Impaction grafting for acetabular reconstruction in primary and revision hip arthroplasty

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Background
Acetabular bone stock loss is a major problem in both primary and revision total hip arthroplasty (THA). The loosening of primary cemented and cementless components of THAs is also accompanied by a loss of bone stock. There are several options for reconstruction of the acetabular defects. In 1979, a biologic method was introduced with tightly impacted cancellous allografts in combination with a cemented polyethylene cup for acetabular reconstruction, to restore acetabular bone stock, to restore normal hip biomechanics, and to allow for further revision if needed.

Aim of the work
In this study, the results of using morcellized impacted bone graft to reconstruct the deficient acetabulum in 54 hips (49 patients) using either cemented or cementless cups are discussed, with a mean follow-up of 36 (6–96) months.

Patients and methods
Between May 2002 and April 2010, 54 hips (in 49 patients) with deficient bone stock on the acetabular side had undergone total replacement with acetabular reconstruction using morcellized bone impaction grafting; out of the 54 hips, 34 (63%) were primary THA (17 after fracture of the acetabulum, 12 for protrusio acetabuli, three for rheumatoid arthritis, one for dysplastic hip, and one after tuberculosis arthritis) and 20 hips (37%) were revision THA. There were 21 (43%) women (bilateral in three of them) and 28 (57%) men (bilateral in two of them). Average age was 53 years (range 26–98 years). Out of the 54 hips, 14 (26%) were cementless and 40 (74%) were cemented. Mesh was used in 27 (50%) hips to convert a noncontained defect into a contained defect. Octopus ring was used in one hip, and Muller ring was used in another hip to overcome pelvic discontinuity.

Results
Fifty-four hips in 49 patients were followed up clinically and radiologically, with a mean follow-up of 36 months. In 46 hips (95.8%), the graft showed radiological signs of union to the host bone and no cup loosening. Cup was loose and revised in two patients (4.2%). One patient had octopus ring and morcellized graft in the first operation, and it was revised using a mesh and morcellized graft 8 years later. The other patient had morcellized graft and Muller ring; this failed after 4 years with cup loosening. It was revised using mesh and morcellized graft.

Conclusion
Acetabular reconstruction is a demanding procedure and needs preoperative planning and armamentarium. Successful results were obtained using the impaction technique for reconstruction. The aim of bone graft is to restore the normal hip mechanics. The union rate of the impacted graft is relatively satisfactory compared with other grafting methods. Augmentation of the grafting technique by mesh or rings added more stability to the cup component. The use of impaction graft in revisions for infected hip did not increase the risk of reinfection.

Keywords:
acetabular defects, cup loosening, impaction grafting, total hip arthroplasty

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Introduction

Bone deficiency on the acetabular side is a major problem in patients who require total hip arthroplasty (THA). Reconstruction of the acetabulum with bone grafts is a biologically attractive solution. Hastings and Parker [1] described the reconstruction of acetabular bone stock in cases with acetabular protrusion using autologous morcellized cancellous bone grafts in primary THA.

The use of bone grafts in orthopedic surgery is described extensively in the literature and is generally accepted as a reconstructive technique [2–8]. Regardless of the type of

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Table 1 AAOS classification for acetabular deficiency

Type	Defect
Type I	Segmental deficiency
IA	Peripheral
IB	Medial
Type II	Cavitary deficiency
IIA	Peripheral
IIB	Central
Type III	Combined deficiency
Type IV	Pelvic discontinuity
Type V	Arthrodesis

AAOS, American Academy of Orthopedic Surgery.

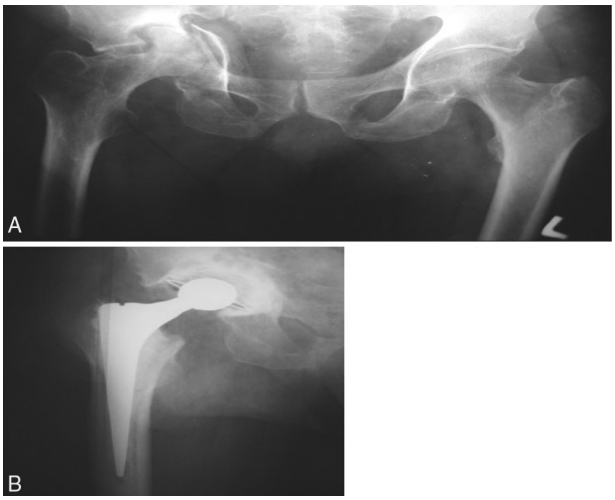
graft used, essential factors that influence the incorporation process are the stability of fixation, the amount of contact between the host and the graft, the strain pattern within the graft, and the degree of antigen matching. However, the size of the graft has also been found to play an important role in the graft incorporation process. Sloof *et al*. [9] have found that grafting with impacted allograft chips does not have the drawbacks of structural allografts. Since the late 1970s, impaction grafting combined with cement fixation of the prosthetic component has been their treatment of choice for restoring bone stock on the pelvic side and since the 1980s also on the femoral side. In 1984, they published their clinical experience [9]. A modification of the techniques was developed by Hastings and Parker [1], and also by McCollum *et al*. [10].

The selection of a proper bone graft for acetabular reconstruction in revision hip arthroplasty is based 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. The first classification system for acetabular bone deficiency was introduced in 1994 by Paprosky and colleagues [11,12]. Many other classification systems then appeared; these systems focus on classifying component migration, location of bone loss, and whether the bone deficiencies are contained or uncontained [11,12]. In our study, we used the classification system of the American Academy of Orthopedic Surgery [13] (Table 1).

Materials and methods

This study approved by the Ethical committee of Assiut University, Assiut, Egypt. Between May 2002 and April 2010, 54 hips (in 49 patients) with deficient bone stock on the acetabular side had undergone total replacement with acetabular reconstruction using morcellized bone impaction grafting; out of the 54 hips, 34 (63%) were primary THA (17 after fracture acetabulum (Fig. 1a and b), 12 for protrusio acetabuli, three for rheumatoid arthritis, one for dysplastic hip, and one after tuberculosis arthritis) and 20 hips (37%) were revision THA. There were 21 (43%) women (bilateral in three of them) and 28 (57%) men (bilateral in two of them). Average age was 53 years (range 26–98 years). Out of the 54 hips, 14 (26%) were cementless and 40 (74%) were cemented. Mesh was used in 27 (50%) hips to convert a noncontained defect into a contained defect. Octopus ring was used in one hip, and Muller ring was used in another to overcome pelvic discontinuity. At the last follow-up, four patients were dead, two were lost to follow-up, and two needed cup revision because of cup loosening (the patients with octopus ring and Muller ring). In the patient with octopus ring, the cup became loose and it was revised by using a mesh and impaction graft 8 years after operation. The other patient with Muller ring needed revision 4 years after the surgery. It was revised using a mesh and impaction grafting (Table 2).

Figure 1



(a) Radiograph of a 98-year-old male patient with fracture acetabulum, which was converted to total hip replacement using impaction graft. (b) Radiograph 2 months after the operation.

Operative technique

Surgical approach

In our study, we routinely used the modified direct lateral approach [14]. Any previously present implant was removed first.

Graft preparation

In primary cases, we used the patients' own femoral head as the autograft; the cartilage was removed from the head using special reamers after dislocation of the hip and before osteotomizing the neck. We found this to be much easier than reaming the head after cutting the neck while holding it with instruments (Fig. 2).

Table 2 Patient data

Number	Age	Sex	Diagnosis	Cup type	Follow-up (months)	Fate	Side	Use of mesh	Defect type according to AAOS
1	45	Female	Protrusio	Cementless	6	Still in	Right	No	IIB
2	55	Female	Revision one stage	Cemented	60	Still in	Left	Yes	IA
3	47	Male	Revision second stage	Cemented	6	Still in	Left	Yes	III
4	52	Male	Revision second stage	Cemented	7	Still in	Left	No	III
5	57	Male	Revision second stage	Cemented	72	Still in	Left	Yes	IA
6	54	Male	Fracture acetabulum	Cementless	12	Still in	Right	No	IIB
7	56	Male	Fracture acetabulum	Cementless		Died 3 days postoperatively	Right	No	IIB
8	62	Male	Fracture acetabulum	Cementless	18	Still in	Left	No	IIB
9	67	Female	Fracture acetabulum	Cemented	17	Still in	Left	No	IIB
10	39	Female	Protrusio	Cemented	12	Still in	Right	No	IIB
11	46	Female	Protrusio	Cementless	14	Still in	Right and left	No	IIB
12	52	Male	Protrusio	Cementless	15	Still in	Right and left	No	IIB
13	33	Female	Rheumatoid	Cementless	17	Lost follow-up	Right and left	No	IIB
14	48	Male	Fracture acetabulum	Cemented	24	Still in	Right	Yes	IV
15	67	Male	Fracture acetabulum	Cementless	96	Revised	Right	Octopus ring	III
16	46	Male	Revision	Cemented	48	Revised	Right	Muller ring	III
17	58	Female	Revision	Cemented	58	Still in	Right	Yes	IV
18	28	Male	Fracture acetabulum	Cemented	12	Still in	Left	Yes	V
19	58	Male	Revision	Cemented	13	Still in	Left	Yes	III
20	59	Female	Dysplastic hip	Cemented	48	Still in	Right	Yes	III
21	56	Female	Revision second stage	Cemented	14	Still in	Left	Yes	III
22	55	Male	Tuberculosis	Cemented	44	Still in	Left	Yes	III
23	49	Female	Protrusio	Cemented	34	Still in	Right and left	Yes	IIB
24	62	Male	Revision	Cemented	30	Still in	Right	Yes	III
25	54	Male	Revision	Cemented	31	Still in	Right	Yes	III
26	98	Male	Fracture acetabulum	Cemented		Died 16 months postoperatively	Right	No	IIB
27	59	Female	Fracture acetabulum	Cemented	23	Still in	Left	Yes	III
28	62	Male	Fracture acetabulum	Cemented	33	Still in	Left	No	III
29	51	Female	Fracture acetabulum	Cemented	31	Still in	Left	No	III
30	66	Male	Fracture acetabulum	Cementless		Died 39 months postoperatively	Left	No	III
31	61	Male	Protrusio	Cemented	39	Still in	Right	No	IIB
32	44	Male	Fracture acetabulum	Cemented	45	Still in	Right	Yes	IA
33	48	Male	Fracture acetabulum	Cemented	48	Still in	Right	Yes	III
34	42	Male	Revision second stage	Cemented	90	Still in	Left	Yes	IV
35	81	Female	Revision	Cemented	96	Still in	Left	No	IIB

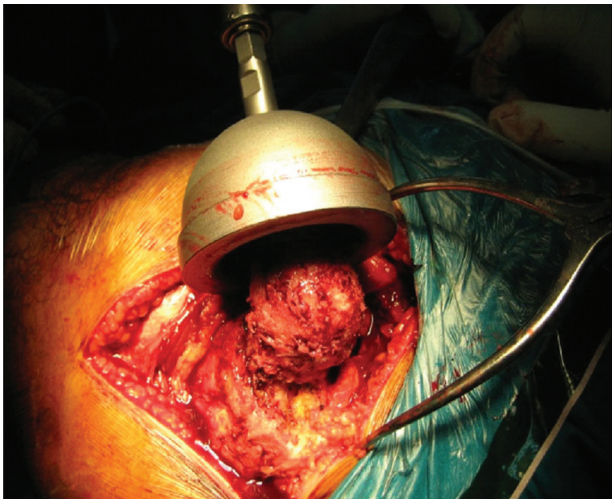
(*Continued*)

Table 2 (***Continued***)

Number	Age	Sex	Diagnosis	Cup type	Follow-up (months)	Fate	Side	Use of mesh	Defect type according to AAOS
36	58	Female	Revision	Cemented	50	Still in	Right	Yes	III
37	32	Female	Revision	Cementless	35	Still in	Left	No	III
38	58	Male	Fracture acetabulum	Cemented	46	Still in	Right	Yes	IA
39	57	Female	Revision second stage	Cemented	14	Still in	Left	Yes	III
40	62	Male	Fracture acetabulum	Cemented	39	Still in	Left	Yes	III
41	28	Female	Revision	Cemented		Died 34 months postoperatively	Left	Yes	III
42	46	Female	Protrusio	Cemented	60	Still in	Right	No	IIB
43	38	Female	Rheumatoid	Cemented	62	Still in	Left	No	IIB
44	56	Male	Revision	Cemented	61	Still in	Right	Yes	IIB
45	54	Female	Revision second stage	Cemented	63	Still in	Right	Yes	III
46	62	Female	Revision second stage	Cemented	60	Still in	Left	Yes	III
47	63	Male	Revision	Cemented	12	Still in	Right	Yes	III
48	26	Male	Fracture acetabulum	Cementless		Lost follow-up	Right	Octopus ring	IIB
49	38	Male	Protrusio	Cemented	96	Still in	Right and left	No	IIB

AAOS, American Academy of Orthopedic Surgery.

Figure 2



A special head reamer is used to remove remnants of cartilage and subchondral bone before cutting the neck, to leave pure cancellous bone.

Bone slices were then cut into small bone chips (5×10 mm) using a bone nibbler or bone cutter, as it was shown that the size of bone parts was important for mechanical stability, as well as the method of impaction [15].

In cases of revision after infection (second stage), we mixed 2 g of vancomycine powder with the cancellous bone chips to decrease the risk of recurrence of infection, as Buttaro *et al.* [16] showed that this resulted in decreased infection and did not affect incorporation of the graft. Next, the acetabulum was reamed and cleaned of any soft tissue in it. Multiple drill holes were then made in the acetabulum to invite vascularity (Fig. 3).

Impaction technique

If the defect was a contained defect – that is, cavitary – bone grafts were impacted with impactors and a mallet. We did not use the impaction technique in which the bone grafts are impacted using an acetabular reamer in a reversed direction combined with manual compression on the reamer [17]. In cases with uncontained defects, the defects were converted to contained defects using a mesh fixed to the acetabular columns with 4.5 mm screws over a trial cup 2 mm bigger than the size planned to be used. Next, the morcellized bone was impacted in the same way.

After impacting the graft as hard as possible, either a cemented or cementless cup was then inserted. In cases with segmental defects in which a mesh was used, only cemented cups were used.

Patients were mobilized 1 day after surgery: toe touch for 2 months using two crutches, and then partial weight bearing for another 2 months. Follow-up was done at 2, 6 months, and then every year as long as there is no problem.

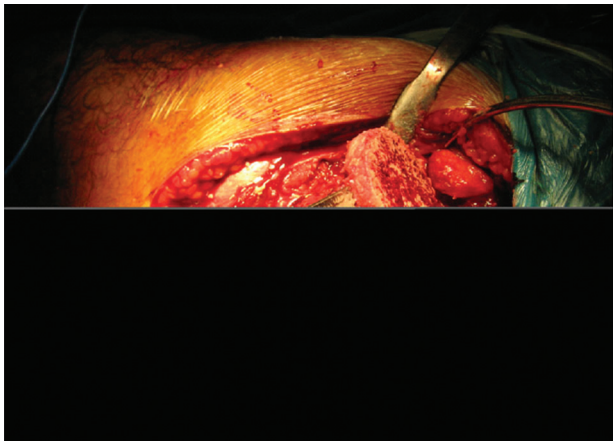
Radiographies were performed at each visit, and cup position and graft incorporation were evaluated.

Distance between the center of the femoral head and a line between both tear drops is measured and compared with the other side. The same distance is measured at each visit and compared with the immediate postoperative one.

Results

Fifty-four hips in 49 patients were followed up clinically and radiologically. At a mean follow-up of 36 months, four patients died at 3 days, 16, 34, and 39 months after operation. The cup was intact, and the graft had incorporated to the host bone at the time of death. Two patients were lost to follow-up. The cup was loose and revised in two patients (4.2%). One patient had octopus ring and morcellized graft in the first operation, and it was revised using a mesh and morcellized graft 8 years later. The other patient had morcellized graft and Muller ring; this failed after 4 years with cup loosening. It was revised using a mesh and morcellized graft. Both are still intact, and there were no signs of loosening until the last follow-up.

Figure 3



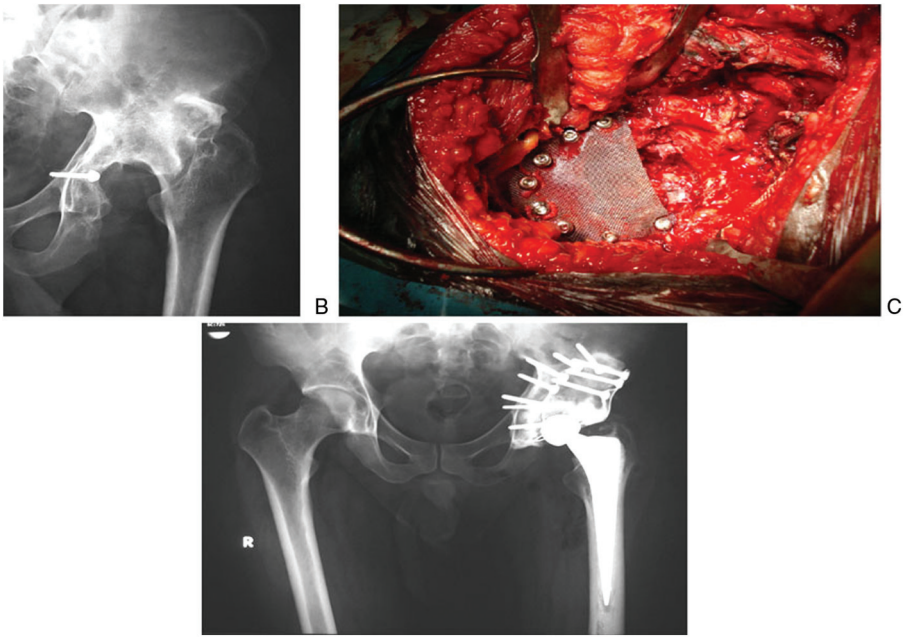
The power saw was used to cut the head into slices also before cutting the neck.

In the remaining 46 hips (95.8%), the graft showed radiological signs of union to the host bone and no cup loosening. Cup position was evaluated in the postoperative radiographs by measuring the distance between the center of the head and a line joining both tear drops and comparing to the other side. The head center was within 5 mm from a line joining both tear drops, when compared with the other side in 42 (91%) hips (Fig. 4a–c). Hip center was higher than the other by 6–10 mm in two patients (4.5%), and it was higher than 10 mm in two patients (4.5%). Computed tomography was performed in some cases, and it showed complete union of the graft to the host bone (Fig. 5).

Discussion

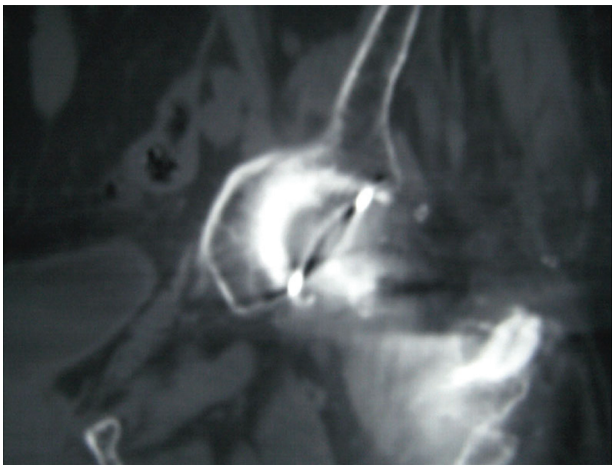
Since 1979, the literature shows several options for reconstruction of the acetabulum with concomitant

Figure 4



(a) Patient with old fracture acetabulum after metal removal. (b) Mesh covering the superolateral wall of the host acetabulum and fixed with screws. (c) Radiograph 1 year after the operation.

Figure 5



Computed tomography of an 82-year-old female patient showing incorporation of the bone graft into the host bed at 8-year follow-up.

bone loss whether in primary or revision hip arthroplasty [1,10,18,19]. The aim of bone graft is to restore the normal hip mechanics, to obtain stability, and to restore the bone stock, allowing also for further revision if needed. All of these can be obtained by using morcellized bone graft and polymethylmetacrylate cemented cup or cementless cup in some selected cases. Serious acetabular defects, even in combination with compromised acetabular columns, were restored successfully with this reconstruction method.

Harris [18] introduced a reconstruction method that involved autogenous solid and structural grafts that were fixed with screws and bolts to the iliac wall. Five years later, he reported an increasing number of graft resorptions. The authors of the current study believe that the quality of these degenerative femoral heads may be inadequate, and during the revascularization phase of the incorporation process this structure will partly resorb and collapse.

On the other hand, the morcellized grafts adapt easily and closely to the irregularities of the host bone bed without gap formation. After impaction, the surface of the graft is rough, which enhances the cement interdigitation and improves the primary stability. The tight impaction of the graft and the cement extrusions into the graft provide an increase in the initial stability of the entire reconstruction. Several studies showed that new bone formation is possible in direct contact with bone cement [19–22].

In several long-term follow-up studies, the bone impaction reconstruction technique with a cemented cup showed acceptable results [23–26]. In our study, morcellized impaction grafting for acetabular reconstruction in both primary and revision hip arthroplasty accompanied with the use of polymethylmethacrylate cemented cups with follow-up to 96 months showed good results with incorporation to the host bed.

The use of impaction graft in revisions for infected hip did not increase the risk of reinfection [27].

Conclusion

Acetabular reconstruction is a demanding procedure and needs preoperative planning and armamentarium. Successful results were obtained using the impaction technique for reconstruction. The aim of the bone graft is to restore the normal hip mechanics. The union rate of the impacted graft is relatively satisfactory compared with other grafting methods. Augmentation of the grafting technique by mesh or rings added more stability to the cup component. The use of impaction graft in revisions for the infected hip did not increase the risk of reinfection.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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