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Review article

MEDIUM-TERM RESULTS OF THE USE OF CEMENTLESS, PLASMA-COATED WITH DISPERSED TITANIUM POWDER AND HYDROXYAPATITE, ANATOMICAL ACETABULAR CAGES

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ABSTRACT

Background: The purpose of this study is to report the medium-term clinical and radiographic results of Paprosky type II and III acetabular bone defects revised with a cementless anatomical cage and cemented lipped acetabular cup.

Methods: We retrospectively analyzed 58 patients who underwent revision hip arthroplasty with cementless anatomical cages and lipped cemented acetabular cups between April 2009 and December 2013. We registered the following bone defects: Paprosky type IIA - 12 patients, Paprosky type IIB – 15 patients, 14 patients were with Paprosky type IIIA - 14 patients and with Paprosky type IIIB – 17 patients (pelvic discontinuity). Clinical assessment included Harris Hip Score (HHS) and Short Form-12 (SF-12). The radiographic assessment included the center of rotation, cage migration, and osteointegration of the implant.

Results: We followed up the patients included in our series with a mean follow-up of 89.5 months (range 38–141), The Harris Hip Score (HHS) improved from 29.5 (12–41) points preoperatively to 87.7 (57–96) points during the last follow-up, and the Short Form – 12 (SF–12) also increased. In 1 patient we did revision due to cage loosening and broken screw 57 months after surgery. In 2 patients we registered non-progressive radiolucency in the AP and Lateral radiographs without any clinical complaints.

Conclusion: The cementless anatomical cage combined with a cemented lipped acetabular cup achieves a good result with a high osteointegration rate in Paprosky type II and III acetabular bone defects.

Keywords: Cementless acetabular cage, revision hip arthroplasty, acetabular bone defects,

INTRODUCTION

In revision hip arthroplasty, all severe acetabular bone defects are a complex problem with the goals of achieving stable and durable fixation of the acetabular component, restoring acetabular bone stock and reconstructing the hip rotation center [1]. There are several reconstruction options to choose including impaction bone grafting and cemented cup [2], hemispheric acetabular component [3, 4], porous metal augments [5, 6, 7], ring and reconstruction cage [8, 9], oblong components [10], cup-cage reconstruction [11, 12, 13], and custom triflange implants [14, 15].

The porous hemispherical components provide structure for bone ingrowth in order to achieve firm fixation and have satisfactory follow-up results [5, 6, 7]. But when the acetabular bone defect is severe, placing the acetabular components in an anatomical position and simultaneously achieving stable fixation may be difficult. In this situation, the reconstruction cage is an alternative option [16].

Previous reports on reconstruction cages show good mid to long-term results in acetabular revision arthroplasty [8, 9, 17, 18]. When combined with bone allografts, the cage can bridge the bone defect to protect the underlying allograft during the bone remodeling phase. This may contribute to restoring acetabular bone stock and further revision surgery [19]. All these studies combined the results of Paprosky type II and III bone defects [8, 17, 18].

Gamma irradiation is widely used for allograft sterilization in tissue banks, and its effectiveness and safety has been confirmed. But, it can result in a decrement in the mechanical strength of the allograft and affect the biological performance of the allograft [20]. Povidone-iodine has good sterilization ability, and it has advantages in maintaining the tissue viability of allograft when used for allograft sterilization [21, 22, 23]. At the same time, the process of allograft sterilization with povidone-iodine is relatively simple compared to gamma irradiation. Therefore, povidone-iodine may be an alternative option for allograft sterilization.

The purpose of this study is to report the mid-term clinical and radiographic results of using cementless anatomical reconstruction cages and lipped cemented acetabular cups for Paprosky type II and type III acetabular bone defects in acetabular revision.

MATERIAL AND METHODS

Our institution's Ethics Committee approved this study. We systematically searched the patients whose diagnosis included acetabular bone defects in the joint replacement registration system of our hospital from April 2009 to December 2013. There were 156 patients diagnosed with type II and type III acetabular bone defects according to the Paprosky classification [24], 58 of whom underwent revision hip arthroplasty with cementless anatomic reconstruction cage and lipped cemented acetabular cup (Fig. 1). The preoperative and postoperative clinical and radiographic examinations and surgical data of these 58 patients were available.

Fig. 1. a) Medial and **b)** Lateral view of the cementless anatomic reconstruction cage (Metrimed – Hungary) that we used. Note that the cage is not hemispherical but oval, elliptical, shape to better fit the elliptically worn acetabulum.

Fifty-eight patients had 58 revision hips. Twelve patients had a type IIA bone defect, 17 patients had a type IIB bone defect, 14 patients were with Paprosky type IIIA and 17 with Paprosky type IIIB (pelvic discontinuity). The type of the acetabular defect was determined by preoperative radiographic examination and intraoperative assessments. There were 23 males and 35 females whose average age at revision was 66.4 years (range 46–83), and their average body mass index was 23.9 kg/m2 (range 18.3–29.6). Twenty-three had left hip involvement, and 35 had right hip involvement. Thirty-one were total hip revisions, 27 were acetabular revisions, and 15 had primary total hip replacement or hip revision on the opposite side. The main cause of revision was aseptic loosening (AL), including 45 patients, and 13 had periprosthetic infection. The initial diagnosis of these patients was osteoarthritis in 43 cases, posttraumatic osteoarthritis in 7 cases, femoral head necrosis in 4 cases, and osteoarthritis secondary to hip pyogenic infection in 4 cases. In this series, 43 hips had the first revision, 13 had the second revision, one had the third revision, and one had the fourth revision arthroplasties (Table 1). Before surgery, C-reactive protein and erythrocyte sedimentation rate were obtained for every patient. If the infection could not be ruled out, hip aspiration was performed. If the acetabular component was entering into the pelvis, the iliac artery angiography was performed.

Table 1. Demographics of Patients

Parameters	**Values**
• Gender (male/female)	23/35
• Age (y)	66.4 (46-83)
• Body mass index (kg/m^2)	23.9 (18.3–29.6)
• Side (R/L)	23/35
Diagnosis	
Aseptic loosening	45
Periprosthetic joint infection	13
Paprosky (IIA/IIB/IIIA/IIIB)	12/17/14/17

Surgical technique

The revision arthroplasty was performed by 2 senior surgeons in a specialized operating room. The Bauer-Hardinge approach was used in all patients. First, the original acetabular component was exposed and removed. Curettes, osteotomes, and hemispherical reamers were used to debride cement and scarred capsular tissue to fully expose the acetabulum and achieve a well-vascularized bone bed, at this point, the surgeon would assess whether hemispherical implants and augments or other materials can be used to complete the revision. In this step, attention should be paid preserving the bone stock. At the same time, on other aseptic table, the theatre nurse started preparing the antibiotic acrylic bone cement that we used for fixation of the lipped polyethilene cup in the cage. When the bone bed was ready, we washed several times with betadine solution. The flanges of the cementless anatomical reconstruction cage (Metrimed - Hungary) were bent and shaped to fit the specific anatomy of the reamed acetabulum. The cage was hammered inside the acetabular cavity to achieve a press-fit fixation. The superior flange was fixed to the iliac bone with cancellous bone screws, and the inferior spike was press-fitted to the ischium and the pubis. Additional screws were passed from the cage to the ilium in the safe zone. A lipped polyethylene cup was then cemented into the cage with an appropriate anteversion and abduction angle. Fifty-two mm (range 48–62) cages were most commonly used, and the 32-mm stainless steel femoral heads were used in all cases. An average of 4.2 (range 2–7) screws per cage were used.

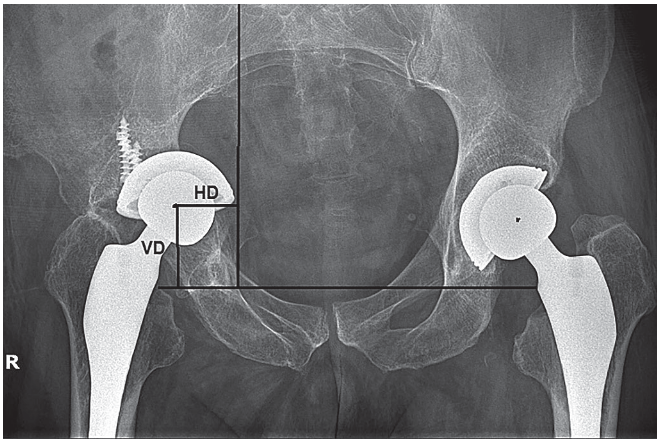
Postoperative management

All patients received cefotaxim and vancomycin for 6 days after operation. Enoxaparin was used to discharge, followed by Eliquis for 3 weeks. Patients began training the quadriceps femoris strength, hip flexion, and hip abduction at the first day after operation and made touch-down weight bearing at two or 3 days after operation. Partial weight bearing began at 6 weeks after the operation and then transferred to full weight-bearing gradually. The patients were advised to avoid forced internal rotation and keep slight abduction with the use of a wedged pillow for 2 months. Clinical and radiographic evaluation were performed at 3 months, 6 months, and 1 year after the operation, and then once a year until the last follow-up.

Clinical assessment included Harris Hip Score (HHS) [25], Short Form-12 (SF-12) [26], and complications. For HHS, both pre and postoperative were obtained, 90 to 100 points were defined as "excellent", 80 to 89 points were defined as "good", 70 to 79 points were defined as "fair", and lower than 70 points were defined as "poor". For SF-12, physical and mental component were evaluated independently.

Radiographic assessment was accomplished by taking standard anteroposterior radiographs of the pelvis and anteroposterior and lateral radiographs of the hip at each follow-up of all patients, and if necessary, 3-dimensional computed tomography of the hip was obtained. We measured the hip center of rotation in standard anteroposterior radiographs of the pelvis [24]. The distance between the femoral head center and reference line through the teardrop figure is defined as vertical distance (VD), and the distance between the femoral head center and perpendicular reference line through the teardrop is defined as the horizontal distance (HD), the changes of which is defined as vertical migration (VM) or horizontal migration (HM) (Fig. 2). According to the criteria of Gill et al. [27], more than 5 mm cage migration in the horizontal or vertical, screw breakage and progressive radiolucent lines present at the cage–bone interface medially and superiorly or around the screws were defined as loosening. As Gross et al. reported [28], the incorporation of the cementless cage was defined radiologically by the presence of trabecular crossing the cage–host interface. The bone resorption was evaluated by anteroposterior radiographs and was graded as minor (<1/3 of bone resorbed), moderate (1/3 to 1/2 of bone resorbed), and severe (>1/2 of bone resorbed). We also described bone resorption in the three zones of acetabulum as defined by DeLee and Charnley [29].

Fig. 2. Preoperative AP radiograph of a 64-year-old male patient with central protrusion of the right acetabular shell. VD, vertical distance; HD, horizontal distance



Statistical analysis

Quantitative data were presented as mean values ± standard deviation. Statistical package SPSS version 22 (SPSS version 22; IBM Corporation, USA) was used to perform statistical analyses. The pre and postoperative clinical and radiological data were compared using a paired Student's t-test. P<0.05 was considered to be statistically significant.

RESULTS

Clinical results and complications

All patients were followed up with a mean follow-up of 79.5 months (range 38–141). We had 1 re-revision, the implant survival with acetabular re-revision as the end point is shown in Fig. 2. The HHS improved significantly from 31.4 (13–43) points preoperatively to 84.6 (55–94) points at the last follow-up (p<0.01), in which 14 (25%) patients had an excellent score; 32 (57%) had a good score; 8 (14%) had a fair score; and 4 (4%) had a poor score (55 points) which was performed re-revision as mentioned later. Compared with preoperative, the SF-12 at the last follow-up has improved significantly (Table 2). There was 1 recurrent dislocation at 8 months after the operation, treated with plaster immobilization for 2 months with no re-dislocation afterwards and HHS of the patient was 85 points at the last follow-up, 1 sciatic nerve palsy recovered partially, and the HHS of the patient was 72 points at the last follow-up, 1 acute renal injury was successfully treated, and 1 femoral prosthesis loosening at the 2nd years after operation treated with femur re-revision, whose acetabular prosthesis was stable and the HHS of the patient was 87 points at the last follow-up. There was no periprosthetic joint infection, no deep vein thrombosis, no vessel damage, and no complaints about limbs length discrepancy.

Table 2. Preoperative and postoperative comparison of Clinical and Radiological evaluation

Indicator	Preoperative	Postoperative	Last Follow-up	P Value
HHS	31.4±10.4		84.1±7.8	.000
Rating (no. of hips)				
Excellent	0		14	
Good	0		32	
Fair	0		8	
Poor	58		4	
SF-12				
Mental component	12.8±3.1		23.9±2.7	.000
Physical component	7.8±1.3		21.3±2.6	.000
Hip center (mm)				
Horizontal distance	42.1±11.5	42.7 ± 6.2	43.1±6.5	.773/.351
Vertical distance	47.9±17.2	22.3 ± 7.7	23.6±9.2	.000/.012
horizontal migration			1.4±1.7	
vertical migration			1.3±2.5	

With the acetabular component protruding into the pelvis, iliac angiography was performed on one of the patients and found that the acetabular shell was compressing the internal iliac artery, so we performed the surgery together with a vascular surgeon. The operation of the patient went uneventfully.

Radiological results

As for the hip center of rotation, the horizontal distance was corrected from preoperative 42.1 mm (range 15.2–61.5) to postoperative 42.7 mm (range 34.3–53.5) (P>0.05). The vertical distance was corrected from preoperative 47.9 mm (range 15.8–78.0) to postoperative 22.3 mm (range 12.2–40.5) (P<0.05). There were only two (4%) patients with a postoperative vertical distance of more than 35 mm, which was defined as a high hip center [30]. Compared with 23 (82%) patients whose preoperative vertical distance was more than 35 mm, the hip center of rotation was improved. There was no significant difference between postoperative and last follow-up horizontal distance (43.1 mm, range 34.1–56.9) (P>0.05), and horizontal migration from postoperative to last follow-up was 1.4 mm (range 0.1–9.6). There was a significant difference between postoperative and last follow-up vertical distances (23.6 mm, range12.4–54.3) (P<0.05), and vertical migration from postoperative to last follow-up was 1.3 mm (range 0–13.8) (Table 2). Although the difference between postoperative and last follow-up vertical distances was significant, there was only 1 patient whose vertical migration (13.8 mm) and horizontal migration (9.6 mm) were both more than 5 mm at the last follow-up. And the cage of this patient was loosening with one screw breakage at 61 months after surgery, we performed acetabular re-revision surgery using a bigger size of cementless anatomic cage and antibiotic cement augmentation (Fig. 3). For 2 patients (7%), non-progressive radiolucency appeared at the bone implant interface, the width of which was less than 2 mm. The radiolucency of 1 patient was in the junction of DeLee and Charnley zone II and zone III, and the other patient was in DeLee and Charnley zone III. And according to Gross et al. [28], the resorption of these 2 patients was graded as minor. Complete incorporation was encountered in 25 patients (Fig. 4).

DISCUSSION

Severe acetabular bone defects and pelvic discontinuity are extremely complicated and challenging in revision arthroplasty. In this study, the acetabular bone defects of all patients were too large to treat with the combination of hemispheric cup and augments, therefore, we used cementless anatomic reconstruction cages and antibiotically loaded cement to reconstruct the bone defects. The mid-term follow-up clinical and radiographic results are successful.

In our study, two patients (4%) with pelvic discontinuity suffered re-revision for the cage loosening with one screw breakage at 61 months after surgery, but we found that the cementless cage was partially incorporated into the host bone and the pelvic discontinuity was healing, and we performed the re-revision with bigger size of cementless anatomic cage and antibiotically loaded bone cement. Abolghasemian M, et al. [31] reported that they performed in 50 hips acetabular re-revision surgery and used structural or morselized allograft bone with a cage or ring for previous revision, and they found that a simple revision without using allograft, augments, rings or

Fig. 3. Radiographs of a 51-year-old woman with Paprosky IIB acetabular bone defects and pelvic discontinuity was found intraoperatively. **a)** Immediate postoperative radiograph showed acceptable positioning of the cemented acetabular cup. **b)** Radiograph at 12 months after the swos loosening of the cup and dislocation of the prosthesis. **c)** Radiograph after revision with a bigger size of cementless anatomic cage and antibiotic cement augmentation.

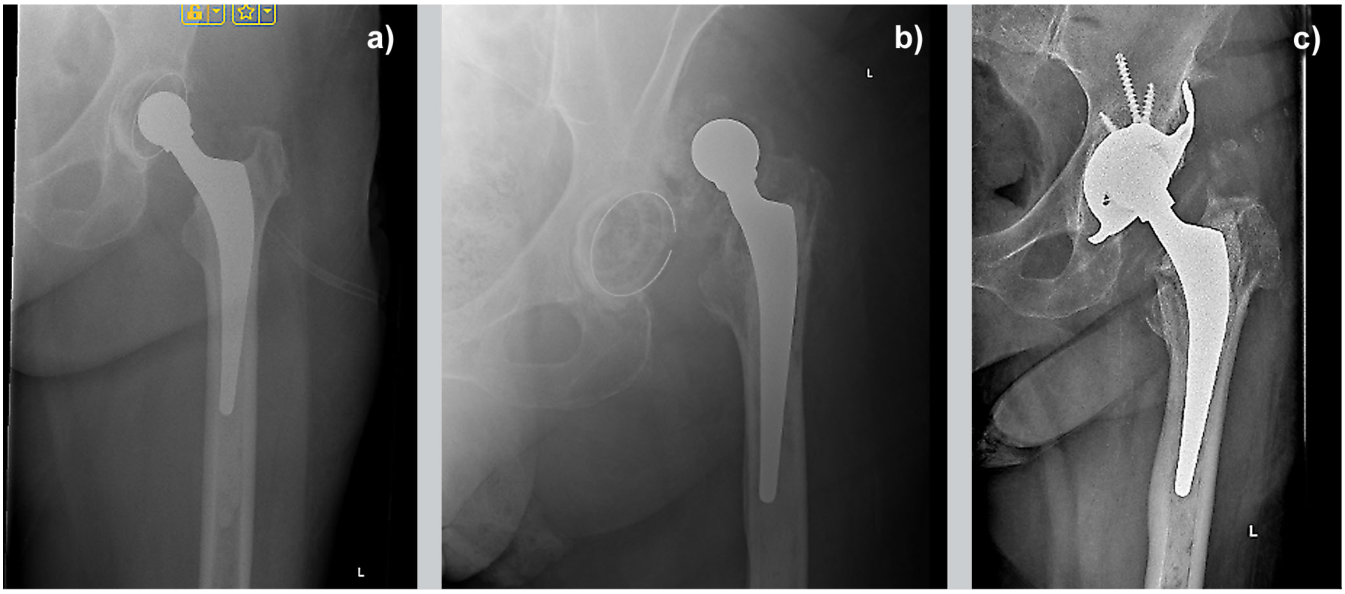
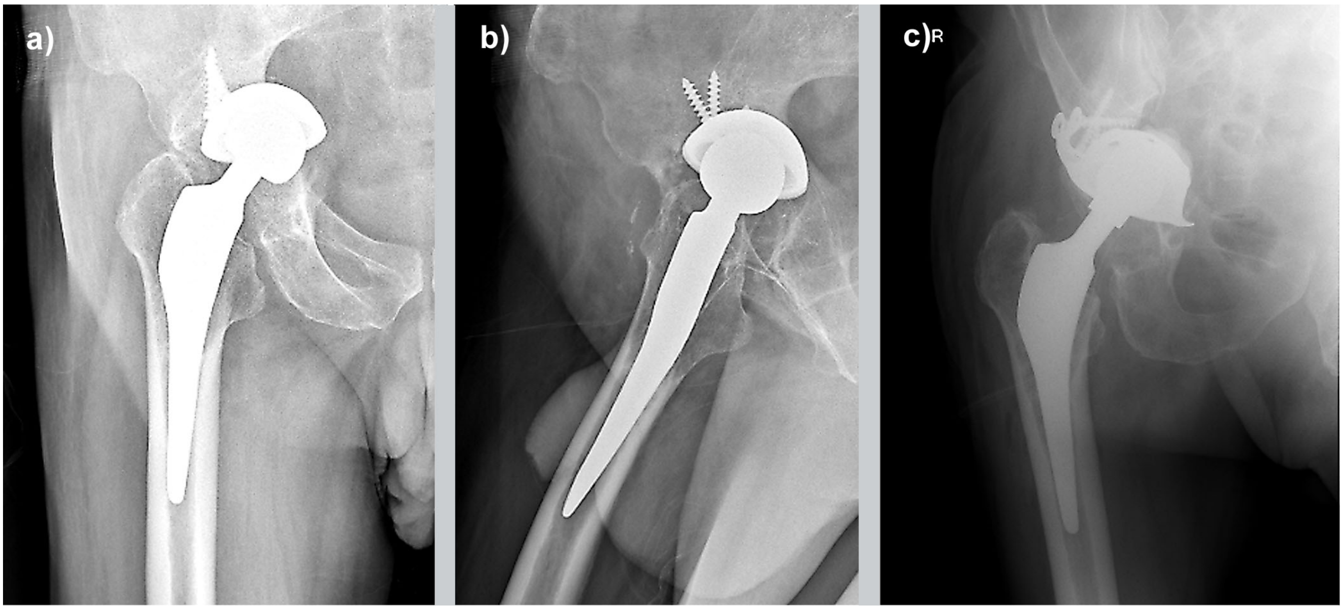


Fig. 4. Radiographs of a 64-year-old man with Paprosky IIIB acetabular bone defect and pelvic discontinuity. **a)** Preoperative radiograph. **b)** Lateral view preoperative radiograph. **c)** Radiograph at 96 months after revision surgery show that the cage remained stable.



cages could be performed in 31 (62%) hips and 17 hips (34%) owing to the restoration of bone stock. In a prior review by Baauw M, et al. [32], the average re-revision rate of large acetabular defects revised with antiprotrusio cage in 8 studies, including 315 hips, is 3.5%, which is similar to the results of this study.

In revision arthroplasty, the use of allografts is related to a high risk for infection, which remains an important cause of reoperation. According to Aponte-Tinao LA, et al. [35], their average 106 months follow-up of 673 patients using massive bone allografts showed that 60 patients (9%) had a bacterial infection of the allograft. The allograft we used was from the bone bank of our province and was stored at -80°C, we sterilized it with povidone-iodine and vancomycin solution before surgery. It is well-known that polyvidone has excellent antimicrobial efficacy in gram-positive bacteria, fungi, and bacterial endospores. Polyvidone was widely used to sterilize the dropped bone graft, Bauer J, et al. [21] and Soyer J, et al. [22] showed that 10% povidone-iodine not only had good sterilization ability but also had a relative advantage in maintaining the tissue viability of the bone. In recent years, the animal testing of Jiang Y, et al. [23] and Zhao Y, et al. [20] found that povidone-iodine could promote osteogenesis and protect the properties of allogenic bone compared with commonly used irradiation. Pandey AK, et al. [36] used cancellous bone allograft with vancomycin in revision hip arthroplasty, and they found that this method did not affect allograft incorporation, had no nephrotoxicity and seemed to be beneficial by preventing infection. In our study, there was no infection, but we should consider that we had a smaller sample size. In summary, according to our follow-up results, the cementless anatomic cage that we used promoted bone incorporation, and the antibiotic cement had a protective effect regarding any infection.

In this series, we reamed to healthy bone the acetabulum, which is similar to Ding H, et al. [17]. In their series, 29 hips with an average follow-up of 73 months had a good mid-term outcome with no patient need re-revision and 23 hips achieved complete incorporation. In our study, complete incorporation was encountered in 25 patients (89%), which achieved good outcome and seems better than Ding (79%) [17]. In previous studies, mid-term results of impaction bone grafting combined with a cage showed a failure rate of 0–16%. Recently, Akel I, et al. reported a long-term result of this combination, the failure rate was 8.1% [38]. Although the results of these studies were good, the results mixed Paprosky type II and III bone defects. Our study shows that the cementless anatomic reconstruction cage and antibiotic bone cement is also a good option for Paprosky type II and III bone defects in acetabular revision.

In this series, one patient experienced sciatic nerve palsy after the surgery, which gradually recovered by using an ankle brace. In some prior studies, this complication was also reported with an incidence lower than 3%. However, in complicated acetabular revision, it seems impossible to completely avoid sciatic nerve palsy. Limiting the dissecting of the posterior and inferior soft tissue of the ischium may reduce the possibility of postoperative sciatic nerve palsy. Also, there was 1 recurrent dislocation in this series. Babis GC, et al. [37] summarized that using a lateral approach and strictly arranged rehabilitation plan may attribute to a reduction of the dislocation rate, and we think that appropriate anteversion and abduction angle of the cup is also important.

As a retrospective and observational study, there are several limitations. First, like most of the previous studies, this study lacks a control group using different devices, so we can just draw a general conclusion by comparing with previous similar studies. Second, we assess the cage osteointegration by radiograph, which cannot display the central part of the dome suface. The developing technique of reducing metal artefact CT may be useful. Third, our study is with a mid-term follow-up; and longer term follow-up is required to evaluate the outcome. But to our best knowledge, the clinical follow-up outcome of the cementless anatomic cage that we use in combination with antibiotically loaded bone cement is barely reported.

CONCLUSION

In this study, the cementless anatomic reconstruction cage combined with a lipped polyethilene acetabular cup achieves a good result with a high osteointegration rate in Paprosky type II and type III acetabular bone defects, which restores acetabular bone stock and may be beneficial to further revision. But in patients with pelvic discontinuity, this method should be used cautiously. Our mid-term follow-up outcome indicates that the cementless anatomic acetabular cages are reliable implants, but long-term follow-up and large sample studies are required to further evaluate the efficiency.

Abbreviations

HHS - Harris Hip Score

SF-12 - 12-item short-form health survey questionnaire

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