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The Survival and Fate of Acetabular Reconstruction With Impaction Grafting for Large Defects

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Abstract
Background Impaction bone grafting has been used for acetabular reconstruction in revision surgery. However, most series do not establish differences in survival in revisions with differing severity of bone loss.
Questions/purposes We therefore determined (1) the survival rate for rerevision associated with varying degrees of bone loss; (2) the frequency with which bone graft resorption occurred; and (3) whether the reconstruction restored the anatomic center of rotation of the hip.
Methods We retrospectively reviewed 165 patients (181 hips) who underwent rerevision for major bone loss. Using the classification of Paprosky et al. 98 hips had a Grade 3A defect and 83 a Grade 3B. We determined survival rates for revision and graft resorption. Cup position was determined measuring vertical and horizontal positions and the distance from the center of the prosthetic femoral head to the normal center of rotation of the hip in both groups according to Ranawat. The minimum followup until rerevision or the latest evaluation was 0.3 years months (mean, 7.5 years; range, 0.3–17.7 years).
Results The survival rate for revision at 8 years was 84% (95% confidence interval: 61–100) for Grade 3A and 82% (95% confidence interval: 68–100) for Grade 3B. Twelve hips were rerevised. Seventeen grafts showed bone resorption. Acetabular cup position was anatomically restored in both Grades 3A and 3B.
Conclusions The midterm results for impacted bone allograft and cemented all-polyethylene cups were similar in both Grade 3A and Grade 3B hips. Acetabular reconstruction allows anatomic positioning of the cups and is associated with a low rate of rerevision.
Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent was obtained.
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Introduction

The use of a cementless cup in acetabular revision surgery has low rates of loosening [35, 37, 38, 51], especially in hips with a minor defect affecting less than 30–50% of the host-bone bed. However, biologic fixation of a cementless porous-coated component is unlikely when over 50% of the host bone-bed has been lost [17, 23, 32]; the amount of porous coating in contact with living host-bone then is often limited and bone ingrowth fixation is not obtained [23]. Other surgical techniques include structural allograft with either cementless or cemented cups, implantation of nonhemispheric cementless cups (triflanged, oblong cups), new biomaterials such as tantalum cups and devices, or antiprotrusio cages. Midterm results of these different techniques vary [2, 12, 16, 28, 32].

Impacted morselized bone allograft and cement in the acetabulum have been used in revision surgery [13, 18, 45, 48] and bone graft incorporation has been reported in histologic studies [5, 41, 44, 47]. In a goat model of impacted allografts, Schimmel et al. [41] showed complete incorporation of the allograft by 48 weeks. Studying 24 human acetabular biopsies after reconstruction, Van der Donk et al. report similar findings [53]. However, most series regarding impaction bone grafting in acetabular revision surgery do not consider differences between bone defects of differing severity.

We therefore determined (1) the survival rate for rerevision associated with varying degrees of bone loss; (2) the frequency with which bone graft resorption occurred; (3) whether the reconstruction restored the anatomic center of rotation of the hip; and (4) the functional scores and complications related to this technique.

Patients and Methods

We retrospectively reviewed all 188 patients (208 hips) revised for aseptic loosening of a cemented or uncemented cup with a large defect without pelvic discontinuity between 1992 and 2003 with followup until rerevision or a minimum of 5 years. The average time between the initial total hip replacement (THA) and the revision acetabular surgery was 76 months (range, 38–194 months). Twenty-three patients (27 hips) were excluded: nine patients died for reasons unrelated to the revision surgery, 13 (17 hips) were lost to followup, and one had a deep infection (0.5%) although he was included in the rerevision survivorship analysis. These exclusions left 165 patients (181 hips). Acetabular bone status was classified during the operation according to the criteria of Paprosky et al. [38] as Grade 3A (98 hips) and Grade 3B (83 hips). A first revision surgery was more frequent in hips with Type 3A bone defects, whereas metallic meshes were more frequently used in bone Type 3B defects (Table 1). Minimum followup for the 181 hips until rerevision or the latest evaluation was 0.3 years (mean, 7.5 years; range, 0.3–17.7 years).

Different cemented (104 hips) and cementless (77 hips) THAs were revised in this series. Each revised cup was individually assessed; 70 (39%) only underwent acetabular revision, whereas 111 (61%) underwent revision of both components. Cemented stems (Exeter; Stryker, Howmedica International, Newbury, UK) were used with bone impaction grafting in 68 hips; cementless stems used were: Solution (Johnson & Johnson, DePuy, Warsaw, IN) in 31, Wagner (Zimmer, Warsaw, IN) in four, and others in eight hips.

Table 1. Demographic data (N = 181)

Paprosky bone defect [38]	Type 3 A	Type 3 B	p Values
Male/female	28/70	33/50	0.113
Mean age (yrs and range)	67.5 (28–89)	64.3 (31–86)	0.103
Diagnosis			
Osteoarthrosis	59	51	
Rheumatoid arthritis	4	13	
Secondary arthitis	2	1	
Avascular necrosis	14	10	
Posttraumatic arthritis 12	3		
Acetabular dysplasia	7	5	
Number of revisions			
First	84	61	0.033
Second	10	13	
Third	4	7	
Fourth	–	1	
Sixth	–	1	
Metallic meshes			
No mesh	57	16	< 0.001
Medial wall	23	38	
Lateral mesh	16	5	
Both	2	24	

We used a posterolateral approach in all hips. Acetabular cup and cement were removed and the membrane excised and sent for histologic and bacteriologic study. The acetabular margins were defined and the cup always positioned as close to the center of hip rotation as possible. In revision surgery with large bone defects, use of the transverse acetabular ligament is not practical, and the obturator foramen is always a good reference for positioning the cup inferiorly and medially. Before impacting the morselized bone allograft and cement, segmental acetabular defects were reconstructed with metallic meshes screwed to the bone bed (Fig. 1). Until 1997, we implanted thin Vitallium meshes using ASIF miniscrews. Afterwards, we used special meshes designed for this technique (X-change; Stryker, Howmedica International, Staines, Middlesex, UK). Fresh-frozen femoral head allograft from the bone bank was used in all hips. Allograft bone chips were morselized with a bone mill (Lere Bone Mill; Johnson & Johnson, DePuy) or manually using a rongeur with a size of 0.7 to 1 cm^2 and impacted with a trial prosthesis socket from X-Change instruments (Stryker, Howmedica International) according to the Nijmegen technique [26, 48]. The acetabulum was cleaned and filled with a substantial layer of bone graft to a thickness of at least 5 mm [50]. An all-polyethylene cup was cemented using antibiotic-loaded bone cement (Palacos with gentamicin; Merck, Darmstadt, Germany). The standard low-profile socket was used in almost all cases (Stryker, Howmedica International). In cases in

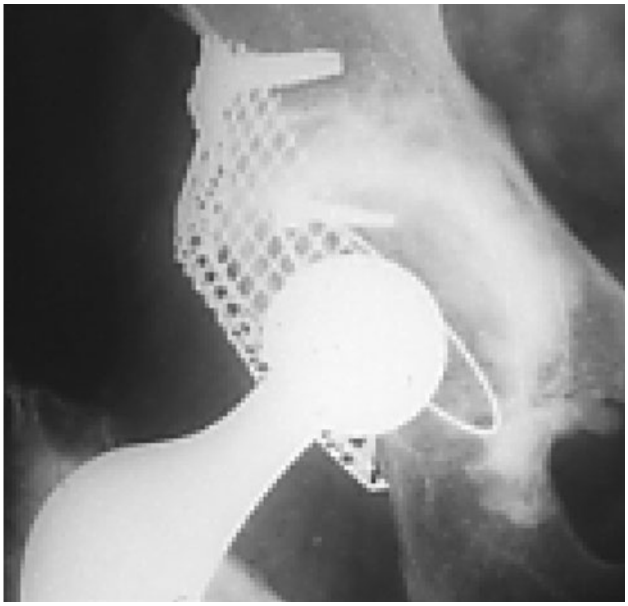

Fig. 1 Postoperative radiograph of the hip of a 57-year-old woman taken at the seventh year followup examination shows a segmental acetabular defect treated with impacted bone graft and cement. A metallic mesh with screws was used to reconstruct the acetabulum. The cup is stable, the bone graft is incorporated, and the patient has a good clinical result.

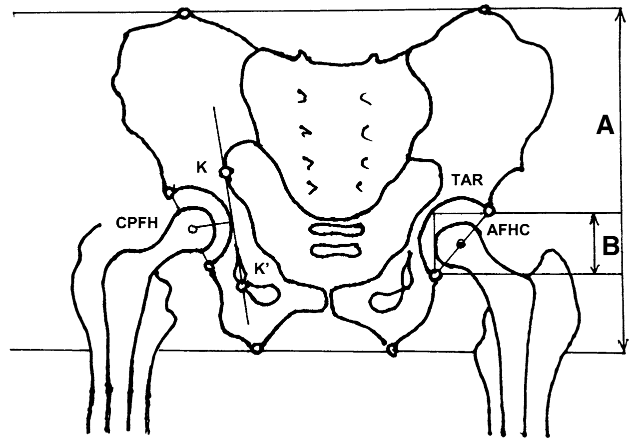

Fig. 2 Diagram showing the method for preoperative and postoperative measurements of the cup. The true acetabular region (TAR) is measured as the area enclosed by a right-angled triangle with the height and width (*B*) equal to 20% of the height of the pelvis (*A*). The midpoint of the hypotenuse of the triangle is defined as the approximate center of the femoral head (AFHC) and represents the normal center of rotation of the hip. CPFH indicates the center of the prosthetic femoral head and KK′ the Köhler line, which is drawn from the medial border of the ilium to the medial border of the ischium.

which a well-fixed Charnley stem was associated with a loosened 22.25-mm Charnley cup, a Charnley cemented cup (Johnson & Johnson, DePuy) was used (25 hips).

The postoperative management in our early patients included bed rest for 14 days. Beginning in 1997, patients spent 5 days in bed with the leg in abduction, and then, depending on intraoperative bone quality and the resulting reconstruction of the acetabulum (and frequently the femur), they were allowed to walk with partial weightbearing using crutches or a walker at 6 weeks with full weightbearing after 3 months. Antibiotic prophylaxis (1 g cefazolin every 6 hours) was discontinued at 48 hours. Subcutaneous heparin was used as a routine preventive measure for thromboembolic problems until the patients were fully mobile.

Clinical evaluation assessed pain, function, and motion following the Merle D'Aubigné and Postel scale (range 1–6) [31] at every followup examination: 6 weeks, 12 weeks, 6 months, 1 year, and annually thereafter. Levels 5 and 6 are considered a good clinical result and levels 4 and lower, a poor result [31]. Clinical failure was defined as rerevision or removal of the cup, pain (level 4 or worse), or both. Thigh pain was not considered evidence of clinical acetabular failure, although groin and buttock pain were recorded as signs of clinical failure resulting from acetabular loosening [39].

Standard AP and lateral radiographs of the pelvis were made for all patients immediately after the operation and every followup examination. All postoperative and followup radiographs were made at our institution following the same protocol [24]. Measurements were made by a single author (EGR) who had not been involved in the surgery. The locations of radiolucent lines around the cup were recorded using the DeLee and Charnley zones [11]. The preoperative and postoperative positions of the cup were assessed by determining the acetabular inclination of the cup. The center of rotation of the hip was defined using the center of the femoral head and the interteardrop line or obturator foramina. The true acetabular region (TAR) was defined as a right-angled triangle whose height and width are equal to 20% of the height of the pelvis according to Ranawat et al. [40]. The hypotenuse of the triangle is the diameter of the mouth of the acetabulum and its midpoint coincides with the approximate femoral head center (AFHC), the center of rotation of the hip. The AFHC was used as the reference point to measure distances between the center of rotation of the patient's normal hip and the center of the prosthetic femoral head (CPFH). These distances were recorded for each hip (Fig. 2). If the CPFH was initially superior or lateral to the TAR, the cup was defined as being outside the TAR and changes of over 5 mm in cup position in followup radiographs were compared with the immediate postoperative images. To facilitate the assessment of the radiolucent lines, regardless of their thickness, we used Hodgkinson et al. criteria [22]. Radiographic cup loosening was difficult to evaluate because of the frequent use of metallic meshes. However, cup migration was defined as change of more than 5° in the abduction acetabular angle or 5 mm in either in the height or lateral position of the cup. Radiographic cup loosening was defined based on Schmalzried and Harris criteria [42] and classified as definite loosening, probable loosening, and possible loosening. Although bone graft density, appearance of the graft-host junction, and trabecular continuity between bone graft and acetabular bone could be assessed by radiographs, these parameters are of limited usefulness in evaluating bone graft remodeling [21, 46]. The anatomic center of the hip was considered as reconstructed when the AFHC-CPFH distance was less than 5 mm.

We used Kaplan-Meier survivorship analysis [25], with 95% confidence intervals to estimate the cumulative probability of not having a cup revision as well as the cumulative probability of not having cup loosening. All patients including lost hips were assessed. The “best-case” scenario curve was compared with the “worst-case” scenario curve [15, 33]. The former included patients who had been lost to followup but whose available data indicated a good result as success. The latter curve considered the patients who had been lost to followup as failures. Differences in survival were determined using the log-rank test. Analysis of the reconstruction of the anatomic center of the hips considered the inclination acetabular angle, height, and horizontal location of the center of the hip, as well as the AFHC-CPFH distance within each group and then between groups. Pre- and postoperative changes in the inclination angle, the height and location of the center of the hip, and/or the AFHC-CPHF distance between the two groups were compared using two-way analysis of variance of repeated measures factoring for Grade 3A and 3B hips. Statistical analysis was performed by statistical package SAS 9.1 (SAS Institute Inc, Cary, NC).

Results

The cumulative probability of not having a rerevision for any cause at 8 years was similar ($p = 0.1143$) in Grade 3A and Grade 3B (Fig. 3). If the patients excluded from the followup study were included (208 hips), the cumulative probability of not having a revision of any prosthetic component for any cause was 83.9% (95% confidence interval, 61.5%–100%) for 3A and 81.6% (95% confidence interval, 67.5%–95.6%) for 3B in the “best-case” scenario and 72.3% (95% confidence interval, 52.1%–92.6%) for 3A and 75.6% (95% confidence interval, 61.6%–89.6%) for 3B in the “worst-case” scenario at the same interval. There were 12 cup rerevisions, 11 for loosening and one for infection. Rerevised cups were less frequent in Grade 3A (four hips) than in Grade 3B (eight hips).The hip that failed because of septic loosening and another hip with severe dysplasia that failed because of aseptic loosening and major bone graft resorption were not reconstructed and were converted to permanent resection arthroplasties. In the other rerevised cups, a new reconstruction using impaction bone allografting was performed (Table 2).

Bone allograft resorption was difficult to evaluate when metallic mesh was used, but most hips had not migrated and showed uniform graft and host bone density. We observed possible loosening in six hips, probable loosening in two, and definite loosening in 12. All hips revised because of aseptic loosening presented major bone resorption. Three loosened hips were not revised because the symptoms were only mild. Bone resorption was more severe in Grade 3B hips (Table 2). Radiolucent lines were uncommon. Progression of radiolucent lines was infrequent (cup migration was seen in the rerevised cup). Demarcation was categorized as Type 0 when there were no radiolucent

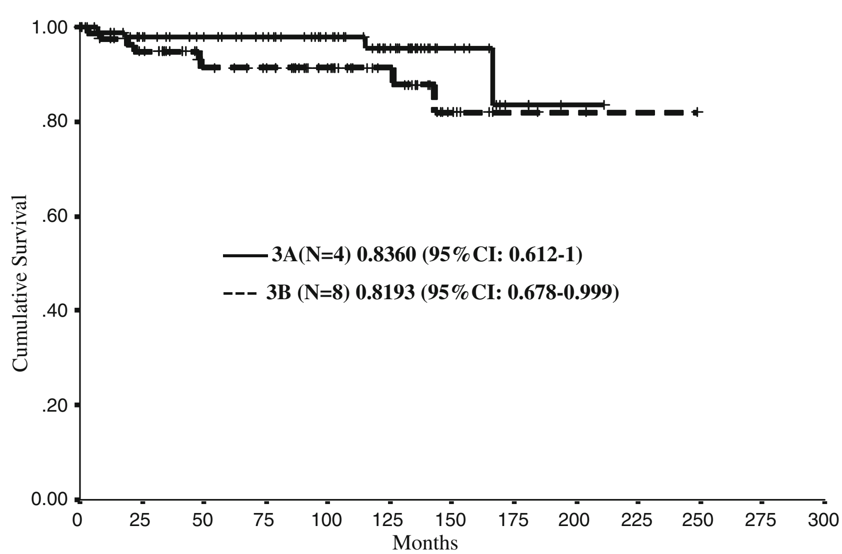

Fig. 3 Graph showing the Kaplan-Meier cumulative probability of not having a rerevision of the cup in Grade 3A and 3B hips. Cross lines represent censored hips. Ranges represent the 95% confidence intervals (CIs).

Table 2. Data on probable or definite loosened and rerevised cups

Case	Gender	Age	Diagnosis	Cause of loosening	Bone defect	Loosening (months)	Bone resorption	Rerevision (months)
1	Male	48	Arthrosis	Aseptic	3A	Definite (102)	Major	IBG (115)
2	Female	70	Arthrosis	Aseptic	3B	Probable (40)	Moderate	–
3	Female	68	RA	Aseptic	3B	Definite (38)	Major	IBG (49)
4	Female	71	RA	Aseptic	3B	Probable (32)	Moderate	–
5	Female	73	Arthrosis	Aseptic	3B	Definite (68)	Moderate	–
6	Female	68	Arthrosis	Aseptic	3A	Definite (118)	Major	IBG (166)
7	Male	48	RA	Aseptic	3B	Definite (102)	Major	IBG (128)
8	Female	78	Arthrosis	Aseptic	3A	Definite (3)	Major	IBG (4)
9	Female	74	Dysplasia	Aseptic	3B	Definite (19)	Major	RArth (22)
10	Female	68	Arthrosis	Aseptic	3A	Definite (48)	Major	IBG (143)
11	Female	79	Arthrosis	Aseptic	3B	Definite (3)	Major	IBG (19)
12	Male	64	RA	Aseptic	3B	Definite (12)	Major	IBG (18)
13	Male	65	RA	Infection	3B	Possible (1)	Minor	RArth (3)
14	Male	78	Arthrosis	Aseptic	3B	Definite (7)	Major	IBG (8)
15	Male	54	Arthrosis	Aseptic	3B	Definite (26)	Major	IBG (48)

IBG = impacting grafting; RA = rheumatoid arthritis; RArth = resection arthroplasty.

Table 3. Progression of radiolucent lines regardless of their thickness between immediate postoperative and latest followup radiographs [22]

Postoperative demarcation	Latest followup demarcation				
	Type 0	Type 1	Type 2	Type 3	Type 4
Type 0 (N = 160)	152	2	1	1	4
Type 1 (N = 19)	2	8	2	1	6
Type 2 (N = 2)	–	–	–	1	1
Type 3 (N = 0)	–	–	–	–	–
Total (N = 181)	154	10	3	3	11

lines around the cup, as Type 1 when the line was in zone 1 of DeLee and Charnley [11], as Type 2 when it was in zones 1 and 2, as Type 3 when it was in all three zones, and as Type 4 when the acetabular cup had migrated (Table 3). The cumulative probability of not having probable or definite radiographic loosening at 8 years was greater ($p = 0.0453$) with Grade 3A than grade 3B (Fig. 4).

The horizontal and vertical distances from the center of the femoral head to the reference points and acetabular inclination angle improved after surgery in both grades. The surgery also improved distances between CPHF and the AFHC in both groups (Table 4; Fig. 5). The

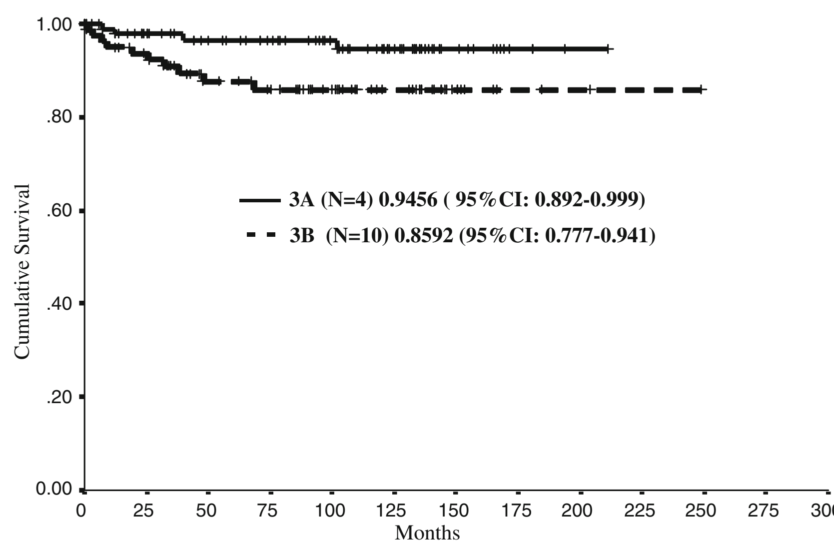

Fig. 4 Graph showing the Kaplan-Meier cumulative probability of not having probable or definite cup loosening in Grade A and 3B hips. Cross lines represent censored hips. Ranges represent the 95% confidence intervals (CIs).

preoperative radiographs showed that only five hips (all with a 3A defect) had a AFHC-CPFH distance equal to or lower than 5 mm. Radiographic accurate reconstruction was more frequent ($p = 0.004$) in Grade 3A (40 hips) than in Grade 3B defect (17 hips). Although the postoperative AFHC-CPFH distance was less in the 3A hips than the other group, the change in distance was greater ($p < 0.001$) for the 3B hips, which also had the greater AFHC-CPFH preoperative distance (Fig. 6). Surgery was able to place most of the outside-the-TAR CPHF hips in both groups inside the TAR (Table 5).

There was an improvement in the functional score from a mean of 7.8 to 16.5 points. Mild pain (Level 4) was only present in rerevised hips. Postoperative complications

Table 4. Radiographic cup position

Paprosky bone defect [38]	3A	3B	p values
Acetabular inclination angle			
Preoperative	50.5 + 11.2	57.7 + 20.4	0.005
Postoperative	45.7 + 4.1	46.1 + 4.6	0.53
p values	< 0.01	< 0.001	
Horizontal distance (KK')			
Preoperative	23.2 + 12.9	15.9 + 17.2	0.002
Postoperative	26.6 + 9.2 NS	23.7 + 12.0	0.069
p values		< 0.01	
Vertical distance			
Preoperative	36.3 + 8.6	43.6 + 11.1	< 0.001
Postoperative	26.9 + 7.1	29.3 + 7.8	0.038
p values	< 0.001	< 0.001	
Distance from AFHC to CPFH			
Preoperative	16.9 ± 7.9	25.8 ± 9.6	< 0.001
Postoperative	7.5 ± 5.0	11.4 ± 6.5	< 0.001
p values	< 0.001	< 0.001	

NS = not significant.

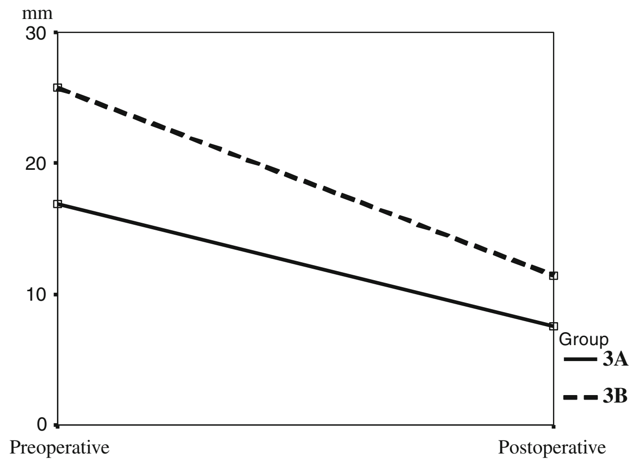

Fig. 6 Graph showing distances from the approximate femoral head center (AFHC) to the center of the prosthetic femoral head (CPFH) pre- and postoperatively in both Grade 3A and 3B. The postoperative AFHC-CPFH distance is less in the 3A hips than the other group. However, the change in distance is greater for the 3B hips, which also had the greater AFHC-CPFH preoperative distance.

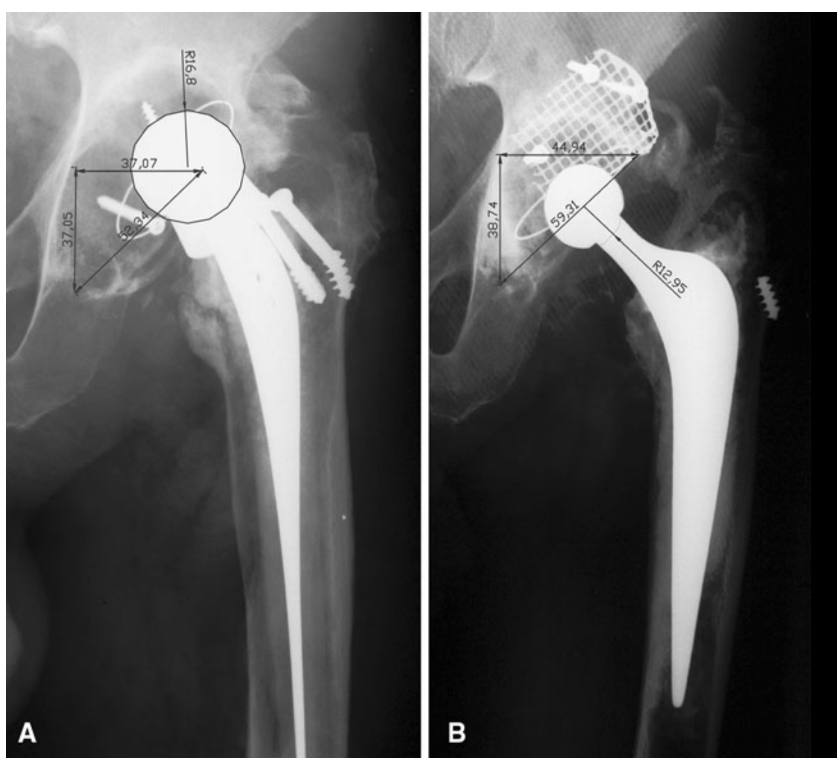

Fig. 5A–B (**A**) Preoperative radiograph in a 68-year-old woman showing the distance from the approximate femoral head center (AFHC) to the center of the prosthetic femoral head (CPFH). (**B**) Postoperative radiograph of the same patient showing the distance from the approximate femoral head center AFHC to the center of the prosthetic femoral head (CPFH).

Table 5. Surgery was able to place most of the outside-the-TAR CPHF hips of both groups inside the TAR

Preoperative	Postoperative	
	Outside	Inside
Paprosky 3A bone defect [32]		
Outside (N = 28)	6	22
Inside (N = 70)	–	70
(McNemar test p < 0.001)		
Paprosky 3B bone defect		
Outside (N = 66)	16	50
Inside (N = 17)	–	17
(McNemar test p < 0.001)		

included four dislocations, which were treated nonoperatively. A woman with rheumatoid arthritis had a deep infection and was included in the survival rerevision analysis.

Discussion

The use of a cementless cup used in acetabular revision surgery has low rates of loosening [35, 37, 51], especially in hips with a defect that affected less than 30% of the host-bone bed. Impacted morselized bone allograft and cement in the acetabulum have been used in revision surgery [13, 18, 37, 48] and bone graft incorporation has been reported in histologic studies [5, 41, 44, 47]. However, most series reporting impaction bone grafting in acetabular revision surgery do not establish differences between different defects of differing severities. We therefore determined (1) the survival rate for rerevision associated with varying degrees of bone loss; (2) the frequency with which bone graft resorption occurred; and (3) whether the reconstruction restored the anatomic center of rotation of the hip.

Our study has some limitations. First, although we have routinely used CT for preplanning since November 2003 [20], most of the hips in this study were operated on before then, so CT is not included in this series. Given radiographs can underestimate bone defects, we cannot ensure the severity of the defects was accurately ascertained, although they can be compared to bone loss in other studies using only radiographs. Second, we have only used conventional radiographs and they are inadequate for detecting migration of less than 4 to 6 mm [34]. Radiostereometric analysis (RSA) could have detected migration and rotation of the cup at an early stage and over time [34]. Third, we lacked a control group of patients of similar age and acetabular defects who were operated on with other techniques with which to compare our observations. Fourth, we lacked biopsies and autopsy retrieval of acetabula reconstructed with this technique to confirm the bone graft remodeling and new bone formation.

Rerevision rates in this series are similar to those obtained in other series using this technique (Table 6). Van Haaren et al. [54] report a high rate of failure by impaction bone grafting in large acetabular defects, including pelvic discontinuities. Our series excluded cases with pelvic discontinuity because major bone defects associated with pelvic discontinuity usually require complex acetabular reconstructive techniques using cages or plates, which effectively excluded them from this series [1]. Buttaro et al. [6] suggested metal mesh, impaction bone grafting, and a cemented acetabular component can be considered when reconstructing acetabular defects of medium severity, but severe combined deficiencies would be treated with an acetabular ring. Impaction bone allografting was used for reconstruction in most of the revised cups (10 of 12 cups). Like in other series [45], the impression at rerevision was that the original bone grafting had been incorporated, and a new bone impacting grafting was performed because part of the existing graft looked viable and well healed to the host-bone. Unfortunately, we did not make core biopsies in any case to confirm whether the bone was viable on the periphery of the graft.

Radiological assessment of bone graft resorption is difficult after the use of the impacted bone allograft with cement in an acetabular revision, but the cup and graft remodeling is clearly stable. Most hips presented uniform graft and host bone radiodensity. Histologic studies of cup loosening in humans report bone substitution, but at a slower rate than in animal models [5, 41, 44, 47]. Although bone graft resorption has been described in areas of substantial weightbearing [21], it is not common with this technique. Somers et al. [49] recommended using bulk allograft in very large defects. However, two other studies suggest bulk allografts are at risk for mechanical weakening during the process of creeping substitution whereas a strong buttress is needed [27, 30]. The open structure of the cancellous bone graft, associated with cement, permits good vascularization, and thus bone substitution takes place without mechanical loosening [48]. In an in vitro study Board et al. [3] found BNP-7 was released from the graft in proportion to the strain imposed, and suggested strain from vigorous graft impaction and postoperative load transformed bone allograft from osteoconductive to osteoinductive. Clinical studies using PET for evaluation of the spatial and temporal development of bone formation report that the impacted bone allograft had transformed to living bone in acetabular revision surgery [52]. Like in other series, radiolucent lines were quite infrequent in this series [46, 48].

Placing the acetabulum in the anatomic position is important for good long-term results [9, 19, 36, 40].

Table 6. Results of different series of revision acetabular reconstruction with impaction grafting

Authors (year)	Number of hips	Bone defect	Type of graft	Followup	Survival rate for rerevision	Survival rate for aseptic loosening
Schreurs et al. [46] (1998)	60	Cavitary 37, combined 23	Fresh-frozen	11.8 years (10 to 15)	90% at 11.8 years	94% at 11.8% years
Ornstein et al. [34] (1999)	17	Different grades	Fresh-frozen	5 years	100% at 5 years	5/17
Schreurs et al. [43] (2004)	61	Cavitary 38, Combined and segmental 23	Fresh frozen	16.5 years (15–20)	79% at 15 years	84% at 15 years
El-Kawy et al. [13] (2005)	28	Paprosky 3	Fresh-frozen and freeze-dried	72 months (48 to 91)	96.4%	92.8%
Buckley et al. [4] (2005)	123	different grades	irradiated	60 months (24–145)	88%	9/123
Wang et al. [55] (2005)	60	Different grades	Fresh frozen	5.8 years (3–9.5)	100%	
Comba et al. [7] (2006)	142	different grades	fresh frozen	51.7 months (24–156)	95.8%	98%
Van Haaren et al. [54] (2007)	71	All, included pelvic discontinuity	Fresh-frozen	7 .2 years (1.6 to 9.7)	72%	20/71 (14 large defects and pelvic discontinuity)
Deakin and Bannister [10] (2007)	51	different grades	Irradiated allograft and autologous marrow	44 months (6–132),	no data	96%
Buttaro et al. [6] (2008)	23	Segmental	Fresh-Frozen	35.8 months (24 to 59)	90.8% at 24 months	8/23
Mehendale et al. [29] (2009)	50	Paprosky 1 to 3	Irradiated	Mean 45 months	6 hips	5 hips
Schreurs et al. [45] (2009)	62	No data	Fresh-frozen	22.2 years (20 to 25)	75% at 20 years	87% at 20 years
Emms et al. [14] (2009)	86	different grades	irradiated	123 months (60–197)	83.3% at 10 years 71.3% at 15 years	95%
Comba et al. [8] (2009)	30	different grades	fresh frozen	86.5 months (34–228)	86%	96%

Theoretically, the location of the center of rotation of the hip affects the load and a higher and more medial position will result in greater loads than a lower position [56]. In this series, all the parameters for defining the reconstruction of the anatomic center of the hip showed improvement in both groups. These distances decreased in both groups after surgery, although the postoperative AFHC-CPFH distance is less in the 3A hips, the change in distance is greater for the 3B hips, which also had the greater AFHC-CPFH preoperative distance.

The midterm results for impacted bone allografts and cemented all-polyethylene cups were similar in both Grades 3A and 3B hips. Acetabular reconstruction allows us anatomic positioning of the cup and is associated with a low rate of rerevision due to graft resorption and cup loosening. We believe it reasonable to reconstruct the acetabulum using morselized bone allografts and cement when hips have an acetabular defect greater than 30% (Grades 3A and 3B), especially in young patients who will probably require a new cup revision at some time in their future. Continued followup will be required to determine if this technique results in less rerevision and loosening.

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