Original Article

Early results of revision acetabular cup using antiprotrusio reconstruction rings and allografts

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Abstract

Background: Hip arthroplasty is one of the most frequently performed orthopedic procedures with high scores of success while its most common complication is aseptic loosening of the acetabular component, which may result from host bone loss or even from pelvis discontinuity. The purpose of the study was to evaluate results in patients after revision acetabular arthroplasty with reconstruction rings and allografts.

Materials and Methods: Retrospective data was collected from 69 revisions of acetabular components, performed in a group of 69 treated patients (the mean age 65.1 years). Before surgery, the patients had bone defects of type IIb (*n* = 5), IIc (*n* = 20), IIIa (*n* = 27) or IIIb (*n* = 17), according to Paprosky *et al*.

Results: The mean followup period of the patients was 7.2 years (range 3-19 years). A Kaplan–Meier analysis showed that a 3- and 10 year survival rate was 92.8% and 84.8% respectively, using further revision for any reason of the acetabular device as an end point. Eight patients revealed implant related complications. Four patients presented with ring loosening, one with a loose acetabular polyethylene cup, two hips demonstrated recurrent dislocations and one patient was with deep infection. Regarding the remaining 61 patients without re-revision surgery, the mean Harris hip score improved from 30.5 to 73.8 points.

Conclusion: A modified, antiprotrusion cage provides an acceptable survival rate and radiological results, but complications could still be expected. It seems that the observed massive bone loss with pelvic discontinuity and an insufficient fixation of the cage to the ischium may result in implant loosening. Stable fixation of the ischial ring flange with screws is an essential condition to expect a good outcome.

Key words: Acetabular revision, loosening, reconstruction ring, allograft
MeSH terms: Acetabulum, allograft, arthroplasty, hip

Introduction

Hip arthroplasty is one of the most frequently performed orthopedic procedures with high scores of success while its most common complication is aseptic loosening of the acetabular component, which may result from host bone loss or even from pelvis discontinuity.[1,2] In revision hip arthroplasty, reconstruction rings are commonly used for the acetabular restoration of massive bone stock losses.[3,4]

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The purpose of the study was to analyze results of acetabular cup revision with reconstruction rings - Recon ring (shell) (Aesculap/BBraun, Tuttlingen, Germany).

Materials and Methods

69 patients (11 men and 58 women with unilateral cup loosening) with revision surgeries of acetabular component using reconstruction rings between January 1993 and November 2009 were included in the study. None of the patients from a consecutive series was excluded. The mean age of patients at the time of surgery was 65.1 years (range 30.7-88.4 years). Four patients passed away during the followup for other reasons, but there were no signs of loosening in that group. Those patients were included in the study and results from the last followup were analyzed. The initial diagnoses before primary hip arthroplasty included: Idiopathic coxarthrosis (*n* = 35), rheumatoid arthritis (*n* = 10), femoral neck fracture (*n* = 10), dysplastic coxarthrosis (*n* = 11) and avascular necrosis (*n* = 3). It was the first acetabular revision for 40 patients, the second one for 19, the third one for 6 and the fourth for 1 patient. Three patients had history of infected hip arthroplasty. In 14 cases,

revision of the femoral stem was performed together with acetabular revision. All the patients presented with bone defect of type IIb (n = 5), IIc (n = 20), IIIa (n = 27) or IIIb (n = 17), according to Paprosky *et al*.[2] [Table 1].

The size of reconstruction ring (Recon ring (shell) (Aesculap/BBraun, Tuttlingen, Germany) was determined before the operation, using templates and the most recent radiographs of the hip. All the hips were operated from the anterolateral approach in the supine position, through ilio-tibial band, then between the rectus femoris muscle and the gluteus medius muscle. Scar tissue and ectopic bone were removed. A loose acetabular component was removed with all bone cement fragments if existed. Acetabular host bone stock was thoroughly debrided from soft scar tissue, and sclerotic areas were perforated by multiple 2 mm drill holes. Once the preparation of the acetabulum was completed, the acetabular bed was examined to evaluate bone defects and to determine if its bone stock could provide an adequate mechanical support for the cage and its flanges. Following acetabular bone loss assessment (if bone stock was inadequate to give support for acetabular cup only), the final measurement of ilioischial reconstruction ring was performed. One of the three available ring sizes (54 mm, 58 mm or 64 mm) was chosen and fixed to the bony acetabulum. Depending on implant size and host bone quality, as many cancellous screws as possible were used to fix the cage into the bone. Special attention was paid to cross the screws fixed in the ilium and to anchor lower part of the cage to ischium. Having achieved bone support of the cage, the remaining space between the bone acetabulum and the spherical dome of the ring was filled with cancellous, morselized allografts.[5] Grafts were introduced through a hole in ring dome. The chips were impacted with a metal impactor and a mallet in all type III defects and in 12 cases of IIc defects with a deep lack of the medial acetabular wall. A frozen, cancellous, morselized allograft was used in 21 cases and morselized femoral head allografts in 35 cases. In 13 cases of revisions, the reconstruction rings were used alone, without the grafts, due to the proper, full support of the cage dome in the ilium (all IIb defects and 8 IIc). In the case of the allografts from the femoral head, each graft was first defrozen and then divided into 7–9 mm chips of the cancellous bone. All the allografts, used for that procedure, were sterilized by radiation and picked up from the local bone bank. No massive structural bone grafts nor other fixation techniques (plates) or tantalum augments were used anytime. When the ring was stabilized, a standard polyethylene cup was implanted and fixed with cement in proper inclination and anteversion.

Table 1: Paprosky *et al*.[2] (1994) classification of acetabular defects

Defect type	Defect characteristics
I	Acetabular rim, anterior and posterior column are intact and supportive. There are small, locally contained defects
IIA	Destruction of the dome and/or the medial wall, the anterior and posterior columns are retained and supportive. Moderate superior migration, <3 cm, above the obturator line. Contact surface >50%
IIB	Destruction of the dome, the anterior and posterior columns are retained and supportive. Less than 1/3rd of the rim circumference is deficient. Moderate superolateral migration (<3 cm) above the obturator line. Contact surface >50%
IIC	Isolated medial migration, medial to Kohler's line; the rim is intact and supportive
IIIA "up and out"	The acetabular rim is not entirely supportive. Intact medial support. The acetabular dome and the columns are compromised. The defect encompasses less than a half of the circumference. Severe superolateral migration more than 3 cm; 40-60% host-bone contact; inadequate stability
IIIB "up and in"	The acetabular rim is missing. The acetabular dome and the columns are nonsupportive. The defect encompasses more than a half of the circumference. Severe superomedial migration more than 3 cm; <40% host-bone contact; inadequate stability; medial to Kohler's line; a risk of pelvic discontinuity
Pelvic discontinuity	Fracture line through the columns. Broken Kohler's line or obturator foramen asymmetry on AP pelvis. Superior and inferior hemipelvis separation

AP=Anteroposterior

All the patients were postoperatively followedup, both clinically and radiographically, every 3 months for 1 year and then every 6 months. Harris hip score (HHS)[6] was applied for clinical assessment before operation and at followup visits. The ten point visual analog scale for pain (VAS) score was used to evaluate pain before surgery and at the last followup visit. Data from the most recent visit were used in the study. Anteroposterior and lateral radiographs were obtained after surgery and at subsequent followup visits. The actual position of the acetabular cup and of the ring was evaluated in each radiograph. Radiolucent signs around the acetabulum were analyzed in each of the three zones of DeLee and Charnley.[7]

Shapiro–Wilk test was used to check normal distribution for HHS and VAS. The distribution for both parameters was not normal. The Wilcoxon signed rank test was used to determine whether there was a statistically significant difference between preoperative and postoperative (last followup) HHS, as well as between preoperative and postoperative (last followup) VAS scale. The survival rate analysis was performed by the Kaplan–Meier method, using the need for further revision of the acetabular device as an end point.[8] Statistical analyses were performed, using the Statgraphics Plus Program for Windows 5.1 (Statpoint Technologies, Inc., USA) and $P < 0.05$ were considered to be statistically significant.

The research project was approved by the Bioethics Commission at our institution (protocol No. RNN/2/12/KE).

Written informed consent for participation in the study was obtained from participants.

Results

In 61, out of the 69 hip implants, stability was confirmed at the last followup with need for revision surgery. In those 61 cases, no migration of the ring or cup was observed. A Kaplan–Meier analysis showed a 3-year and 10-year survival rate in 92.8% and 84.8%, of the patients respectively, using further revision for any reason of the acetabular component as an end point. In those cases, all the applied morselized, cancellous allografts healed without fracture or resorption. The average clinicoradiological followup was 7.2 years (range 3-19 years) [Table 2]. In three cases, radiolucency was found in zone 3, according to DeLee and Charnley, without clinical symptoms or radiological features of loosening. No implant migration was observed, either.

Eight patients demonstrated implant related complications [Table 3, Figures 1 and 2], one with an iliac flange of the ring fracture in the reconstruction ring at screw hole level, together with cracked screws [case 1 in Table 3]. The failure was probably caused by material fatigue in consequence of multicyclic plastic implant deformities in the process of loosening. The iliac flange of the cage was well fixed to the bone, while the ischial flange became loose, and the dome had no sufficient bone support. The ring and the acetabular cup were replaced.

Table 2: Final results (n=61)

Classification	Preoperative	Postoperative	*P*
HHS	Mean 30.5 (the range from 5.075 to 49.4)	Mean 73.8 (the range from 47.425 to 89. 5)	0.005
VAS for pain	5.9 (range from 1 to 8)	1.9 (range from 0 to 5)	0.004

VAS=Visual analog scale, HHS=Harris hip score

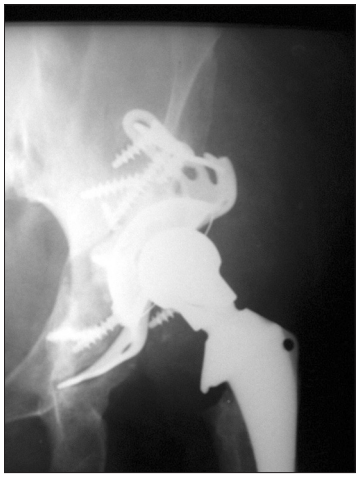

Figure 1: The roentgenogram in anteroposterior projection of patient hip with an iliac flange fracture in the reconstruction ring at screw hole level, together with 3 cracked screws

In the other three of the rings [cases 2, 3 and 4 in Table 3], evaluated in our series, failure fixation was noted, in both cases with cracking of screws, medial implant migration and inferior flange of the cage loosening. Resorption of bone grafts above the ring dome and subsequent bone loss were recorded in each case on radiographs. An additional fixation failure of the ischial flange of the ring resulted in the whole implant instability. Those rings also required revision and replacement.

In the above mentioned four cases of compromised stability, massive bone stock losses with pelvic discontinuity were found. During subsequent revisions of the patients, the good quality of the previously implanted bone grafts was confirmed. The grafts were still well incorporated into the host bone. In one of the cases, a consecutive revision was done without reconstruction ring application as the bone stock status allowed for cementless cup fixation with a solid bone graft. In the remaining three patients, reconstruction rings and bone grafts were used as in prior procedure.

One acetabular polyethylene cup was found loose [case 5 in Table 3]. The cup was re revised and replaced with success. Two hips were dislocated [cases 6 and 7 in Table 3]. In one, socket malposition developed with cup reorientation. In the second one, a femoral neck adapter (Merete, The BioBall Company, Germany) was used as the identified dislocation was related to poor quality muscles around the hip.

One patient had a deep infection, treated by removal and debridement of acetabular implants [case 8 in Table 3].

Other complications in those revision surgeries included nerve palsy: Four peroneal and 2 femoral. Both femoral

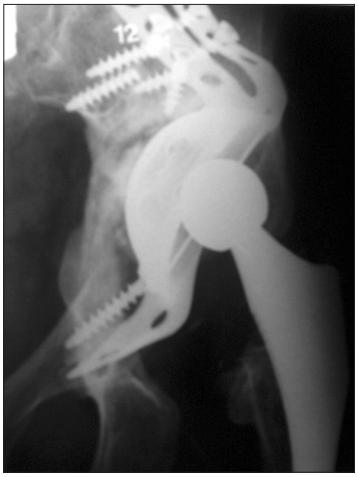

Figure 2: The roentgenogram in anteroposterior projectionof patient hip with a fixing screw fractures

Table 3: Clinical and demographic data of 8 patients with acetabulum related complications

Age (years)	BMI	Followup	Previous acetabular operations	Acetabular bone loss[3]	Bone graft	Femoral revision	Complication	HHS before revision[6]	Success after last revision
46	49	18 months	4	IIIb	Yes	No	Breaking and loosening of reconstruction ring	45.075	Yes
50	22.3	5-year	4	IIIa	Yes	No	reconstruction ring loosening	31.85	Yes
78	26.2	14 months	1	IIc	Yes	No	reconstruction ring loosening	31.775	Yes
66	28.3	24 months	2	IIIa	Yes	No	reconstruction ring loosening	29.7	Yes
60	29.7	6 months	3	IIc	Yes	No	Loosening of polyethylene cup	26.3	Yes
68	34.4	10-year	2	IIIb	Yes	No	Multiple dislocations	24.125	Yes
78	29.3	8-year	3	IIc	Yes	Yes	Multiple dislocations	39.325	Yes
70	30.4	2-year	2	IIIa	Yes	Yes	Deep infection	7	No

BMI=Body mass index, HHS=Harris hip score

and three peroneal palsies resolved between 2 weeks and 9 months while one was permanently maintained.

Discussion

A considerable number of the patients after revision hip arthroplasty demonstrated large acetabular bone defects, extensive scaring and muscle loss. The application of Bruch-Schneider antiprotrusion cage is a durable solution, provided those proper indications and techniques are used. The survival rate, when using these implants, ranges from 83% to 95% at mid-and long term followup.[4,9-20] In most series, the average HHS ranges from 70 to 83.[4,10,13,15,20] The success rate of acetabular revision operations, defined as stable, functional hip, amounted to 61, out of 69 patients in our series. The survival rate at 10 year followup was 92.8%. We are aware that the HHS does not fully reflect reconstruction success as many of the patients had 2 or more joint surgeries in the past. The mean functional score of 73.8, presented in our study, is not fully satisfactory, when comparing to primary hip arthroplasty. However, patients revealed a significant functional improvement in the operated joints, comparing with the preoperative status. Hip function as weight bearing joint was restored, bringing significant pain reduction. Some of our patients reported mild pain after surgery. Given the criteria of nondislocating and nonmigrating hip, the success rate in the series of Goodman *et al*.[10] was 76%. The percentage would have been even higher, having added the cases, in which both the reconstruction ring and the bone graft were left *in situ*. Schlegel *et al*.[4] noted that the 5-year and 8-year survival rate after revisions with reinforcement ring was 95% and 90% respectively. The mean HHS in that series was 70. In the study of Regis *et al*.[14] HHS was 75 at 11.7 years on the average and the survival rate achieved 87.5%. Symeonides *et al*.[16] described 89% survival during maximum 21-year in 57 patients. The results of Peters *et al*.[12] are also encouraging. Clinically, 80% of their patients functioned as, at least, community ambulators and 80% sensed mild or no pain. In 14% of hips, some implant migrations were identified, but none of the patients required reoperation. Using antiprotrusion cages with grafts enabled bone stock restoration in those patients. Jones *et al*.[11] reported a 95% survival and significant functional improvement after 9 year, using the Burch Schneider antiprotrusio cage. Using the in built roentgen analyse they found some evidence of implant migration above 1 mm in all the cases, but there was no evidence of radiological loosening and no screws were found to be broken.

The aseptic loosening rate, reported in the literature, ranges from 0% to 18% in mid and long term results.[4,9-20] In the revision operations of the acetabulum in our series, 11.6% of the patients had implant related problems: Reconstruction ring loosening, cup loosening, dislocation or deep infection. Four of our patients demonstrated a loose reinforcement ring (with its fracture in one case). In all those hips, massive bone loss was found during revision operation with concomitant pelvis discontinuity. The implant fractures in the iliac part were secondary to instability of the ischial flange and the ring dome. It seems that in the most severe cases of pelvic discontinuity, implants do not restore stability and get loose, first in the ischial part. Then, cracking of proximal screws or of the ring may be expected, with secondary bone graft lysis. Other potential causes of loosening – high body mass index, patient's noncompliance and specially too early full weight bearing were also possible, however, difficult to prove on the basis of our material. Loosening of the acetabular cup is a rare complication, seen in one of our cases. That problem has also been described by Goodman *et al*.[10] postoperative dislocation is another issue, sometimes observed after this kind of surgery. Even if the positioning of implants, seen on postoperative radiographs, is satisfactory, the hip joint surrounding muscles may be a week or damaged during previous operations. In our opinion, this is the main factor that may lead to postoperative hip dislocation.

In the study of Goodman *et al*.[10] the rate of complications after the use of antiprotrusion, cages was higher than in our series. Among their 61 cases, 5 rings lost fixation, 3 rings cracked, 3 acetabular cups were loose, 7 hips were

dislocated and 3 deep infections were diagnosed. They also reported a relatively high prevalence rate of sciatic and peroneal nerve palsy that may have been related to ischial flange of the implant slotting and inferior screws to the ischial bone. Winter *et al*.[20] did not find any radiographic signs of implant migration or loosening. One patient was with postoperative dislocation and one with deep infection, both being successfully treated. Despite some intraoperative and temporary postoperative complications, the eventual clinical results were satisfactory in the vast majority of patients. Among the patients of Peters *et al*.[12] two dislocations, out of 28 acetabular revisions, were nonoperatively managed. In the study of Crockarell[9] two, out of 11 revisions with reconstruction rings, required reoperation. No neurovascular complications were noted. We fully agree with the author, who found out that massive bone defects and poor ischial fixation were common in the identified cases of implant loosening. The author recommends rigid ischial fixation with screws. In the study of Udomkiat *et al*.[17] the mechanical failure rate was17% and dislocation occurred in 23% of hips at 4.6 followup.

Despite a loose antiprotrusion cage, bone stock restoration might be expected. In one of our cases, following cage revision, the bone bed remained so well shaped that we decided to implant a cementless cup with support of structural bone graft. Kosashvili *et al*.[21] reported results of 15 failed acetabular cage revisions with bone stock restoration, performed with the use of bone graft during index procedure. In all those cases, they implanted highly porous cementless hemispheric cups during re revision. Three of the hemispheric cups failed.

The antiprotrusion cage gives an opportunity to implant a polyethylene cup in a more anatomical position, acting as a bridge between the ischium and the ilium, providing more stability, protecting bone grafts and allowing for graft remodelling. In cases of massive bone stock, it is sometimes the only possible surgical option. Definitely, it is an extensive procedure and striping of the gluteus medius muscle from the ilium is necessary. In the postoperative period, patients have for many months to exercise, walking with partial weight bearing to allow bone graft integration as the primary stability of the implant is not sufficient to transfer full body weight.

The modified antiprotrusion cage technique provided an acceptable survival rate and radiological results, but complications might be expected. It seems that a massive bone loss with pelvic discontinuity and insufficient fixation of the cage to the ischium may be related to implant loosening. Stable fixation of the ischial ring flange with screws over the bone grafts is essential for a good outcome.

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