Combined cementless acetabular reconstruction with bone grafting in total hip replacement after acetabular fractures treated nonoperatively

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Background

Acetabular fractures are serious and challenging orthopedic injuries. Many of these fractures may potentially result in late complications that can occur with or without initial surgical treatment. Such complications usually end in post-traumatic arthritis. Once symptomatic post-traumatic arthritis has developed, options for salvage are generally limited to total hip arthroplasty (THA) and arthrodesis. Whether initial nonoperative or operative treatment was used to manage acute and highly displaced acetabular fractures, formidable problems such as nonunion, malunion, bone defect, and heterotopic bone may complicate the arthroplasty. More recent studies have evaluated the techniques of THA after an acetabular fracture initially managed by a nonoperative or an operative course. Various reconstructive strategies have been assessed in an attempt to advice improvements in the surgical protocol.

Aim

The aim of the work was to evaluate the early results of THA using cementless acetabular components combined with bone grafting in the reconstruction of the hip joint in patients with post-traumatic arthritis after an old nonoperatively treated acetabular fracture or fracture dislocation.

Patients and methods

This prospective study included 12 patients who had end-stage arthritis. All patients had old acetabular fractures either with or without hip dislocation. All patients had a nonoperative treatment for their fractures 1–5 years before presentation for total hip replacement. Clinical, laboratory, and radiological evaluations before surgery were performed. In all patients, conventional cementless cups combined with bone graft from their own femoral heads were used to fill defects and reconstruct the acetabulum. The duration of the follow-up period ranged from 1 to 3 years.

Results

Clinically, there was marked improvement in the Harris Hip Score (satisfactory results in 83.33% of the study group at the last follow-up) with special concern to postoperative pain relief, the range of hip movement, and the walking distance. Radiologically, all cups were placed in the normal hip center with no early signs of cup loosening, migration, or position change with good integration of the bone graft.

Conclusion

The results were very satisfactory and significantly in favor of using this technique using conventional cementless cups combined with autogenous bone grafting to reconstruct the acetabulum in certain cases of old united fractures of the acetabulum saving the extra costs of metallic augments, special cups, or modular reconstructions using cages or rings and achieving a superior biological and biomechanical reconstruction.

Keywords:

arthritic acetabulum with defect, autogenous bone graft, cementless cup, durable biologic construct, old fracture acetabulum

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Introduction

Total hip replacement (THR) after acetabular fractures remains a challenging reconstructive dilemma. The procedure is much more difficult than a conventional total hip arthroplasty (THA) for nontraumatic arthritis, especially on the acetabular side, whatever the method of treatment used for the acetabular fracture, mainly due to the presence of bone defects, nonunions, malunions, retained implants, and soft-tissue scarring. There is also an increased incidence of complications, especially infection, sciatic nerve palsy, and aseptic loosening, especially in operatively treated cases of acetabular fractures. Acetabular bone deficiencies encountered during THA vary from cavitary or segmental defects to complete pelvic discontinuity [1,2].

Acetabular bony defects are classified according to the American Academy of Orthopaedic Surgeons and Paprosky and Gross's classification [3,4]. This is not completely usable in case of bony defects arising after acetabular fractures, because the bony defect is often combined with an unhealed fracture, pseudarthrosis, especially after nonoperative treatment, or primary osteosynthesis performed for fractures of the dorsal wall and the dorsal column.

Mears and Velyvis [5] recommend a classification for acetabular bony defects arising after fractures, which also provides therapeutically important considerations. According to this clinical classification, acetabular bony defects smaller than 10 mm in diameter are of only minor structural importance and usually no bone grafting is required. Bony defects 10–25 mm in diameter are of moderate importance; defects larger than 25 mm in diameter are relevant and of very high surgical importance. Naturally, localization of the bony defect (the acetabular margin or the central part) makes a significant difference and essentially determines the selection of the cup to be implanted.

Several techniques exist to manage these defects, including placement of jumbo cups, the use of a high hip center, specialized roof and reconstruction rings, modular porous metal augments, bone void fillers, and bulk or morselized bone grafts [6–8].

The use of morselized cancellous bone graft and a cementless porous-coated acetabular component is a well-established technique in acetabular revision surgery in the presence of bone deficiency [7,9]. A high rate of graft incorporation has been reported when morselized bone graft is used in contained bone defects during acetabular reconstruction [10,11].

Patients and methods

This prospective study was carried out in the Orthopaedic Department at Benha University Hospital, Benha, from March 2010 to September 2013, including 12 patients. All patients (100% of the cases) were male. Their ages ranged from 32 to 51 years (mean 42 years). All patients (100% of the cases) had post-traumatic end-stage arthritic hips after old acetabular fractures. The duration between their presentation and the initial injury ranged from 12 to 60 months (mean 38 months). All patients (100% of the cases) were treated by nonoperative treatment in the form of skeletal traction in bed. Four (33.3%) patients had a hip dislocation associated with the acetabular fractures.

Patients were evaluated preoperatively. Obtaining complete history of the initial injury was critical, including the nature of trauma, associated injuries, neurovascular conditions, the interval between the injury and return to preinjury activities, the time of onset of symptoms, and disabilities after the initial trauma; history also included evaluation of any previous radiographs dating since the initial trauma. Physical examination and scoring the condition according to the Harris Hip Score (HHS) was performed, and laboratory evaluation was carried out to exclude any hidden infection and to assess the general condition of the patient was performed.

Complete radiological evaluation of the present condition was performed to plan the strategy for intervention including both plain radiographs and computed tomography (CT) (sagittal–axial–coronal three-dimensional reconstruction).

Iliac and obturator views of the pelvis and the acetabulum can show more details of columns and walls (anterior and posterior) regarding bony union, any residual acetabular displacement, nonunion, or acetabular deficiency (Figs 1 and 2).

Using preoperative radiographs, a CT scan, especially axial cuts, can show the quality and the quantity of the posterior wall and the column and their union; the medial wall of the acetabulum and its integrity can be shown with an axial CT scan. Acetabular bone deficiency was classified according to the American Academy of Orthopaedic Surgeons: type I, segmental deficiency with significant rim defect (IA, peripheral; IB, central with the medial wall absent); type II, cavitary defects (IIA, peripheral; IIB, central with the medial wall intact); type III, combined cavitary and segmental deficiency; type IV, pelvic discontinuity; and type V, arthrodesis. All the studied cases had acetabular deficiency. Two (16.66%) cases had type IA acetabular deficiency. Four (33.34%) cases had type IIA acetabular deficiency. Six (50%) cases had type IIB acetabular deficiency.

Implants used

Cementless stems were used in all cases; on the acetabular side, modular hemispherical, porous-coated, multihole, cementless cups consisting of a titanium shell covered with a titanium fiber–metal mesh, with multiple optional holes for supplemental screw fixation, were used in all cases.

Regarding the bearing surfaces, in eight (66.66%) cases, a 36-mm large-head ceramic was used on a highly cross-linked polyethylene liner. In four (33.33%) cases, a 28-mm metallic head was used on a highly cross-linked polyethylene liner. All the time, there was another system of cemented femoral and acetabular components and also plates and screws that could be used if needed in the fixation of any residual acetabular nonunion.

Cup insertion

The procedure was carried out in the traditional manner as any THR till complete exposure of the acetabulum all around; examination of the acetabulum to assess any acetabular defect either in the walls or within the cavity of the acetabular socket was performed. After reaming, trial cups were inserted to assess the cup seating and fitness within the socket and to assess whether any part of the socket was uncovered or unsupported by the acetabular bone. The acetabulum was wide and conical other than hemispherical in two cases with slight retroversion due to maluninon of the previous posterior column and posterior wall fractures. Bone grafting was performed to maintain the integrity of the dome and the medial wall and also to provide two-column support for the acetabular component if less than two-thirds rim fit of the cup to the host bone was obtained.

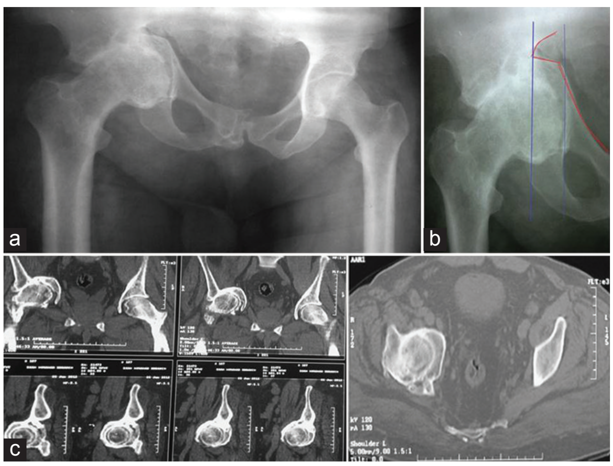
In type II cavitary defects, adequate host peripheral bone is present in the anterior and the posterior columns to allow implantation of press-fit hemispherical components without structural grafting. Central cavitary defects in either the superior weight-bearing dome or the medial wall were treated with a morselized cancellous graft taken from the femoral head and from the acetabular reamings impacted into the contained cavitary defect both manually and by reverse reaming. In some cases, thin (<3 mm) wafers of corticocancellous or decorticated bone were obtained from the femoral neck using an oscillating saw and placed in the defect. Supporting and restoring these central defects is critical to prevent long-term axial migration of the components. In the two cases of segmental peripheral defect (type IA acetabular deficiency), there was a peripheral rim fit of more than two-thirds the cup circumference; hence, no structural grafts were required. The acetabular components were secured with two to four titanium screws placed through the shell. Excellent intraoperative primary stability of acetabular components was achieved; the liner was then placed and the procedure was completed as usual till wound closure (Figs 3 and 4).

Postoperative care

Monitoring in the immediate postoperative period included the general condition of the patient, care of the wound and suction drains, neurological assessment, and detection of leg-length discrepancy.

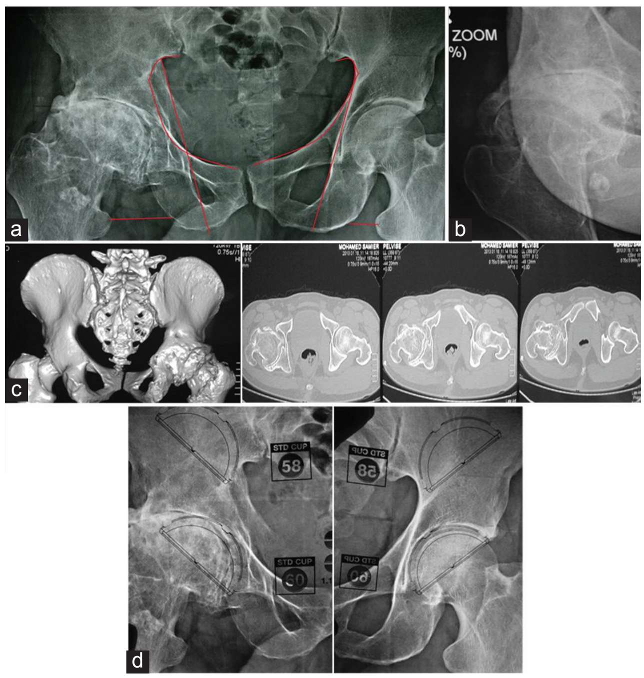
Getting out from bed was started on the first postoperative day. Suction drains were removed 48 h postoperatively. Prophylactic intravenous third-generation cephalosporins were started the day before surgery and continued 7 days after surgery

Figure 1



(a) The preoperative radiograph of a case with old fracture acetabulum with central dislocation treated conservatively, completely united, ended by hip arthritis. (b) The disturbed iliopectineal line and the site of the femoral head beyond the Kohler line, denoting severe acetabular protrusion. (c) Computed tomography cuts showing disturbed anatomy of the acetabulum (wide, deep acetabulum) with medial displacement of the roof and the medial wall.

Figure 2



(a) End-stage arthritis after old fracture acetabulum with a history of hip dislocation. The disturbed ilioischial line denoting an old posterior column fracture. (b) An obturator view revealed an associated old united posterior wall fracture. (c) Three-dimensional reconstruction and computed tomography cuts showing a displaced united posterior wall and column fracture with a very wide acetabular socket. (d) A wide difference in the size between the normal and the affected side.

combined with thromboembolic prophylaxis. Oral antibiotics were continued till suture removal 2 weeks after the procedure. Ambulation was guided by the intraoperative stability of both the acetabular and the femoral components. Weight bearing was restricted to toe touch for 6 weeks, waiting for early graft incorporation and consolidation of the cup–graft–bed construct. This was followed by 50% weight bearing for another 6 weeks. Full weight bearing was permitted at 12 weeks postoperatively.

Regular follow-up visits were carried out and re-evaluation was performed at 6 weeks, 3, 6, and 12 months, and then yearly. The follow-up period ranged from 12 to 36 months, with the average of 22 months.

Results

Clinical results of this study were evaluated according to the HHS. Evaluation of radiological results included the assessment of both the femoral and the acetabular components with special attention to the acetabular component, evaluating the cup position and orientation, cup seating and adequacy of bone graft both behind and around the cup, and screw distribution and position.

Clinical results

The HHS is a comprehensive, widely accepted scoring system that was used for the clinical evaluation of patients preoperatively and postoperatively at 6 weeks, 6, 12 months, and yearly thereafter till the last follow-up. The score was considered excellent if it was between 90 and 100, good if between 80 and 90, fair if between 70 and 80, and scores below 70 were considered poor. The preoperative HHS ranged from 22 to 58, with a mean of 44.6; the postoperative HHS in the last follow-up ranged from 74 to 96, with a mean of 87.4 (Table 1).

Excellent results (HHS ≥90) were obtained in eight of 12 cases, representing 66.66% of the study group; good results (HHS 80–90) were reported in two cases, representing 16.66% of the study group; fair results (HHS 70–79) were encountered in two cases, representing 16.66% of the study group; no patients with poor results (HHS < 70) were reported in this study. Hence, satisfactory results (excellent and good results) were obtained in 10 patients, representing 83.33% of the study group. The range of motion (ROM) accounts for five points of HHS. The preoperative scoring for ROM ranged from 1 to 3.5, with a mean of 2.7; the postoperative scoring for ROM in the last follow-up ranged from 3 to 5, with a mean of 4.8.

There was a statistically significant increase in the ROM at 6 weeks compared with the preoperative score ($P = 0.0001$); the difference remained significant between the postoperative scoring for ROM at 6 weeks and at 6 months postoperatively ($P = 0.04$). This difference became insignificant at 6 months if compared with the ROM score at the end of the follow-up ($P = 0.4$) (Table 2).

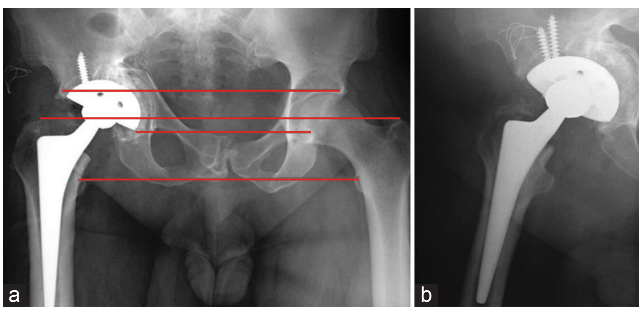
The preoperative and the postoperative ROM in the last follow-up regarding flexion, abduction and adduction, and internal and external rotation are shown in Table 3 and Fig. 5.

Table 1 Results of Harris Hip Score in the last follow-up compared with the preoperative Harris Hip Score

Preoperative HHS		Last follow-up HHS		*P*-value
Mean	SD	Mean	SD	
44.6	11.47	87.4	13.5	0.001*

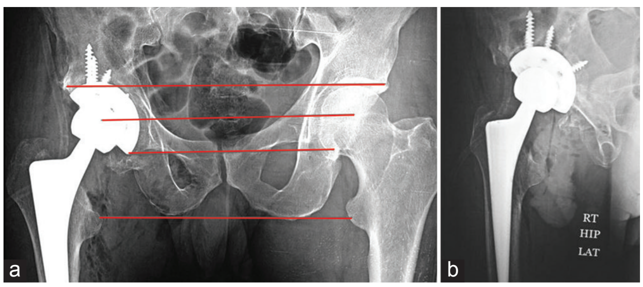
HHS, Harris Hip Score; *Significant.

Figure 3



(a) Anteroposterior radiograph immediately postoperatively showing the cup seating in the normal position with the gap behind the cup to the displaced medial wall completely filled with bone graft, with restoration of all the parameters of good reconstruction. (b) The lateral view radiograph showing the anchorage of the screws, cup antiversion, and graft distribution all around the cup.

Figure 4



(a) Anteroposterior radiograph immediately postoperatively showing the cup seating in the normal position with the bone graft placed mainly inferior, posterior, and medial to the cup. (b) The lateral view radiograph showing the distribution and the anchorage of the screws, and the cup orientation.

Radiological results

Standard radiographs were obtained for all patients immediately postoperatively and at subsequent follow-up assessments.

Acetabular component inclination, position of screws, and distribution of bone graft around the cup

Acetabular inclination was determined in relation to the interteardrop line. Acetabular inclination in all hips ranged from 40 to 49°, with a mean of 43.8°. All cups were intentionally put in a more horizontal position (closed) to ensure better stability. In all cases, additional acetabular screws were inserted to achieve better initial stability necessary for the proper long-term stability by osteointegration. At least two screws were used, but in certain cases up to four screws were used to achieve better stability in cases in which the socket was grafted peripherally around the cup to decrease the size of the needed cup to properly reconstruct the acetabulum. Screws were inserted mainly in the dome of the acetabulum in the superiolateral part and away from the greater sciatic notch in the lateral view (Figs 3 and 4).

Femoral stem alignment

If the tip of the stem was central, it was in neutral alignment. If the tip pointed toward or was resting on the lateral cortex, it was in varus alignment.

If the tip pointed toward or was resting on the medial cortex, it was in valgus alignment; all stems were central in position.

Radiological follow-up

Standard anteroposterior and lateral radiographs were obtained for all patients at subsequent follow-up examinations. The radiographs were examined for consolidation and integration of the bone graft inserted either behind or around the cup to reconstruct the acetabular deficiency, acetabular component migration or position change, early retroacetabular or screw-associated osteolysis (Fig. 6).

The implant–bone interface was evaluated for the presence and the extent of radiolucent lines according to the modification by Martell *et al.* [12] of the DeLee and Charnley [13] technique, which describes five periacetabular zones (A1, A2, B1, B2, and C). An implant was considered radiographically loose if there was more than 2 mm radiolucency in any Charnley zone, component migration in the vertical or the horizontal position of more than 2 mm, any radiolucency in two contiguous Charnley zones, or a change in inclination of more than 4°. Bone graft was considered incorporated if remodeling and trabecular bone formation were observed after an initial increase in radiodensity [12,13].

A radiolucent line of less than 2 mm was detected in all Charnley acetabular zones in a single patient (Fig. 7). This patient was asymptomatic with a HHS of 97; the radiolucent line was nonprogressive till the last follow-up.

Table 2 Comparison between the mean preoperative and postoperative range of motion scores

	Preoperative	6 weeks	6 weeks	6 months	6 months	Last follow-up
	2.7	4.1	4.1	4.4	4.4	4.8
P-value		0.0001*		0.04*		0.4

*Significant.

Figure 5

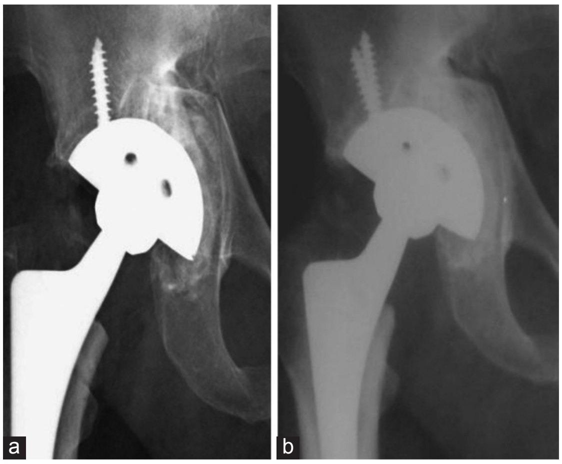
The range of motion and stability of one case in this study.

Table 3 Comparison between the mean range of motion preoperatively and at the last follow-up

	Flexion (°)		Abduction (°)		Adduction (°)		External rotation (°)		Internal rotation (°)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Preoperative	39.9	12.5	18.35	11.2	12.49	5.6	20.31	9.1	7.8	6.7
Postoperative	91.8	9.7	42.5	6.8	24.7	4.2	49.1	4.0	28.8	4.1
P-value		0.0001*		0.0001*		0.0001*		0.0001*		0.0001*

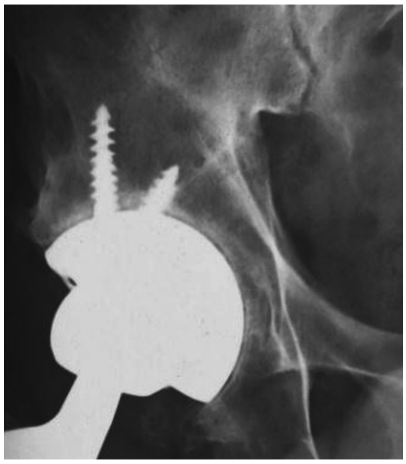
*Significant.

Figure 6



(a) Radiographs immediately after the procedure. (b) Radiograph 3 years after the procedure. The progression of the cancellous graft placed medially to fill the medial cavitary defect behind the cup. There was marked consolidation and osteointegration of the graft to the acetabular bed.

Figure 7



A radiolucent line of 1 mm all round the cup with no change in the cup position after 2 years of follow-up in an asymptomatic patient, with a Harris Hip Score of 97.

Discussion

Ronmess and Lewallen [14] reported revision and loosening rates for the cemented cups used in posttraumatic hip arthritis after acetabular fractures that were four-fold higher than those in osteoarthritic patients; their data demonstrated a cup revision rate of 13.7% and a loosening rate of 49%, with 27% of those hips having symptomatic loosening.

The purpose of this prospective study was to evaluate the results of cementless acetabular reconstruction combined with bone grafting in the reconstruction of the hip joint for the treatment of post-traumatic arthritis with acetabular bone defects. The achievement of the basic principles of hip replacement is challenged by the loss of acetabular bone stock. It is important to achieve direct implant host bone contact in at least part of the dome and the posterior column or after grafting and much more importantly a good rim fit of more than 50% of the surface of the prosthesis.

The principles of acetabular reconstruction include the creation of a stable acetabular bed, secure prosthetic fixation, bony reconstitution, and the restoration of a normal hip center of rotation with acceptable biomechanics. The type and the extent of acetabular bone loss (segmental or cavitary) determines the method of reconstruction.

Weber *et al.* [15] reported 66 cases in which they implanted a cemented cup in 44 cases and an uncemented cup in 20 cases. A hybrid prosthesis was implanted in two patients (uncemented stem, cemented cup). A longer prostheses lifetime was observed after implantation of the uncemented cups.

Ranawat *et al.* [16] reported 32 post-traumatic hip prosthesis implantations, wherein they achieved better results with uncemented prostheses.

Karpos and Christie [17] reported the data of THRs performed without cement in a series of 15 hips with previous acetabular fractures. The acetabular reconstructions were performed with porous-coated or mesh-coated components with supplemental screws. Morsellized bone graft was used in 47%, whereas structural bone graft was necessary in 40% of the reconstructions. The mean follow-up was 68 months (range 48–100 months). There was only one cup revision for malpositioning and recurrent dislocation. There was no case of symptomatic cup loosening, but 27% of the cases showed radiolucencies in at least one acetabular zone. The results of the present study are similar to that of Karpos and Christie. There has been no cup revision in our series, whereas radiographic loosening of less than 2 mm occurred in one (8.33%) case that was asymptomatic.

Bellabarba *et al.* [18] reported 40 cases in which noncemented prostheses were implanted after acetabular fractures; the outcome was almost the same as that after surgeries performed for degenerative diseases. At the same time, they compared previous nonoperatively and operatively treated cohorts, and confirmed that bone grafting was more frequently necessary in the operatively treated group.

Recent reports on the use of impaction bone grafting and cementless acetabular components in primary and revision THA have demonstrated encouraging clinical results [19,20].

Regarding the use of impaction bone grafting in primary THA, Pereira *et al*. [20] reported excellent results with 100% survivorship of impaction bone grafting in a retrospective review of 23 primary THAs at a mean 7.9-year follow-up. Similarly, Patil *et al*. [21] noted a good clinical outcome and satisfactory consolidation of autografts used for the treatment of protrusio in 30 primary THAs at a mean 4.2-year follow-up.

The advantage of grafting is that it avoids the need to use mega cups, oblong cups, or metallic tantalum augments to fill bony voids and to decrease the size of the bony socket, allowing the use of cups the same size as the normal contralateral side, thereby restoring the hip center of rotation to its proper site, restoring the normal biomechanics of the hip and improving the durability of the acetabular construct.

Conclusion

(1) THR after acetabular fractures is considered as a heavy task for the surgeon and must be planned perfectly as a difficult primary or even a revision hip replacement.
(2) The most important aspects to be considered in the preoperative planning are the following; healing of the previous fracture, fracture localization (anterior, posterior column, bottom of the cup, or combined), localization and extent of the acetabular bony defect, the amount and the type of bone grafting needed, and the patient's age and bone quality.
(3) A morsellized allograft is inserted, packed, and/or reverse reamed into any defects. The reconstruction relies on the ability to gain biological fixation of the component to the underlying host bone. This requires intimate host bone contact and rigid implant stability; the fixation is therefore augmented with multiple screws in all cases.
(4) The advantages of bone grafting in acetabular reconstruction include the ability to restore bone stock and restore normal hip center and hip biomechanics.
(5) This study confirms the usefulness and effectiveness of cancellous impaction bone grafting as a reliable technique in the management of bone defects after old united fractures or fracture dislocations of the acetabulum in primary THA, saving the extra costs of metallic augments, special cups or modular reconstructions using cages or rings, and achieving a superior biological and biomechanical reconstruction.
(6) Successful results of cup fixation in this series could have been partially due to less severe anatomic abnormalities of the acetabula in my patients; a longer follow-up is needed to verify the patients and methods both clinically and radiologically.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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