Functional and radiological outcomes of impaction grafts and cemented cup for treatment of acetabular bone deficiency in total hip arthroplasty.

Maysara Abdelhalim Bayoumy*, Mohamed Mosa Mohamed

Department of Orthopaedic and Traumatology, Al-Azhar University, Cairo, Egypt

Abstract

Background: Acetabular bone defects are one of the most difficult problems in both primary and revision Total Hip Replacement (THR). Many techniques have been described to deal with acetabular bone defects in THR, including the use of cement with or without cages and rings, structural bone grafting, and impaction bone grafts with cementless or cemented cups. The aim of this study was to investigate the use of impaction bone grafts to reconstruct the deficient acetabulum with cemented cups. Our hypothesis was that the use of impaction bone grafts with the cemented cups will provide favorable outcomes in patients with acetabular bone defects for both primary and revision procedures.
Methods: We retrospectively assessed the outcomes in 26 patients (mean age at surgery 45.3 years) who underwent THR with acetabular bone defect reconstruction using grafting and cemented cups. We performed 12 primary THRs and 14 revision THRs. Morselized grafts alone were used in eight patients, combined strut grafts and morselized grafts were used in five patients, acetabular rim mesh and morselized grafts were used in 12 cases, and a Kerboul cross ring and morselized grafts were used in one patient. All cases were clinically evaluated with the Harris Hip Score (HHS) in addition to radiological evaluation.
Results: All patients except one showed clinical improvement, with a mean postoperative HHS of 84. Follow-up x-ray showed graft incorporation without loosening or any significant cup migration in all patients except one who required revision surgery due to loosening around the cup.
Conclusion: The use of impaction grafts and cemented cups is safe and effective, even in young patients. Furthermore, this technique reconstitutes bone and provides a stable platform of bone stock to facilitate further revision, if needed, especially in young patients.

Keywords: Acetabular bone, Arthroplasty, Cephalosporin antibiotic.

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Introduction

Acetabular bone defects are among the most difficult problems in both primary and revision Total Hip Replacement (THR). In primary cases, this defect is usually reported with acetabular dysplasia, acetabular fracture, and acetabular protrusion in primary cases, while in revision cases, it usually occurs due to loosening of acetabular components, secondary protrusion after hemiarthroplasty, or during removal of acetabular components [1].

The ideal bone graft selection for acetabular reconstruction in hip arthroplasty with acetabular bone defects depends on four main factors: the size of the defect, the location of the defect, the biology of the defect site, and whether structural support is required or not. The first classification system for acetabular bone deficiency was adopted by Paprosky and colleagues. Since then, many other classification systems have been reported in the literature, and these systems are based on classifying component migration, identifying the location of bone loss, and determining whether the bone deficiencies are contained or uncontained.

Many techniques have been described to deal with acetabular bone defects in THR, including the use of cement with or without acetabular cages and rings, structural bone grafting, and impaction bone grafts with cementless or cemented cups [2].

Acetabular reconstruction using impaction bone grafts is a biologic procedure, which is popular among many surgeons. The use of bone grafts and cemented cups has shown satisfactory results in 94% of cases after 10 years.

The aim of this study was to describe our results of acetabular reconstruction using impaction bone grafts and cemented cups in both primary and revision cases with acetabular bone deficiency indicated for THR, and it is importance in achieving the restoration of hip mechanics, providing a biological solution to bone deficiency

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Materials and Methods

This retrospective study was approved by our institution ethics committee and included 26 patients with THRs (seven females and 19 males) who underwent acetabular reconstruction with bone grafts and cemented cups in the period [3]. The mean age at surgery was 45.3 years (range: 17 to 66 years). Twelve procedures were primary THRs where the preoperative diagnosis was osteoarthritis with acetabular bone defects in 10 patients and rheumatoid arthritis with acetabular defects in two patients (Figure 1a and 1b). Fourteen procedures wererevision

THRs with preoperative diagnosis of secondary acetabular protrusion after hemiarthroplasty in five patients (Figure 2a and 2b), and acetabular bone deficiency after septic loosening with two- stage revision in three patients (Figure 3a and 3b). Demographic data are shown in Table 1.

Table 1. *Patients data.*

case	Age	sex	Diagnosis	Type of graft used	Use of mesh
1	47	M	AVN with posterior-superior wall defect	Combined morselized and strut grafts	No
2	45	F	Infection with 2nd stage revision	morselized bone grafts	Yes
3	60	M	Protrusion after hemiarthroplasty	morselized bone grafts	No
4	50	M	Infection with 2nd stage revision	morselized bone grafts	Yes
5	60	M	Protrusion after hemiarthroplasty	Combined morselized and strut grafts	No
6	55	M	Protrusion after hemiarthroplasty	morselized bone grafts	Yes
7	39	M	OA hip with acetabular defect	morselized bone grafts	No
8	40	F	OA hip with acetabular defect	morselized bone grafts	No
9	30	F	OA hip with acetabular defect	morselized bone grafts	No
10	50	F	Rheumatoid with acetabular defect	Combined morselized and strut grafts	No
11	36	M	Protrusion after hemiarthroplasty	morselized bone grafts	No
12	27	M	OA hip with acetabular defect	morselized bone grafts	No
13	35	M	OA hip with acetabular defect	morselized bone grafts	No
14	45	M	Aseptic loosening of the cup	morselized bone grafts	Yes
15	35	M	Rheumatoid with acetabular defect	Combined morselized and strut grafts	Yes
16	66	M	Aseptic loosening of the cup	morselized bone grafts	Yes
17	60	M	Infection with 2nd stage revision	morselized bone grafts	Yes
18	55	M	Aseptic loosening of the cup	morselized bone grafts	Yes
19	50	M	Aseptic loosening of the cup	morselized bone grafts	Yes
20	30	F	Aseptic loosening of the cup	morselized bone grafts	Yes
21	51	M	OA hip with acetabular defect	morselized bone grafts	No
22	49	F	Protrusion after hemiarthroplasty	morselized bone grafts	No
23	49	M	OA hip with acetabular defect	morselized bone grafts	No
24	42	F	OA hip with acetabular defect	morselized bone grafts	no
25	60	M	Aseptic loosening of the cup	morselized bone grafts	Yes
26	42	M	AVN with postero-superior wall defect	Combined morselized and strut grafts	No + kerboul ring

Abbreviations: M: Male; F: Female; OA: osteoarthritis; AVN: avascular necrosis

Figure 1(a) Figure 1(b)

Figure 1. *1a: Radiograph OA hip with acetabular bone defect; 1b: Radiograph after 30 months of cemented THR with incorporation of morselized bone graft under cemented cup.*

Figure 2(a) Figure 2(b)

Figure 2. *2a: Radiograph OA hip with acetabular bone defect; 2b: Radiograph after 54 months of cemented THR with incorporation of morselized and strut bone graft fixed by screws under cemented cup.*

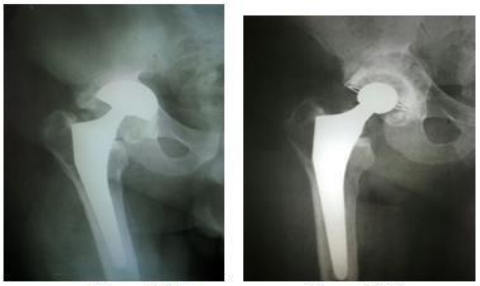

Figure 3(a) Figure 3(b)

Figure 3. *3a. Radiograph shows THR with Aseptic loosening ofcementless cup with acetabular bone defect; 3b: Radiograph after 54 months of revision with incorporation of morselized bone graft under cemented cup.*

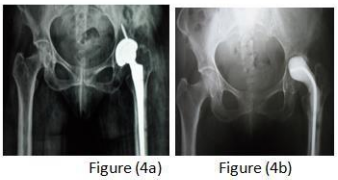

Figure (4a) Figure (4b)

Figure 4(c)

Figure 4. *4a: Radiograph shows THR with septic loosening ofcementless cup with acetabular bone defect; 4b: Radiograph shows 1st stage with acetabular bonedefect; 4c: Radiograph after 54 months of 2nd stage revision with incorporation of morselized bone graft with mesh fixed with screws under cemented cup.*

Operative technique

Manual templating and planning was performed preoperatively. Preoperatively, 1–2 g of first-generation cephalosporin antibiotic was introduced half an hour before surgery (if body weight was more than 60 kg, 2 g was administered) [4]. Lateral approaches to the hip were used in all procedures with extended trochanteric osteotomy performedin two patients only.

In the primary THR procedures (12 hips), the femoral head of the patient was used as an autogenous graft, while in revision procedures (14 hips), fresh frozen allografts (femoral heads) from the bone bank (two femoral heads for each procedures) was used as an allograft [5].

Firstly, we explored the acetabulum and detected the most inferior part of the acetabulum by placing human tissue retractors in the obturator foramen, reaming the acetabulum, and placing the trail cup in the proper position to assess the defect. Morselized bone grafts were used in eight cases only (Figure 4), along with combined strut grafts (fixed with screws) and morselized grafts in five cases, acetabular rim mesh and morselized grafts in 12 cases, and Kerboul cross rings with morselized grafts in one case.

The bone grafts were cut using a saw and rongeured into 0.5–1 cm^2 pieces. The bone grafts were washed in saline, then mixed with 2 g of vancomycin antibiotic. The morselized grafts were placed and impacted by special impactors of different sizes, up to 4 mm larger than the planned cup. In cases where mesh or a strut graft was used, they were fixed first by 3.5 mm screws, and then the morselized grafts were impacted. In cases where a Kerboul cross ring was used, the graft was first impacted and then the ring was fixed [6].

For most hips, cemented polyethylene cups were used, except for three hips in which cemented metal dual mobility cups were used. Next, the stem was inserted (long stem cementless stems in two hips, cemented stems in 12 hips, and cementless stems in 12 cases). Trial reduction and final reduction were performed, followed by closure in layers with suction drains which were removed 24 hours after surgery.

There were no intraoperative complications except for one longitudinal femoral shaft fracture that occurred during stem insertion and was treated successfully with cerclage wires and a fracture acetabular rim during removal of the bipolar head, and acetabular rim mesh and a graft. One patient developed sterile hematoma 3 weeks postoperatively and was treated using operative evacuation and washing.

Antibiotic prophylaxis was administered 5 days postoperatively and anticoagulants (low molecular weight heparin) were administered for 1½ months postoperatively [7].

Patients used crutches after surgery and engaged in no weight bearing for 1½ months, then partial weight bearing for another 1½ months, and then full weight bearing. One patient presented with aseptic loosening 3 months postoperatively.

Follow-up protocol

The follow-up duration ranged between 12 and 60 months with a mean follow-up period of about 38 months. Patients were evaluated clinically using the Harris Hip Score (HHS) preoperatively, 3 and 6 months postoperatively, and then every year [8]. Radiological evaluation with anteroposterior x-ray of the hips and pelvis were performed preoperatively, 1 day postoperatively, 3 and 6 months postoperatively, and then once per year. Radiographic analysis was used to measure limb length discrepancy, hip centers to teardrop pre- and postoperatively, postoperative theta angle, and the distance between the cup and Kohler's line. Linear migration was considered as a change of more than 5 mm in the hip center and the distance between the cup and Kohler's line, or more than 3º in the theta angle on follow-up x-rays, and any signs of loosening of the cup according to the DeLee and Charnely method where the acetabulum is divided into Zone 1 (superior lobe), Zone 2 (superior part of inferior lobe), and Zone 3 (inferior part of inferior lobe), and radiological failure considered when loosening appeared in all three zones [9].

Results

The clinical and radiological results are shown in Table 2. After 6 months, all patients except one showed clinical improvement. The mean preoperative HHS was 38 (range: 25 to 50) and the mean postoperative HHS was 84 (range: 30 to 90), and this improvement continued up to the last follow-up inall patients except one patient who needed revision because of acetabular loosening.

Table 2. *Follow up time, clinical and radiological results.*

case	Follow up (months)	Pre op HHS	Post op HHS	Pre LLD	Post LLD	Post theta angle	COR	Complications
1	30	30	90	-0.7	0	41.8	Restored	No
2	54	30	85	-1	0	46.4	Restored	No
3	30	41	90	-2.87	0	34.3	Restored	broken superior wall
4	54	40	85	-2	0	25.23	Restored	No
5	42	30	80	-1.5	0	30.2	Restored	No
6	42	28	75	4.1	0.5	28	Restored	No
7	54	46	90	-2.5	0	27.81	Restored	No
8	42	46	85	-1.05	0	44.9	Restored	No
9	30	47	90	-1	0	44.1	Restored	No
10	54	43	85	-2	0	32.8	Restored	No
11	30	39	85	-2	0	27.8	Restored	No
12	30	40	90	-3	0	37.1	Restored	No
13	54	46	90	-4.8	0	45	Restored	No
14	54	30	85	-0.5	0	34.4	Restored	No
15	12	28	90	-1.5	0	39.6	Restored	No
16	54	28	80	-1	0	28	Restored	No
17	54	28	80	0	0	41.9	Restored	No
18	66	30	85	-2	0	34.7	Restored	No
19	12	26	85	-2	-1	35	Restored	broken femur
20	54	50	85	-2	-0.5	32	Restored	No
21	18	46	85	-3.5	0.5	40.99	Restored	No
22	18	25	80	-2	0	32	Restored	No
23	30	47	90	0	0	32	Restored	No
24	18	40	85	-0.5	0	35	Restored	No
25	12	30	30	-0.5	0	50	Not restored	failed
26	30	40	85	-2	0	48	Restored	broken superior wall

Abbreviations: Pre op HHS: Pre-operative Harris hip score; Post op HHS: Post-operative Harriship score; Pre LLD: Pre-operative lower limb discrepancy; Post LLD: Post-operative lowerlimb discrepancy.

Radiographic analysis

Limb Length Discrepancy (LLD) showed significant improvement, with the mean preoperative discrepancy of 2.27 cm reducing to 0.15 cm postoperatively [10].

The mean postoperative theta angle was 38 (range: 27 to 50).

Follow-up x-ray showed graft corporation without loosening or any significant cup migration at the last postoperative follow-up visit in all patients except for one patient who required revision due to loosening around the cup. The other 25 hips (96%) showed graft union and consolidation with good-to-excellent clinical outcomes with restoration of hip center without any significant migration of the cup [11].

Discussion

One of the major challenges encountered by hip surgeons is how to properly manage acetabular bone defects, in addition to restoration of hip center and joint biomechanics. This challenge can be addressed with the use of Impaction Bone Grafting (IBG) to establish a stable acetabular bed that facilitates sound implant fixation [12].

Our technique is somewhat different technique. Using this technique, anchorage holes are created in the acetabular roof and in the graft, and the graft bed is then covered with metal mesh. Then, the component is cemented to avoid direct contact between cement and bone grafts that may lead to thermal necrosis and prevent bone incorporation. Despite endorsement

of this technique, a biomechanical and histological study conducted on goats demonstrated that graft incorporation occurs with direct contact between bone grafts and cement. In addition, conducted eight core biopsies from the acetabulum at reoperation after revision THR with impaction bone grafts and cemented cup, and reported full graft incorporation to new trabecular bone [13].

According the use of impaction bone grafts is physiologically sound and provides stability and mechanical support to the acetabular component with the appropriate technique. He also recommended cemented biologic fixation because with this technique, the bone stock can be restored and if revision surgery is needed, it will be easy and has less complications. In their study, reported a survival rate of 72% at 7.2 years in series of 71 revisions using an impaction grafting technique [14].

In our study, bone grafts and cemented cups were applied to all patients and 96% of patients showed satisfactory results at short- to mid-term clinical and radiological follow-up. The incorporation of impaction bone grafts was not jeopardized by bone cement, as reported. Reported incorporation of the bone graft, despite contact with bonecement.

One patient in our study underwent revision surgery due to failure of strut graft incorporation and early loosening. In their study of 3l patients in whom a bulk acetabular allograft had been used during cementless revision of total hip replacement, found that there was definite increase in the failure rate if more than 50% of the cup rested on the strut graft, reported similar findings.

We believe the use of impaction bone grafts may provide significant benefits in the short- and long-term, as the impaction procedure increases the short- and mid-term stability of the construct by restoring the hip centers, whilst the biological behavior of the graft (remodeling with new bone formation and host-graft union) provides long-term stability [15].

In our study, cemented cups were applied to all patients as they provide primary stability. Further, it has also been reported that structural grafts for acetabular defects with cementless THRs show a high failure rate. Attributed loosening after cemented THR to the cement, it was discovered retrospectively that loosening mostly was due to the bad quality of the polyethylene in those days and not due to the cement.

Apart from cases with massive bone loss and pelvic discontinuity, impaction grafts and cemented cups provide good-to-excellent results at mid-term follow-up.

Impacted bone grafts with cemented cup techniques increase long-term survival according to the literature. Moreover, impaction bone grafts allow the placement of the cup at the correct anatomical level and the restoration of the lower limb length, as shown by our results. Comba et al. reviewed the clinical and radiological results of 131 patients treated with acetabular revision with impacted bone grafts and cemented acetabular components. The survival rate was 95.8% at a minimum follow-up of 2 years and maximum of 13.1 years.

Our study showed good results with graft integration and stable fixation of the socket at the 1-year follow-up. On radiographs, bridging trabeculae were present at the host bone-graft interface.

One limitation of our study was the relatively short follow-up duration. However, many studies have reported 93–96% survival rates with 10 years of follow-up.

Conclusion

In conclusion, the use of impaction grafts and cemented cups is safe and effective, even in young patients. Moreover, this technique reconstitutes bone and provides a stable platform for bone stock and further revision, if needed, especially in young patients. On the other hand, it is technically demanding and time consuming, it delays postoperative weight bearing, and incorporation of the graft may be questionable in massive defects.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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*Correspondence to

Dr. Maysara Abdelhalim Bayoumy

Department of Orthopaedic and

TraumatologyAl-Azhar university

Cairo

Egypt

E-mail: mysara2005_r@yahoo.com