancellous bone) liberally to layer the sclerotic bone of the acetabulum. After 1989 we used slurry graft only to fill large cavitory defects and did not layer sclerotic bone, nor fill small cement stud hole defects.

In the 139 hips with rim fit we compared results prior to and after 1989 with particular reference to results with slurry bone graft and screws. Cancellous bone graft for cavitory defects was used in 72.6% (45/62) of hips prior to 1989; from 1989 bone graft was used in 32.5% (25/77) of hips. Bone graft was more commonly used in cavitory defects prior to 1989 ($p < 0.0005$). Prior to 1989, 8% (5/62) of hips had the dome of cup through medial wall, while after 1989, 27.3% (21/77) of hips had the dome of cup through medial wall ($p = 0.011$).

Overall, 70 hips had slurry cancellous bone graft to fill cavitory defects and 69 hips had no bone graft. The Harris pain score was 39.1 points in the hips with slurry bone graft and 40.9 points in the hips without bone graft ($p = 0.09$). The total Harris hip score was 82 points in hips with slurry bone graft and 88.7 point in the hips without slurry graft ($p = 0.008$). However, these hip scores may be influenced by factors other than the acetabulum. With regard to fixation, the hips with slurry bone graft had a trend of worse fixation as compared to hips without bone graft, but there was not a statistical difference ($p = 0.14$).

Adjunctive screw fixation was more commonly used in rim fit sockets prior to 1989. Prior to 1989, 82.3% (51/62) of sockets had screw fixation, while after 1989, 31.2% (24/77) had screw fixation ($p < 0.0005$). Overall, 75 sockets had adjunctive screw fixation and 64 hips did not. The hips with screws had a trend of worse fixation as compared to hips without screws, but there was not a statistical difference ($p = 0.24$). The Harris pain score was 39.3 points in the hips with screws and 40.8 points in hips without screws ($p = 0.13$). There

were no rim fit sockets which had broken screws. In hips with rim fit, the average polyethylene wear was 0.18mm per year. In 66% of the hips polyethylene wear was less or equal to 0.2mm per year; 13.2% had wear between 0.2mm and 0.25mm per year; 7.4% were between 0.25mm and 0.3mm per year; 4.4% were between 0.3mm and 0.35mm per year; and 8.8% were greater than 0.35mm per year. Osteolysis of the pelvis was present in one hip.

DISCUSSION

In our hips with rim fit sockets, the fixation of the sockets is excellent. We have 73.9% of the sockets with no radiolucent lines and 24.7% with only one or two radiolucent lines. Only two sockets developed a complete radiolucent line of 2.0mm or more (Type III) and both of these have been revised. No socket in our series at this time has Type III fixation (impending failure). Only 20.2% of the sockets have demonstrated a progression of the radiolucent lines from the initial postoperative X-ray: 9.4% of this progression was the development of a singular radiolucent line; 9.4% of this progression was from Type I fixation to Type II fixation; and 1.4% of this progression was from Type I fixation to Type III. A rim fit with the dome through the medial wall (Fig. 6) did not differ from cups with an intact medial wall (Fig. 5); 17.4% of this progression of radiolucent lines occurred during the first two years postoperatively, during which time a shifting pattern of radiographic radiolucent lines is common as evidenced by 9.4% of sockets which had improved fixation. After two years postoperative, fixation of only 5 (3.8%) hips became worse. Amstutz reported that 61% of the cemented acetabular components in their series were associated with progressive radiolucency.¹ Kavanagh et al. reported that 70% of the cemented sockets in their series were associated with progressive radiolucency.⁹ Results reported by Lachiewicz using a noncemented acetabular component similar to the APR are nearly the same as ours.¹¹ The number of sockets which show progression in the study of Lachiewicz is 18.3% as compared to 20.2% in ours. Their study does not determine if the results are stable after two years postoperative. This similarity in results between these two studies suggests that the consistent results can be obtained in revision acetabular surgery with the use of a porous-coated hemispheric cup fixed with or without screws.

Our data of results with rim-fit, porous-coated sockets for total hip revision arthroplasties demonstrates superiority of this method of fixation

with or without screws to the use of bone cement. Our mechanical failure rate of 1.4% at follow-up of average 4.3 years with a range of two to 10 years allows us to fairly compare our results to published results with the use of cemented sockets for revision hip arthroplasty. Amstutz reviewed 67 revision total hip arthroplasty with cement at an average of 2.1 years follow-up and reported a mechanical failure rate of 9% and 100% acetabular components had a radiolucent line.¹ Pellicci reported on 110 revision total hip arthroplasties with cement at an average of 3.4 years of follow-up and had a 15% mechanical failure.¹⁶ A subsequent report revealed a mechanical failure rate of 29%.¹⁷ Kavanagh reviewed 210 cemented revision total hip arthroplasties with an average of 4 years of follow-up and reported a mechanical failure rate of 18% and 45% of the acetabular components were deemed probably or possibly loose.⁹ Wirta reported 101 cemented revision total hip arthroplasties with an average follow up of 5 years and 13% of acetabular components had become loose.¹⁹ In our present study the revision for loosening was 1.4% and no other acetabular component is loose. Our results are better than those of cemented revision sockets reported.

Our data of the use of noncemented porous coated sockets with bulk allograft reveals unsatisfactory results. Our experience with the use of bulk allograft has previously been reported.^{20, 22} In the study by Young, et al., we reported that the failure rate with bulk allograft was similar to that previously reported by Harris.⁸ Zmolek reported our results with the use of intact whole cortical acetabular allograft. The failure rate in both these studies was unacceptably high. The results in our present study are consistent with our previously reported results. This is expected because some of the same patients from the previous studies are included in this patient population. We continue to recommend that sockets that are used with bulk allograft be cemented if the coverage of the cup by the allograft exceeds 30% to 40%. At this time we limit the use of bulk allograft to those severely osteolytic and deficient acetabula in patients below the age of 60. In patients over the age of 60, we prefer to use a metal ring support in combination with cancellous bone graft or hydroxyapatite bone graft substitute (Interpore, Irvine, California) with a cup cemented into the composite ring and bone graft reconstruction.^{13, 18, 21}

Wear of the plastic inserts in these modular cups average 0.18mm per year. The percentage of hips that had wear which averaged over 0.25mm per year was 20.6% and those that averaged over 0.30mm per year was 13.2%. The incidence of

osteolysis in this revision series was 0.6%. The incidence of osteolysis in the series of Lachiewicz was 0%.¹¹ This data indicates that osteolysis is not a serious problem with a porous-coated, hemispheric titanium shell that is fixed with or without screws in revision surgery. We believe the incidence of wear is satisfactory in our revision series because the size of sockets we used was, on average, larger. Furthermore, in many of these hips, we used the protrusio plastic insert which provided an additional 5.5mm thickness of polyethylene. The thickness of the polyethylene would seem to be protective against accelerated wear and the volume of debris required to produce significant osteolysis within a two- to 10-year time period of follow-up.

Our conclusions are that a rim-fit porous-coated socket fixed with or without screws gives excellent results in revision total hip replacement surgery. These results in combination with those of others would suggest that the fixation of choice for revision total hip surgery should be a rim-fit porous-coated socket.^{5, 11, 14} If bulk allograft is required for reconstruction of the acetabulum, then we recommend that the socket be cemented into the reconstructed acetabulum if coverage of the socket by the allograft is more than 30% to 40%. We would recommend in these same osteolytic deficient sockets that require bone graft in patients older than 60 years of age that a cancellous bone graft with metal ring support be used instead of a bulk allograft.

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