Large Acetabular Defects Can be Managed with Cementless Revision Components

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Published online: 5 October 2010
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Abstract

Background Optimal techniques for acetabular revision in the setting of major pelvic osteolysis have not been established. Bilobed components, structural grafts, and reinforcement cages have demonstrated 10–24% midterm failure rates. While cementless hemispherical components have been utilized to treat large acetabular defects, most reports have not focused specifically on patients with extensive deficiencies.

Questions/purposes We report midterm clinical scores, component revisions, and complications following focal bone grafting and cementless acetabular revision in cases with major periacetabular osteolysis.

Methods We identified 30 patients (32 hips) who underwent cementless acetabular revision to treat massive acetabular bone loss at an average followup of 53 months.

We excluded three patients lost to followup and two patients who died prior to minimum 24 month followup. Harris Hip Scores were assessed before and after surgery. Postoperative radiographs were evaluated for graft incorporation and component migration. Component revision and component migration are reported as failures.

Results Mean Harris Hip Score improved from 52.5 (range, 17.7–90.7) to 87.3 (range, 25.3–100) points. Three hips (9%) were revised for aseptic loosening. Three components (10.7%) demonstrated radiographic migration, but were not revised. Complete graft incorporation was seen in 17 cases (68%). There were five major complications (14%).

Conclusions Cementless acetabular fixation and bone grafting result in clinical scores and survivorship comparable to other options at midterm followup, with potential for biological fixation.

Level of Evidence Level IV, clinical research study. See the Guidelines for Authors for a complete description of levels of evidence.

One or more of the authors (JCC) have received funding from the Curing Hip Disease Fund related to this work. One or more of the authors (WJM) have received funding from Zimmer, Inc. related to this work.

This work was performed at the Washington University School of Medicine in St. Louis.

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

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Introduction

Major osteolytic lesions of the acetabulum can present reconstructive challenges during revision total hip arthroplasty (THA) [4, 14, 19, 39]. In addition to potentially compromising component stability, both focal and linear osteolytic processes may adversely impact osseointegration potential through decreased bone-implant contact area or the effects of chronic inflammation on biological capacity for ingrowth. Several surgical techniques have been utilized to reconstruct or bypass periacetabular bone deficiency. These include (1) retention of well-fixed components with particulate grafting of osteolytic defects

[27, 38]; (2) cemented or cementless component revision with impaction grafting [5, 12, 23, 32, 49]; (3) “jumbo” noncemented components [16, 48]; (4) bilobed acetabular components [3]; (5) reconstruction with a high hip center [15]; and (6) the replacement of bone with structural grafts or augments [17, 41–43] with or without the protection of grafts with a reconstruction cage [10, 11, 33, 34, 37, 45]. Although 80–90% survivorship has been reported with the use of acetabular reconstruction cages [33, 34, 45], concerns remain over the long-term durability of these constructs in the absence of biologic fixation. Sporer et al. reported a 37.5% failure rate between 2 and 8 years followup for patients with major central acetabular defects treated with reconstruction cages [44]. Della Valle et al. reported 97% long-term survivorship with aseptic loosening as an endpoint for a series of patients who underwent cementless acetabular reconstruction across a spectrum of acetabular deficiencies. While 30 of their 138 hips were reported to have major structural bone loss (Paprosky Grade II-C, III-A, III-B), results were not reported specifically for this subset of patients [8]. Lingaraj et al. [24] and Van Kleunen et al. [47] have recently reported on the use of cementless components to treat major acetabular

bone loss. These two studies report on a total of 120 reconstructions in 112 patients [24, 47]. Additional reporting on cementless reconstruction in the setting of major osteolysis will help to define the durability of this approach.

We therefore report the clinical scores, revision rate, radiographic graft incorporation and complications associated with cementless acetabular revision in the setting of major pelvic osteolysis at midterm followup.

Patients and Methods

We reviewed our institutional joint replacement registry and identified 434 THA revision cases performed for 398 patients between January 1, 1996 and May 1, 2005 (Fig. 1). We included only patients who had undergone acetabular component revision for aseptic failure of cemented or cementless implants associated with massive periacetabular osteolysis (Figs. 2, 3). Massive osteolysis was determined to be present for lesions where the area of the lesion was at least 4 cm² visualized on any one radiographic view (Figs. 4, 5). In our experience, this correlated

Fig. 1 The flow chart shows how the patient cohort was created.

Fig. 2A–D (A) Preoperative anteroposterior and (B) iliac oblique radiographs of an active, healthy 62-year-old man with right hip pain and massive osteolysis are shown. (C) The patient was treated with complete socket revision with implant removal, massive morselized allografting and a cementless component fixed with screws. (D) Four years after surgery the patient has no hip pain, graft incorporation and a well-fixed acetabular component.

with a lesion of sufficient size to introduce some concern over long term implant stability during revision THA. We excluded cases with pelvic discontinuity, septic failures, cases where the acetabular component was retained, and cases where major structural grafts, augments, or reinforcement cages were utilized. This resulted in the exclusion of 397 of the 434 revision procedures (92.4 percent), leaving 35 patients with 37 revision procedures (Fig. 1).

After obtaining institution review board approval, the clinical notes, hospital records, radiographs, and operative reports for these 37 revision surgeries were retrospectively reviewed.

Of the 35 patients, three (three hips, 8%) were lost to followup. Three additional patients (three hips, 8%) died from causes unrelated to their revision arthroplasty at an average of 28.3 months (13, 19, and 53 months) (Table 1). Although none of these hips were either radiographically loose or required revision, we excluded the two patients who did not survive to minimum followup. Thus, five

patients were excluded for inadequate followup, and one deceased patient was included in the cohort. Of the remaining 29 patients, four (13%) were unable to return for radiographic followup but were willing to participate in a telephone survey. At a minimum of 24 months, there were 30 patients (32 hips, 86%) who had clinical followup, and 26 patients (28 hips, 76%) had both clinical and radiographic followup. Mean followup for those not requiring subsequent revision was 53 months (range, 24 to 88 months). Mean patient age at time of surgery was 62.4 years (range, 30.9–86.2 years). There were 15 female (16 hips) and 15 male (16 hips) patients.

We performed 25 revisions (78%) to treat aseptic loosening of the acetabular component with component migration or associated osteolysis. The revised components included 13 loose cemented components (41%) and 12 loose cementless components (38%). There were also seven well fixed cementless components with concerns that directed component revision (22%). The indications for revision of a well-fixed acetabular component included

Fig. 3A–C (A) A preoperative anteroposterior radiograph of a 58-year-old man with painful left THA with aseptic loosening is shown. This radiograph demonstrates massive acetabular osteolysis. (B) The patient was treated with implant removal, morselized grafting

and acetabular component revision with screw fixation. (C) Six weeks postoperatively the patient was doing well with the component in good position. Twenty-four months later the patient had not shown any signs of loosening and the bone graft was completely incorporated.

component malposition, a poor implant track record for osseointegration, and massive lysis inaccessible to grafting either through or around the component. Twelve cases (38%) included revision of the femoral component. Multiholed, titanium mesh acetabular implants were utilized for the first 27 cases (84%), with trabecular metal modular revision shells used for the most recent five cases (16%) after these components became available (Zimmer, Inc., Warsaw, IN). Cup size averaged 60.6 mm (range, 52–70 mm) and supplemental fixation was accomplished with a mean of 3.6 screws (range, 2–6).

Surgery was performed by one of the two senior authors (JCC, WJM), using a posterolateral approach for all procedures except a single case that was accomplished with a direct lateral approach. An extended trochanteric osteotomy was utilized for three cases (9%) associated with femoral component revision. Wide surgical exposure is performed to provide adequate visualization to assess the integrity of the anterior and posterior columns, medial wall and superolateral buttress. Well fixed components are removed using a commercially available acetabular component extraction system. After clearing pseudomembrane from the acetabular interface, reamers are placed to size the defect, assess for contact with host bone, and prepare for cup placement. In the presence of large, central deficiencies, cementless fixation is still accepted as long as at least 40–50% of the component can be supported against

host bone. Major segmental defects, when present, are assessed for appropriateness of structural grafts or augmentation. This is most important for substantial (> 30%) deficiency of the superolateral buttress, but may also be considered for large superomedial defects. Cancellous allograft, procured from commercially available sources, is obtained from either fresh frozen femoral heads for the largest defects or freeze dried cancellous bone croutons or chips for smaller defects. The graft is delivered into the defect, gently pressed into the defect manually or with a tamp and followed by reverse reaming of the acetabulum. After placement of the acetabular component in appropriate inclination and anteversion, screw fixation is utilized to enhance acetabular component fixation using the maximum number of fixation points that can be attained through the modular acetabular shell. This typically includes fixation points in the ilium and posterior column and, when feasible, into the ischium. Cautious judgment is utilized when anterior column fixation is warranted, as medial component placement frequently leaves minimal thickness of bone in the anterior column for preparation and screw placement. With cases of major osteolysis, periacetabular bone deficiency may limit the number of fixation points that can be attained. After acetabular component placement, stability of fixation against the host bone is then assessed, an acetabular insert is placed, and trial reduction of the hip is performed in routine fashion. Patients are kept on toe-touch

Fig. 4A–D (A) This preoperative anteroposterior radiograph shows (B) the method for lytic defect measurement. (C) A frog-leg lateral radiograph shows (D) a massive defect in the ilium.

weight bearing for 3 months and hip abduction braces are used for 8 weeks.

Patients were seen after surgery at 6-week, 3-month, 6-month, and 1-year intervals. After the first year, patients are recommended to followup annually until 5 years after their surgery and are scheduled for a 10-year followup appointment if there are no clinical or radiographic concerns identified. Patients are seen intermittently at other intervals if they express symptoms or concerns. Anteroposterior (AP) pelvis, AP hip, and crosstable lateral radiographs are routinely performed at each scheduled appointment. Harris Hip Scores [13] are assessed prior to surgery and again at 3-month, 6-month, 1-year, 2-year, 5-year, and 10-year intervals when patients return for followup. These are entered into an institutional arthroplasty registry database.

Harris Hip Scores were obtained from the registry database. Clinical notes and radiographs were obtained and reviewed for evidence of perioperative complications

including: infection, instability, nerve injury, vascular injury, heterotopic ossification, periprosthetic fracture, or any other complication related to the surgical procedure. Complications were defined as major if further surgery or a decline of more than 10 points in the Harris Hip Score resulted from the complication. Other complications were described as minor.

Radiographs were evaluated by an orthopaedic surgery resident (ESP) not involved in the care of the patients and by one of the treating surgeons (JCC), with consensus attained for reporting of all measurements. Vertical, horizontal, or angular component migration was assessed from immediate postoperative and most recent followup radiographs. Horizontal component position was measured relative to a vertical line drawn from the edge of the teardrop and vertical component position was measured by the perpendicular distance of the cup center from the interteardrop line (Fig. 5) [9, 36]. Component migration was defined using criteria as established by Hendricks and

Fig. 5 The radiograph measurement technique for migration assessment is demonstrated. A line is drawn between the tear drops and the center of the acetabulum is located. The horizontal distance from the tear drop and the vertical distance from the interteardrop line is measured; the abduction angle of the acetabular component is measured as well. Four mm of horizontal or vertical migration, or 5° of angular change is considered migration and evidence of loosening.

Table 1. Demographics

Variable	No. of cases	Percentage
Total cases	37	100
Deceased (died before minimum followup)	3 (2)	9
Lost to followup	3	9
Gender (M/F)	16/16	50/50
Cases with adequate followup	32	86

Harris [15]: either a change of 4 mm or greater horizontally or vertically, or an angular change of the acetabular component of greater than 5°. Acetabular abduction was defined by the angle made between the interteardrop line and a line drawn tangential to the acetabular component. Previous validating reports of plain radiographic analysis for assessing component migration found good interobserver reliability ($k = 0.52$ – 0.63 [22] and 0.76 [46]) and excellent intraobserver reliability ($k = 0.89$) [46].

Preoperative osteolytic lesion size was determined from anteroposterior (AP) and crosstable or frog-leg lateral radiographs. The largest diameter in both vertical and horizontal axes were utilized to calculate area from the equation for an ellipse ($\text{Pi} * X/2 * Y/2$). Osteolytic defects were classified utilizing AAOS [6].

Bone graft incorporation was classified using the system described by Benson et al. [1]. The first author (ESP)

reviewed all cases with the senior author (JCC) and consensus was reached on graft incorporation. Grade 0 incorporation is identified by an absence of trabecular pattern and no change in the defect appearance between preoperative and postoperative radiographs. Grade 1 incorporation is defined by the presence of either a blurred lytic border or the presence of a trabecular pattern distinct from the appearance of the surrounding bone. Grade 2 graft incorporation is denoted by a trabecular bone pattern continuous with the surrounding bone and absence of a border between the defect and surrounding bone.

Heterotopic ossification was assessed using the classification of Brooker et al. [3]. Overall failure was defined by reoperation for acetabular revision. Radiographic loosening was defined by component migration.

Results

Thirty-two hips were available for followup at a minimum of 24 months or until failure. Average preoperative defect size was 12.8 cm^2 (range, 4.7 – 49.5 cm^2). Twenty-nine revisions (91%) were performed for AAOS Type III defects, with both cavitory and segmental deficiencies, and the remaining three (9%) addressed large, but contained, cavitory (AAOS Type II) defects. Mean Harris Hip Score improved from 52.6 (range, 17.7 – 90.7) to 87.3 (range, 25.3 – 100) after surgery. Twenty-one patients (23 hips,

Table 2. Clinical scores and revision rates

Outcome	Cases	Percentage
HHS 81–100 at final followup	23	82%
HHS 71–80 at final followup	1	4%
HHS < 70 at final followup	4	14%
HHS decline in those alive, available for followup and unrevised	2 (of 28)	7%
Implant survival at final followup or time of death	29 (of 32)	91%
Revision for aseptic loosening	3 (of 32)	9%
Migration/loosening (pts with adequate radiographic – > 4 mm horizontal or vertical migration – > 5° abduction)	3 (of 28)	10.7%
Mechanical failure rate (revision and loosening)	6 (of 28)	21.4%

82%) had a Harris Hip Score between 81 and 100, correlating with a good or excellent outcome, and four patients (14%) had a score less than 70. Only two patients (7%) had a decrease in their Harris Hip Score (Table 2). Twenty-nine of 32 hips (91%) were in place and functioning well at an average followup of 53 months (Table 2). Three hips (9%) that required rerevision were initially revised for aseptic loosening of a cementless acetabular component (Fig. 5). The average preoperative age of patients who required rerevision surgery was 58.2 years (range, 47.6–77.7 years). Two of the three failures were titanium mesh cups fixed with two and five screws, respectively. One trabecular metal cup augmented with two screws failed. All three failures occurred in hips with previous AAOS III defects. The failures occurred at 12, 22, and 132 months. The cup with the longest interval to followup was a titanium mesh cup fixed with two screws. Migration greater than 4 mm was seen in three of the 28 hips (10.7%) that had adequate radiographic followup and had not been revised. Although these implants were considered radiographically loose, Harris Hip Scores improved an average of 49.6 points to a mean of 91.0 points (range, 82.5–97.7). All three of these hips were revisions of AAOS type III defects, and the cup sizes were 52, 68 and 70. No hips had a change in cup abduction angle greater than 5°. Both patients had well-fixed implants radiographically.

Radiographic evaluation showed some element of graft integration in 25 of the 28 hips with adequate radiographic followup (89%). Grade II incorporation was seen in 17 hips (68%), Grade I in seven hips (28%), and Grade 0 in one hip (one patient) (4%). Of the three hips requiring subsequent revision, two hips had Grade II incorporation prior to reoperation and one had Grade 0 incorporation. Intraoperative findings at the time of rerevision for one case with Grade II radiographic incorporation revealed that bone

Table 3. Complications following cementless acetabular revision for major osteolysis

Complication	No. of cases	Percentage
Major		
Instability with dislocation	2	5%
Early washout with liner exchange for infection	1	3%
Intraoperative fracture	1	3%
Hematoma requiring operative intervention	1	3%
Total major complication rate	5	14%
Minor		
Heterotopic ossification—Grade III	3	8%
Hematoma not requiring operative intervention	1	3%
Total minor complication rate	4	11%

graft had incorporated fully in certain areas, with remaining or new osteolytic defects present in other areas. One rerevision was performed at another institution and the intraoperative appearance of consolidation is not known.

In the 37 index procedures, there were five major (14%) and four minor (11%) complications (Table 3). Major complications included two dislocations, one infection treated with liner exchange and IV antibiotics, one hematoma requiring surgical débridement, and one intraoperative periprosthetic femur fracture that healed uneventfully using a cortical strut graft and cable fixation. All were treated successfully without long-term morbidity. The four minor complications included three cases of Brooker Grade 3 heterotopic ossification (HO) and one postoperative hematoma that resolved without surgical intervention. HO was noted in four other hips (4 patients), two with Grade 2, and two with Grade I HO. None of these patients required additional surgery. There were no cases of nerve palsy, vascular injury, or deep venous thrombosis in the treatment group. Two of 30 patients (2 hips) with clinical followup sustained a single postoperative hip dislocation (7%), but did not require revision surgery.

Discussion

Periprosthetic osteolysis develops as a biological response to particulate wear debris [20, 28, 31]. Access of particulate debris to the interface around loose cemented and cementless acetabular components may either contribute to the development of focal osteolytic lesions or may result in substantial bone loss as loose components migrate proximally into the pelvis [18, 21, 39]. Expansile focal

osteolytic lesions may develop in association with well-fixed cementless components. While component retention may be an option for implants with a good track record for osseointegration and a favorable locking mechanism, component revision is frequently necessary [27]. Regardless of pathogenesis, major pelvic osteolytic deficiencies challenge revision initial implant stability and long-term construct durability. Although several techniques have been reported, including some that suggest successful management of major defects with reconstruction cages [33, 34, 37], other authors have reported poor clinical performance of these constructs [2, 44]. While cementless fixation in acetabular revision is reported to have 97% long-term survivorship [8, 32] associated with acetabular bone loss, the literature contains limited reporting on the use of cementless implants exclusively for the most major bone deficiencies (AAOS III; Paprosky 2B through 3B). We report on the use of focal impaction grafting and cementless acetabular revision for major periacetabular osteolytic defects (Table 4).

Our study has several limitations. First, a sizeable number of patients eligible for consideration in this study

were either lost to followup (9%) or did not return for radiographic assessment (13%). When considering best and worst case scenarios for these patients, implant survivorship is between 84 and 92% with revision as an endpoint, and between 73 to 84% when including any radiographic signs of loosening. However, the rate of patients lost to followup is comparable with other studies reporting on patients with severe pelvic defects [35, 47]. Second, although we are reporting on patients with similar acetabular deficiencies previously reported with other techniques, we are not able to adequately compare patient demographics to those other studies. While our mean clinical scores are higher, this may be reflective of the overall physical health of our patients, and not directly to the surgical technique utilized. Third, since the average followup was less than 5 years, long-term durability may not necessarily be extrapolated from our results. Fourth, our cohort was not large enough to statistically evaluate the reasons or risk factors for failure. While we have noted that only two screws were utilized to augment cup fixation in two of the three failures, a third failed component was augmented with five screws. The small

Table 4. Comparison of key variables among reported studies

Study authors	Construct	HHS/MA*	Survival	Mean F/U	Complications^	Deaths	Lost to F/U
Boscainos et al. [2]	Cup-cage	NR	100	32 months	5.4%	1/14	0/14
Chen et al. [3]	Bilobed cup	NR	76	41 months	15%	1/38	1/38
Dearborn and Harris [7]	High hip center	81	90	10.4 years	36.9%	6/46	0/46
Della Valle et al. [8]	Cementless hemispherical	82	97	15–19 years	9.4%	43/138	8/138
Gerber et al. [10]	Reinforcement ring	16*	94	6 years	13.1%	7/61	4/61
Goodman et al. [11]	Reinforcement cage + Structural graft	NR	76	4.6 years	26%	4/61	6/61
Hallstrom et al. [12]	Cementless hemispherical	78	85	12.5 years	13.9%	36/188	30/188
Hendricks et al. [16]	Jumbo cup	79	100	13.9 years	12.5% [#]	8/24	
Lakstein et al. [23]	Cementless hemispherical +/- Augment	10.6*	96	45 months	9%	5/58 (died or lost to F/U)	
Park et al. [32]	Cementless hemispherical	79	82	20–24 years	NR	55/138	7/138
Pieringer et al. [33]	Reinforcement cage	74	93 61 ^{##}	50.3 months	36%	20/87	3/87
Regis et al. [34]	Reinforcement cage	75	87.5	11.7 years	16%	12/71	3/71
Schlegel et al. [37]	Reinforcement cage	70	90	6 years	4.2% [#]	39/164	3/164
Shinar and Harris [41]	Structural graft Cemented cup	74	39	16 years	NR	9/71	NR
Symeonides et al. [45]	Reinforcement cage	15.2*	89	11.5 years	2%	3/57	1/57
Wedemeyer et al. [48]	Jumbo cups	83	88	82 months	24%	2/17	4/17
Van Kleunen et al. [47]	Cementless hemispherical +/- Augment	76	100**	45 months	25%	5/90	13/90^^
Weeden and Paprosky [49]	Cementless hemispherical	86	95	13.2 years	9.5%	7/137***	8/137
Paxton et al. [current study]	Cementless cup	87	91	53 months	14%	3/37	3/37

F/U = followup; *Infection was the only reported complication; ^{##}Including radiographically loose components not revised; *Merle d'Aubigne Score reported (no HHS); **Component revision for loosening/osteolysis as endpoint; ***All had minimum 8-year followup; ^infection, dislocation, hematoma surgically drained, fracture, nerve injury; ^^ did not have minimum 2-year followup per authors (loss to followup not specified, but inferred).

sample size does not allow us to differentiate patient factors, bone deficiency, or screw augmentation as the most important factors in component failure in this series. While these cases lack statistical power to determine an ideal number of screws to utilize, we recommend use of at least three screws and attempt to add fixation in the ischium when possible. The quality of press fit of the revision component, either at the rim, between the columns, or throughout the acetabular bed, may influence the minimum number of screws the surgeon is willing to accept. Fourth, our radiographic measurements were made using plain radiographs which may underestimate the preoperative size of defects and overestimate the degree of graft incorporation. Mall et al. noted only 47% of graft fill and 36% graft healing in acetabular osteolytic defects following complete component revision using postoperative CT scan analysis [25]. This is much lower than previously reported rates of 90–100% using plain radiographs for analysis [26, 40]. Other forms of imaging may provide more accurate measurement of bone graft incorporation and component position to assess for migration. Finally, we had only one observer for the radiographic findings. We did not determine and do not know the interobserver variability of assessing bone graft incorporation radiographically.

In this study, mean Harris Hip Score (HHS) improved by from 53 to 87 points and only one patient with a treated AAOS Grade III defect had a substantial decrease in HHS (by 13 points).

The mean clinical score that we report is higher than what has been reported in the literature for high hip center (81 points), cementless acetabular revision (82 points), jumbo acetabular components (79 points), highly porous cementless components (76 points), and reconstruction cages (70 points) (Table 4).

We report a component survivorship of 91% at a mean of 53 months, with an additional 10.7% of potentially loose components unrevised. Chen et al. noted 24% failure at a mean of 41 months with bilobed acetabular components [3]. Dearborn and Harris noted a 10% conversion from a high hip center to a resection arthroplasty [7]. Della Valle et al. noted 97% survivorship of cemented components

with loosening as an endpoint, but noted 20/87 surviving patients (23%) requiring a revision for all reasons [8]. Gerber et al. noted seven revised or loose components (14%) with roof reinforcement rings at a mean of 6 years [10]. Schlegel et al. noted an 18% rerevision rate with an additional 2% radiographic or clinical failure rate at 8 years using reconstruction cages [37]. Regis and Pieringer have reported survivorship of 87.5 and 93.4%, respectively, but acknowledge a substantial number of additional cases that are radiographically loose [33, 34].

Our study identified complete radiographic bone graft incorporation for 68% of the cases. However, our limited intraoperative assessment of bone graft incorporation on rerevision cases suggested that radiographs may overestimate the actual amount of bone incorporation. There are few studies that have specifically focused on bone graft incorporation (Table 5). McNamara et al. noted 60% of cases had graft incorporation utilizing a mixture of allograft and synthetic osteoconductive material [29]. Mehendale et al. suggested that complete radiographic incorporation was only present with 40% of patients treated with irradiated bone [30]. Mall et al. have recently reported a 30% average defect fill and 24% average bone healing rate using CT scans for evaluation, with lower graft incorporation rates among patients treated with impaction grafting behind retained acetabular components than during cases where component revision had been accomplished [25].

There were five major complications (13.5%) and four minor complications (10.8%), with an overall rate of 24.3%. While a majority of reports have not cited complication rates, the range of reported complications within these groups ranged from 11–24.7%. Gerber et al. reported a 16% complication rate [10]. DellaValle et al. noted a 12% revision rate for infection or dislocation [8]. Van Kleunen et al. noted a 24% complication rate at a mean of 45 months [47].

Cementless acetabular fixation and bone grafting result in improvement in mean Harris Hip Scores and greater than 90% implant survivorship at midterm followup. The results in this study fare well in comparison with other techniques that have been described to manage similar major

Table 5. Radiographic measure of bone graft incorporation

Author	Technique	Total hips	Followup	Bone graft incorporation
McNamara et al. [29]	Impaction Grafting with allograft and synthetic osteoconductive material	50	60.3 months	60%
Mehendale et al. [30]	Impaction grafting with irradiated allograft	50	45 months	40%
Mall et al. [25]	Grafting around well fixed component, or complete revision	40	4.8 years	24%
Paxton et al. [current study]	Morcelized grafting and cementless cup	32	53 months	61%

periacetabular bone loss. Attention should be given to the restoration of acetabular bone stock and the achievement of stable initial fixation of the acetabular component against host bone. Morselized bone graft can accomplish restoration of bone in the acetabulum, but is not sufficient in itself to guarantee clinical success. Multiple screws should be used to enhance the initial stability of the implant. Future studies should provide long-term followup of the use of highly porous cementless fixation implants, and to identify effective strategies to evaluate bone graft incorporation and to establish criteria for both acetabular component loosening and failure.

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