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Main Subject [Orthopedic Surgery]

Original Article

Impacted Bone Graft in Revision Acetabulum Surgery: A clinical experience

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Article information

Received: 12-01-2022

Accepted: 12-03-2022

DOI: 10.21608/ijma.2022.59285.1249

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Citation: El Said MM. Impacted Bone Graft in Revision Acetabulum Surgery: A clinical experience. IJMA 2022 March; 4 [3]: 2217-2224. doi: 10.21608/ijma.2022.59285.1249

ABSTRACT

Background: With the advancement of hip surgery and increased life span in many nations, the need for acetabular revision surgery is expected to grow. Many options are available for such surgery, including the use of impacted bone graft.

The Aim of The Work: This work aimed to assess the clinical results of impacted bone graft in reconstructing the acetabular bone defect after a failed hip surgery.

Patients and Methods: Between 2013 and 2019, we performed reconstructions of the acetabulum for 20 patients, who had at least one acetabular operation before revision. Surgical reconstruction was conducted using an impacted cancellous bone graft. Each patient was directed to long-term clinical [primary outcome] and radiological evaluations. The direct postoperative clinical and radiographic outcomes were evaluated and the patient continued regular follow up visits for at least 12 months after surgery.

Results: According to the modified Harris-Hip [MHH] score, the results rated as excellent [35%], good [25%], fair [25%] and poor [15%]. No pain was recorded for 40%, slight pain for 30%. Thirteen patients [65%] were able to walk alone without support, while the remaining 7 used a support in the form of a cane [25%] or crutches [10%]. Leg-length discrepancy [>2.5 cm] was reported in two patients.

Conclusion: Successful results were obtained using the impaction technique for acetabular reconstruction, with restoration of near normal mechanics. The union rate is satisfactory. Augmentation of the grafting technique by mesh or rings added more stability to the cup component.

Keywords: Impacted Bone Graft; Revision Surgery; Acetabulum Reconstruction; Failed hip surgery.

INTRODUCTION

Following the surgery of primary total hip arthroplasty, long-term evaluation of these patients revealed an increasing frequency of complications that led to a growing number of acetabular revision surgery [1]. The main aims of revision acetabulum surgery are the provision of cup stability, restoration of the hip rotation center, and bone replacement in patients with bone deficiency [2].

The major challenge combated in revision acetabular surgery is the deficit of bone store that frequently disturbs the support of acetabular graft [3]. Several authors have classified acetabular bone loss. The two most frequently used classifications are ones made by Paprosky [4] and The American Academy of Orthopedic Surgeons [5] [AAOS classification]. Such classifications are intended to direct the treatment option or to compare outcomes, but often have poor correlation between observers. This conflict might be related to the difficulty in the assessment of bone loss, and the discrepancy between the intraoperative findings and the radiographic assessment [6].

In most cases of acetabulum revision surgery, bone defect is usually present. These defects may represent a challenge to the surgeon during the revision hip arthroplasty. There are various surgical choices and procedures for the control of bone defects. Most of these defects can be operated with an uncemented hemispherical cup. Good outcomes are also described for acetabulum revision with impacting bone graft with cemented cups [7]. However, impacted bone graft may be associated with the trouble of poor cup support, if the impact technique is inadequate or if the mesh is too weak to repair partial defects [8].

Furthermore, rigid reinforcement rings linked with impacted bone grafts have the drawback that the bone grafts are protected from periodic loading and thus the stimulation of bone formation is reduced [9]. The condition of loss of acetabular bone resulted in more complicated revision surgery requiring the use of allogeneic intensification. Some immediate follow-up studies have shown good graft integration into the host's bone, while others have disapproved the use of allogeneic grafts due to possible slow graft absorption and component loosening at longer follow-up periods [3]. With the increased frequency of revision hip arthroplasty, which represent a surgical challenge in most of the patients, the need for longitudinal follow-up studies to evaluate the functional and radiological effects of this procedure is warranted.

THE AIM OF THE WORK

This work aimed to assess the clinical and radiological results of impacted bone graft in reconstructing the acetabular bone defect after a failed hip surgery.

PATIENTS AND METHODS

Between 2013 and 2019, we performed reconstructions of the acetabulum for 20 patients. The study was conducted at Orthopedic Department of Damietta Faculty of Medicine, Al-Azhar University, Egypt.

The inclusion criteria were osteolysis with loosening, infection followed by loss of bone and iatrogenic loss in the course of removal of an implant. On the other side, the exclusion criteria were the incapability to control a segmental defect, medial, or peripheral. It can be impossible to contain significant defects of the anterior and posterior columns with enough stability to allow effective impaction grafting, and other techniques for reconstruction should be considered in these circumstances and large superolateral defects spreading down both the anterior and posterior columns, which are difficult to be contained.

Sample size calculation and technique: A convenient sample was the method of sampling. Actually, all patients presented for reconstruction during study duration and fulfilled the inclusion criteria were included.

During the operation, the defects were identified as cavitary, segmental or combined defects with variable degrees. According to the system of the American Academy of Orthopedic Surgeons [3], the defects were later reclassified. By this system, type I [segmental defect], type II [cavitary defect], and type III [combined segmental and cavitary]; these groups are furthest subdivided into peripheral superior, anterior, posterior, or central defects, according to their location. Furthermore, type IV characterizes pelvic gap, and type V denotes arthrodesis.

Surgical intervention: The approach was either a posterior [15 patients] or a direct lateral [five hips]. Initially, the acetabulum was reamed carefully to toughen the surface of the bones. No trials were done to over ream to present a circular cavity. A testing cup that fits the tightest diameter [mostly anteroposterior] was enclosed, and the requirement for allograft reconstruction was evaluated. Reestablishment of major defects was performed with impacted cancellous autograft or allografts [frozen or freeze-dried] were operated, and fixed to

the host bone by cement, buttress plate, mesh, or reconstruction ring. Cancellous grafts were located into the acetabular and were reverse-reamed with an acetabular reamer that was two mm minor than the testing cup. This technique condensed the graft into a cavity, resulting in a hemispherical acetabulum. Usually, the entire acetabulum will be lined with allogeneic bone. A cup of the determined size was placed and struck in place. In patients with infections, the procedure was performed in two phases. Firstly, the prosthesis components and cement were eliminated, antibiotic beads with spacers were inserted, and the antibiotic was given intravenously for a minimum of 6 weeks. After that, a reconstructive revision was made.

Clinical Follow-up Evaluation [Primary outcome]: Patients are instructed for follow-up observation at six weeks, three months, six months, and 12 months after the operation. Then, the follow-up continued each year. Radiological assessment was obtained at each visit. In addition, the range of hip movement and the limb-length discrepancy was documented, and the patient was asked about complications. Patients also completed a standard questionnaire, used to calculate their modified Harris hip scores [HHSs]. The score described as excellent [> 90 points], good [80 to 89 points], fair [70 to 79 points], and failure [< 70 points] [10]. The questionnaire also included patient satisfaction.

Radiographic Evaluation: Radiographs was done directly after the surgery to define the degree of cup coverage, and documented as a fraction of the cup hemisphere. Graft coverage was classified as 90-I00%, 80-89%, or 70-79%. Consecutive X-rays were obtained to detect the integration time of the graft. For all radiographic evaluations, graft density was recorded in one of three classes: normal, sclerotic, or porotic. The cup is considered failed if there is as a revision of the cup regardless of the cause. A cup was considered loose if comparisons with follow-up examinations showed a linear displacement greater than 4 mm or an apparent angular rotation greater than 3°. The secondary outcome included any postoperative compilations or mortality.

Statistical analysis of data: The collected data was anonymized and fed to personal computer running Microsoft windows. The Microsoft Excel [one of Microsoft office package] was used to calculate data. Categorical data were explained as numbers [frequency] and percentage. Quantitative data were described using mean and standard deviation.

Ethical considerations: An informed consent was obtained from each patient. The study was approved by the institutional Review Board [IRB] and local ethical committee. The study was completed according to ethics and research regulations [codes] of Helsinki declaration for research conduct and reporting.

RESULTS

Demographic and disease characteristics: The indications of revision surgery were loosening of a cemented cup in three hips, infected loosening in one hip, loosening of a cementless cup in five hips, and a neglected fracture in nine hips, and conversion of a hemiarthroplasty in two hips. Twelve patients had undergone surgery at right hip and eight patients at the left hips. Regarding sex, 13 were men, and seven were women. The mean age at the time of surgery was 50.15 years [range, 31-80 years]. Each patient had at least one previous hip surgery [range 1-6 surgeries; average 1.8]. The mean duration of follow-up was 4.5 years [range, 2-7 years].

Radiographic Results: The mean time of healing was 5.2 months [range, 4-7]. At the last visit, the grafts were sclerotic in ten patients [50%], had normal density in nine hips [45%], and it was porotic in one hip [5%]. Regarding radiologic measurements, the average angle of inclination of the cups was 44.1° [30°-59°]. The average placement of the cups was 2.8 mm at the medial side to Kohler's line [4 mm lateral to 13 mm medial].

Clinical Results: According to the modified Harris-Hip [MHH] score, the results were excellent [seven patients; 35%], good [five patients; 25%], fair [five patients; 25%] and poor [three patients; 15%]. The majority of patients reported no pain [40%], followed by slight pain [30%]. Thirteen patients [65%] walked alone without support, while the remaining seven either used a cane [25%], or needed crutches [10%]. The average difference in leg length was 0.9 cm [0-4 cm]. Leg- length discrepancy [>2.5 cm] was reported in two patients.

Complications and Failures: Three patients had nerve problem, with partial recovery in nerve function. Two of them had sciatic nerve injury and the last patient had femoral nerve injury. One patient had postoperative dislocation that managed by closed reduction and traction treatment for 6 weeks after that needed an extra technique for recurrent dislocations by putting a snap-fit cup.

Table [1]: Clinical and radiological result of the studied patients.

		No.	%
Radiological result according to graft healing	Normal density Sclerotic Porotic	9 10 1	45% 50% 5%
Results according to modified HHS	Excellent Good Fair Poor	7 5 5 3	35% 25% 25% 15%
Results according to pain	No pain Slight pain Mild pain Moderate pain Marked pain	8 6 4 1 1	40% 30% 20% 5% 5%
Results according to walking	Without support Use a cane Need crutches	13 5 2	65% 25% 10%

Table [2]: Detailed data of the studied population

N	Sex	Age [Y]	Side	Type of acetabulum Defect	Reconstruction method	Radiological density	Modified HHS
1	Female	65	Right	**I a** [segmental peripheral]	Impacted bone graft, floor mesh, and posterior plate	Normal	**Excellent**
2	Male	38	Right	**III** [combined segmental &cavitary]	Impacted bone graft and posterior plate	Sclerotic	**Good**
3	Male	38	Left	**IV** [pelvic discontinuity]	Impacted bone graft and posterior plate	Sclerotic	**Excellent**
4	Female	40	Right	**II b** [cavitary central]	Impacted bone graft	Sclerotic	**Excellent**
5	Female	31	Left	**I a** [segmental peripheral]	Impacted bone graft and posterior plate	Normal	**Excellent**
6	Male	40	Right	**I a** [segmental peripheral]	Impacted bone graft, floor mesh, and screw	Sclerotic	**Good**
7	Female	48	Right	**II a** [cavitary peripheral]	Impacted bone graft	Normal	**Excellent**
8	Male	51	Left	**II b** [cavitary central]	Impacted bone graft and Muller ring	Sclerotic	**Good**
9	Female	56	Right	**II b** [cavitary central]	Impacted bone graft	Normal	**Good**
10	Male	40	Left	**Ia** [segmental peripheral]	Impacted bone graft and posterior plate	Sclerotic	**Excellent**
11	Male	45	Left	**I a** [segmental peripheral]	Impacted bone graft, floor mesh, screw, and posterior plate	Normal	**Good**
12	Female	45	Left	**I a** [segmental peripheral]	Impacted bone graft	Sclerotic	**Excellent**
13	Female	52	Right	**I a&I b** [segmental peripheral &enteral]	Impacted bone graft, floor mesh, and screw	Normal	**Fair**
14	Male	53	Right	**I a** [segmental peripheral]	Impacted bone graft, floor mesh, screw, and posterior plate	Normal	**Poor**
15	Male	56	Right	**I a** [segmental peripheral]	Impacted bone graft, floor mesh, and screw	Normal	**Fair**
16	Male	55	Right	**I a&I b** [segmental peripheral &enteral]	Impacted bone graft, floor mesh and screw	Sclerotic	**Poor**
17	Male	80	Left	**II b** [cavitary enteral]	Impacted bone graft and Muller ring	Sclerotic	**Fair**
18	Male	35	Right	**I a** [segmental peripheral]	Impacted bone graft	Normal	**Fair**
19	Male	60	Right	**II b** [cavitary enteral]	Impacted bone graft	Porotic	**Poor**
20	Male	75	Left	**II b** [cavitary enteral]	Impacted bone graft	Sclerotic	**Fair**

Case presentation

Male patient 50 years-old who had old right hip avascular necrosis [AVN]. Resurfacing of the right hip was done 10 years ago. Right total hip replacement was done after the failure of resurfacing within one year. Aseptic loosening of cup and stem was done. On examination, the patient had a significant Trendelenburg limp on the right side. The right lower extremity was approximately 6 cm shorter than the left. The right hip had 50 degrees of flexion on the range of motion testing, no internal rotation, 20degrees external rotation, and 10 degrees of abduction. Neurovascular examination of both lower extremities was normal. Radiology studies are shown in figures [1, 2].

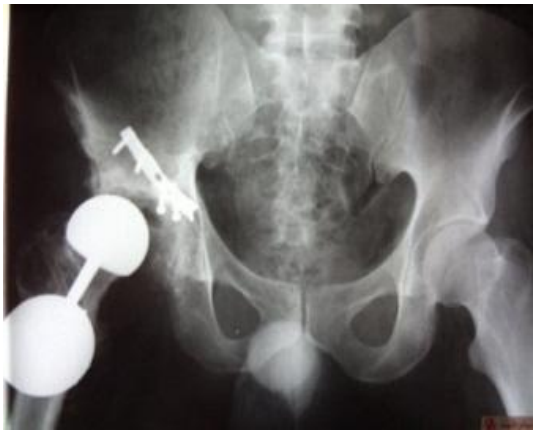

Figure [1]: Plain x-ray AP view showing both hip with resurfacing of right hip. RT acetabulum Posterior wall and roof defect fixed by plate and screw.

Figure [2]: Plain x-ray AP view showing both hips with the total hip replacement of right hip with aseptic loosening of cup and stem.

Diagnosis: Chronic subluxation of the right hip with massive osteolysis of the right acetabulum.

Type of the defect: Type IA [segmental peripheral posterior, superior]

Surgical Technique [Figures 3-14]: A posterior approach was used. A total capsulectomy was achieved, then the femur is moved to show the whole acetabular rim, then the previous prosthesis was removed. The acetabulum was reamed to expose bleeding bone, and a trial acetabular shell of the same size as the final reamer diameter was inserted. The medial loss was filled with morselized allograft mingled with demineralized cortical bone powder and tightly compressed by a smooth hemispherical reamer. We implanted bone mesh and fixed it with a screw in the acetabulum and the graft with a buttress plate in the posterior wall. A cemented hemi-spherical component was implanted. Exeter stem was implanted in the femur.

Figure [3]: Photograph picture intraoperative showing the approach.

Figure [4]: Photograph picture intraoperative showing the previous prosthesis.

Figure [5]: Photograph picture intraoperative showing the head and cup before removal.

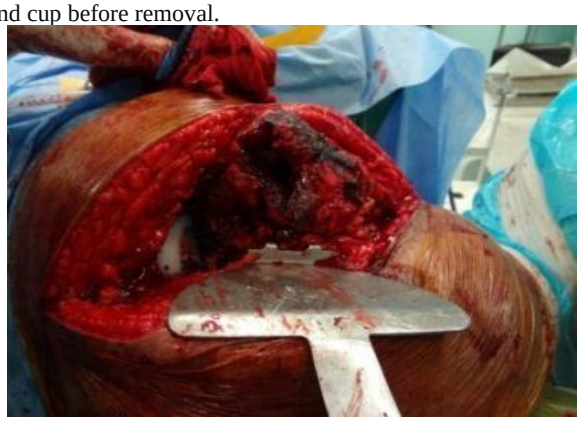

Figure [6]: Photograph picture intraoperative showing the proximal femur after removing the stem.

Figure [7]: Photograph picture intraoperative showing the cup

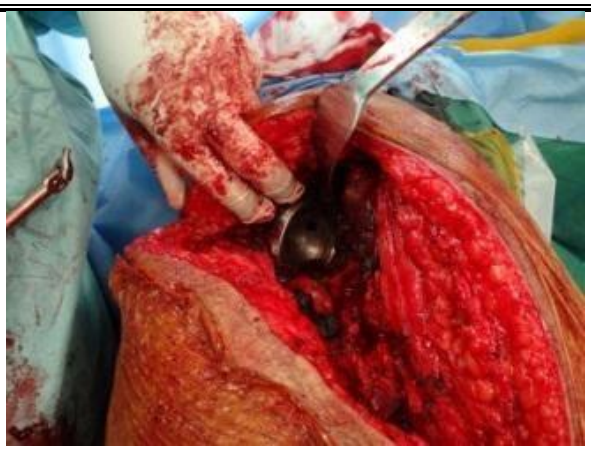

Figure [8]: Photograph picture intraoperative showing the cementless cup after removal of the insert liner

Figure [9]: Photograph picture showing the previous prosthesis after removal.

Figure [10]: Intraoperative picture showing the acetabulum defect after removal of the cup

Figure [11]: the acetabulum defect after reconstruction by impacted bone graft and posterior buttress plate.

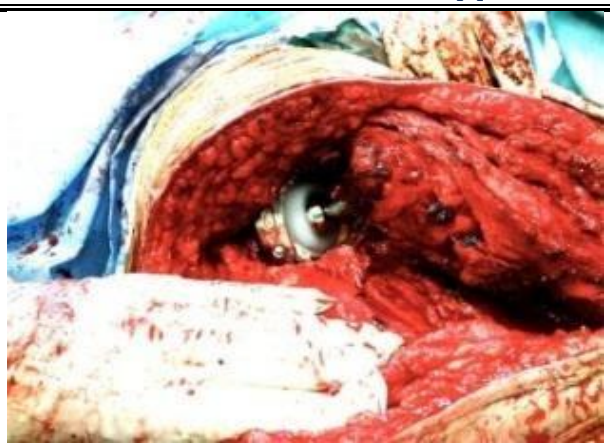

Figure [12]: the prosthesis in place after reconstruction of the acetabulum

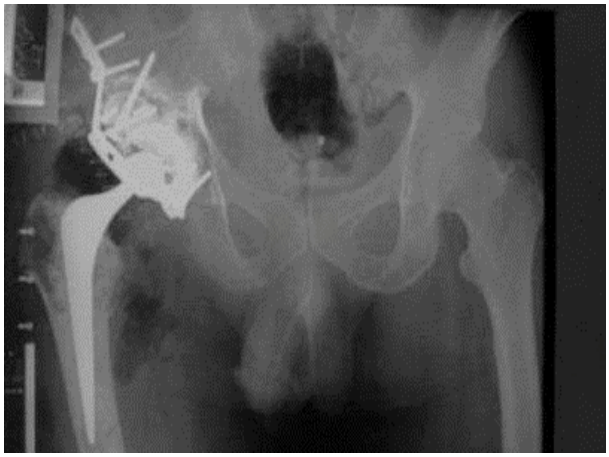

Figure [13]: Postoperative X-ray showing reconstruction of LT acetabulum by impacted bone graft augmented by mesh and buttress plate with cemented THR

Figure [14]: Final X-ray after the graft was taken.

DISCUSSION

Despite increasing evidence supporting the assessment, classification, and management of acetabular bone loss in hip arthroplasty revisions, there was no consensus guidelines are available until now, and many issues in the management remain controversial [3]. The main challenge encountering the surgeons of hip arthroplasty is the defects of acetabular bone, which can be very problematic to

rebuild. Many procedures have been designated to deal with this issue; most of them are complex and associated with many complications. They include bone grafts, trabecular metal supplements, "mega" or "jumbo" cups and screw fixation, cemented or cementless fixation and cages [11]. Impacted implants can be used to restore a healthy layer of bone that can be implanted with cement or a snug-fitting acetabular component [12].

In this series, the success rate of bone graft impaction was excellent [19 out of 20 patients; 95%], following at least 2 years of follow up. Arumugam et al. [13] studied sequential 64 cup revision with follow-up period of 10 years, with survival rate of the graft being 95.5%. Verspeek *et al*. [14] reported higher failure rate [27%; 13 out of 44] in their 15 years follow-up study. They reported improvement in the HHS, and radiographic loosening of 20% of patients. In the cohort study conducted by Busanelli *et al.* [15], the survival rate was 88% at ten years for bone graft revisions and 87.5% for revision without bone grafts. In another study, the survival rate of an implant operated for aseptic loosening was 96.3% [95% CI 94.1 to 98.5] at ten years, which reduced to and 92.8% [95% CI 89.2 to 96.6], when calculated at 15 years [16].

The achievement of impacted bone graft is eventually reliant on the condition of micro interlock within bone ingrowth. Factors influencing this ingrowth are insufficiency of micromotion, lack of infection, and sufficient host bone for invasion [17].

Additional significant factor is the surgeon's capability to decide, if the remaining acetabular cups will maintain the uncemented components, before and during surgery. The acetabular rims and reinforcing columns are significant inherent stabilizing structures [18]. The principle of rebuilding of impaction grafts is a combination of mechanical and biological. Cancellous allograft impacted into bony defects with a cemented cup has to get the stability to permit for slow graft integration into host bone [19].

Most revision cases had some components on the rim, which provide good to excellent results. In these cases, particulate or bulk grafts are required to fill the small defects in the acetabulum. However, if the margin is insufficient and does not support the acetabular component, then the structural support allogeneic grafts should be used. Structural grafts repair the acetabular margin and maintain the stability of the rigid component until tissue invasion had occur [3].

The designers of bone impacting and other technique have reported outstanding long-term outcomes for impact bone implants and cement parts in small and sealed defects that can achieve good initial implant fixation [20]. But, if these techniques are used in larger defects [AAOS three or four], the survival of the implants appear less effective except if strengthened by a mesh [21]. On the other hand, cementless acetabular cups in corrective surgery appear to be more reliable with Type 3 defects [22], which was rarely encountered in our study. The revision using cementless implants allows the shell to be pushed between the opposing host bones, resulting in less than 50% stability in host bone contact [16].

The main limitation of the study is the relative short period of follow-up for some patients [2 years]. In addition, there was variability in the follow-up period among different patients. Finally, a small sample size made subgroup comparisons not feasible.

Conclusion: Acetabular reconstruction is a demanding procedure and needs good preoperative planning. Successful results were obtained using the impaction technique for reconstruction. The bone graft aims to restore 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.

Financial and Non-financial activities and relations of interest

None

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