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HIP ARTHROPLASTY

Reconstruction of AAOS type III and IV acetabular defects with the Ganz reinforcement ring: high failure in pelvic discontinuity

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Abstract
Background Large acetabular defects and pelvic discontinuity represent complex problems in revision total hip arthroplasty. This study aimed to investigate whether reconstruction with the Ganz reinforcement ring would provide durable function in large acetabular defects.
Patients and methods 46 hips (45 patients, 19 male, 26 female, mean age 68 years) with AAOS type III and IV defects undergoing acetabular revision with the Ganz reinforcement ring were evaluated at a mean follow-up of 74 months (24–161 months). Fourteen patients died during follow-up. All surviving patients were available for clinical assessment and radiographic studies. Radiographs were evaluated for bone healing and component loosening. A Cox-regression model was performed to identify factors influencing survival of the Ganz-ring.
Results In the group of AAOS III defects, 3 of 26 acetabular reconstructions failed, all due to aseptic loosening. In pelvic discontinuity (AAOS IV), 9 of 20 hips failed due to aseptic loosening ($n = 4$), deep infection ($n = 3$), and non-union of the pelvic ring ($n = 2$). With acetabular revision for any reason as an endpoint, the estimated Kaplan–Meier 5-year survival was 86% in type III defects and 57% in type IV defects, respectively. The presence of pelvic discontinuity was identified as the only independent predictive factor for failure of the Ganz ring acetabular reconstruction (AAOS III vs. IV, Hazard ratio: 0.217, 95%, Confidence interval: 0.054–0.880, $p = 0.032$).
Conclusion The Ganz reinforcement ring remains a favorable implant for combined segmental and cavitary defects. However, defects with pelvic discontinuity demonstrate high failure rates. The indications should therefore be narrowed to acetabular defects not associated with pelvic discontinuity.

Keywords Ganz reinforcement ring · Pelvic discontinuity · Acetabular defect · Bone loss · Trabecular metal · Cage · Acetabular reconstruction · Hip revision

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Introduction

Acetabular bone deficiency remains a challenging problem in revision total hip arthroplasty (THA). In large acetabular defects and pelvic discontinuity, the loss of acetabular bone stock is the most challenging factor determining the success of reconstruction [28].

Large acetabular bone defects usually involve a combination of cavitary and segmental bone deficiency that have been classified as type III defects by the American Association of Orthopedic Surgeons (AAOS) [10]. Pelvic discontinuity (AAOS type IV defects), describes the separation of the superior pelvis (ilium) from the inferior pelvis (ischio-pubic segment) through the acetabulum [28].

Various reconstruction techniques with the aid of acetabular reinforcement rings and cages such as the Müller reinforcement ring, the Ganz reinforcement ring, and the Burch–Schneider antiprotrusio cage have been reported [2, 3, 14, 18, 20, 23, 25, 26]. These rings and cages may be used in combination with plating of the anterior and/or posterior columns and different types of bone grafting. More recently, custom-made triflange implants and modular trabecular titanium or tantalum implants such as Trabecular Metal™ (Zimmer, Warsaw, IN, USA) have been popularized for the reconstruction of large acetabular bone defects, in particular pelvic discontinuity [1–5, 8, 13, 17, 22, 24, 29, 33]. Custom-made triflange implants and Trabecular Metal™ do not rely on osseous consolidation of the deficient acetabular bone stock. These implants provide a "non-biologic" solution by bridging the acetabular defect with osseointegrable implants. In contrast, reinforcement rings and antiprotrusio cages require osseous consolidation of the bone deficiency and, in pelvic discontinuity, restoration of the integrity of the pelvic ring to obtain long-term stability. The Ganz reinforcement ring (reinforcement ring with a hook) was designed to reinforce the anterior and posterior walls, the acetabular dome, and the acetabular fossa. In acetabular bone loss, the application of a Ganz ring after bone graft impaction provides protection of the underlying bone stock thereby supporting osseous consolidation and preventing migration of the acetabular component [30]. The Ganz reinforcement ring requires intact anterior and posterior columns to provide sufficient mechanical stability. Thus, in pelvic discontinuity, consolidation of the anterior and posterior column is a prerequisite for long-term survival of the implant [12].

We investigated the clinical and radiographic outcome parameters of acetabular reconstructions of AAOS type III and IV defects with the Ganz reinforcement ring and asked whether biological reconstructions with this implant and bone grafting provide durable function in large acetabular defects.

Patients and methods

We retrospectively reviewed 46 patients who underwent revision total hip arthroplasty with reconstruction of large acetabular defects or pelvic discontinuity using the Ganz reinforcement ring between 1996 and 2011. There were 19 males and 27 females with a mean age of 68 years (range 45–88) at the time of surgery. Inclusion criteria were type III or type IV acetabular defects according to the classification of the American Academy of Orthopaedic Surgeons (AAOS) [10] and a minimum postoperative follow-up of 24 months. Pelvic discontinuity was defined as a defect involving the posterior and anterior columns with separation of the superior from the inferior acetabulum. Classification of acetabular defects was performed based on conventional X-rays, computed tomography scans, and operative reports. Preoperative CT scans were available for 33 patients conventional radiographs and operative reports were available for all patients. Imaging studies and patient files were evaluated by two independent investigators (MA, FMK). The same investigators retrospectively reviewed the surgical reports. Twenty-six patients showed combined segmental and cavitary defects (AAOS type III) and twenty demonstrated additional pelvic discontinuity (AAOS type IV).

The medical records of all 46 patients were reviewed for previous surgeries and relevant medical risk factors including rheumatoid arthritis (RA), diabetes mellitus, smoking, corticosteroids, immunosuppression, obesity, chronic obstructive pulmonary disease, cardiopathy, osteoporosis, and regular alcohol consumption. At least one

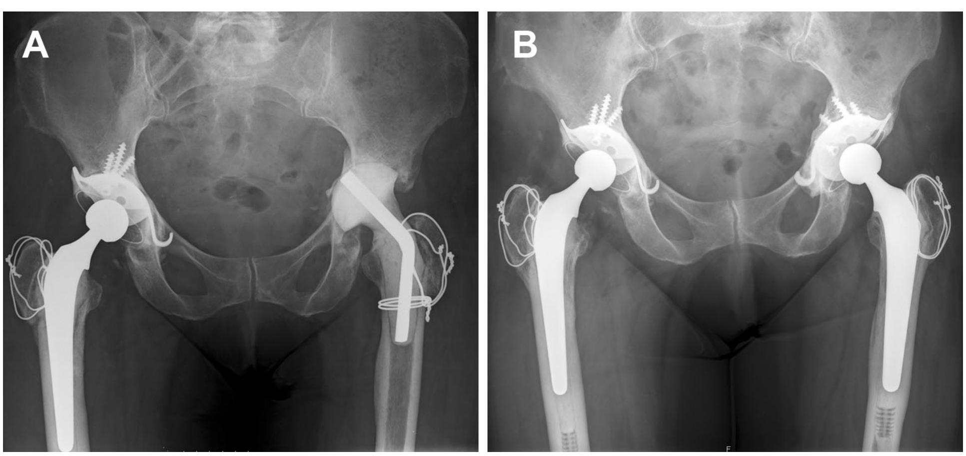

Fig. 1 Radiographs of a female patient with medical history of bilateral synchronic periprosthetic joint infection of the hips at the age of 58 years. Infection was treated with two-staged revision and implantation of antibiotic-loaded cement spacers. The right hip associated with an AAOS II acetabular defect was re-implanted first (**a**). In a second surgery the left hip was re-implanted. The acetabular defect (AAOS III) was treated with a Ganz reinforcement ring and morselized allograft. The postoperative course was uneventful. Radiographic follow-up showed an intact acetabular reconstruction with healing of the bone defect and no signs of implant loosening at 78 months (**b**)

relevant co-morbidity at the time of surgery was found in 15 out of 26 patients with AAOS type III defects and 15 out of 20 patients with pelvic discontinuity. More than one co-morbidity was found in 16 out of 46 patients. The most frequent co-morbidity was cardiopathy ($n = 17$) followed by RA present in 7 out of 46 patients. RA patients were commonly also recipients of corticosteroids or immunomodulatory therapy at the time of surgery ($n = 6$). A total number of 103 surgeries had been previously performed in the 46 hips (2.24 ± 1.65 previous surgeries/hip, range 1–9).

Of the 46 patients, 14 died during the observation time, resulting in 32 patients available for the final follow-up. The radiological assessment was performed on an A/P view of the pelvis, and A/P and lateral views of the hip. Additionally, the Harris hip score (HHS) and the Merle d'Aubigné score were calculated to assess hip function. The mean follow-up was 74 months (range 24–161 months). No patient was lost to follow-up.

Hip arthroplasty revision surgery was performed through a transgluteal approach or trochanteric flip osteotomy and always involved acetabular reconstruction with the Ganz reinforcement ring (Zimmer Inc. Warsaw, IN, USA). In AAOS type III defects, structural bone graft ($n = 15$) and morselized bone graft ($n = 11$) were used to address bone loss (Fig. 1). Bone grafts were obtained from fresh frozen femoral head allografts stored at −80 °C prior to use. For reconstruction of pelvic discontinuity, the Ganz

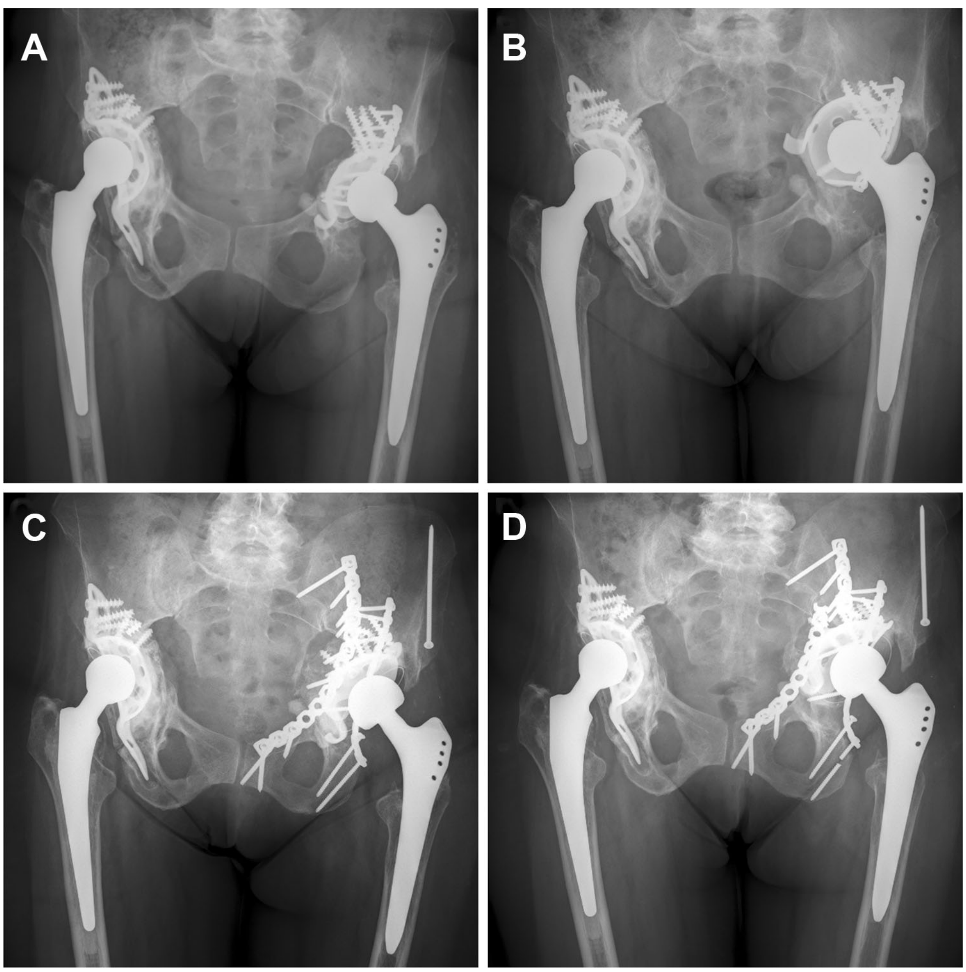

Fig. 2 Radiographs of a female patient with medical history of primary total hip arthroplasty at the age of 61 years. The patient underwent cup revision for recurrent dislocation 1 and 4 years after the primary implantation. 7 years after the primary implantation the patient had a fall resulting in traumatic dislocation of the acetabular component and pelvic discontinuity (**a**). The acetabular component was revised to a Ganz reinforcement ring. The discontinuity was treated with structural and morselized bone grafts, and plating of the posterior column (**b**). Within the first 2 months after the procedure the patient sustained three dislocations, which were treated with closed reduction. Radiographs 3 months after the reconstruction (**c**) showed progressive loosening of the posterior plate (*arrow*), indicative for failure of the construct. The patient was revised again; reconstruction was performed with a Ganz reinforcement ring with cranial flange, structural and morselized bone grafts, and plating of the anterior and posterior column (**d**). Afterwards, the clinical course was uneventful; the discontinuity healed and there were no signs of implant loosening at 24 months (**e**) and 54 months (**f**) after the final procedure

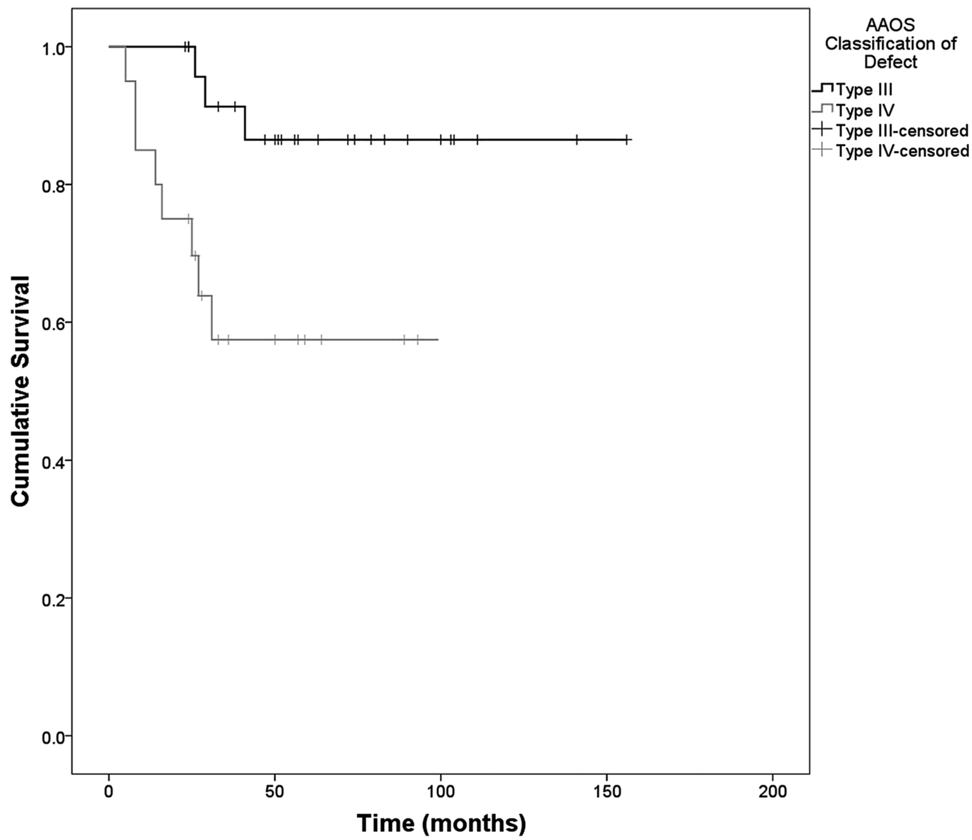

Fig. 3 Kaplan–Meier survival of AAOS III and AAOS IV acetabular defects treated with the Ganz reinforcement ring with revision of the acetabular component for any reason as endpoint. Mean estimated survival was 139 months (95% CI 122;157) in AAOS III defects and 64 months (95% CI 45;84) in AAOS IV defects ($p = 0.003$)

reinforcement ring was combined with structural bone allograft and plating of the anterior and/or posterior column ($n = 18$) (Fig. 2) or plating without bone grafting ($n = 2$).

Continuous data are presented as mean ± standard deviation. Differences in the overall survival of the acetabular component were calculated with the Kaplan–Meier survival; the log rank test of equality of survivor function was applied to compare treatment groups. Analysis of risk factors was performed with univariate and multivariate Cox regression models. Statistical analyses were performed using SPSS (SPSS Inc., Chicago, IL, USA).

Results

Postoperative complications included dislocation ($n = 9$), aseptic loosening ($n = 9$), postoperative hematoma ($n = 4$), deep infection ($n = 4$), non-union of the greater trochanter osteotomy ($n = 3$), non-union of the pelvic ring ($n = 2$), superficial infection ($n = 2$), painful greater trochanter wires requiring removal ($n = 2$), sciatic nerve injury ($n = 1$), and liner malorientation requiring revision ($n = 1$). In 10 patients, multiple complications occurred. A total of 32 revision procedures were performed in 21 patients. These included soft tissue revisions ($n = 13$), total implant exchange ($n = 7$), liner exchange with reorientation ($n = 7$), cup exchange ($n = 3$), and conversion to a Girdlestone situation ($n = 2$).

Overall survival of the acetabular reconstructions was 89% in type III and 55% in type IV defects, respectively (Fig. 3). Three out of twenty-six AAOS type III reconstructions failed due to aseptic loosening and required additional revision with implant exchange of the acetabular components. Revision of the acetabular components was performed with a Ganz ring ($n = 2$) or a Burch–Schneider cage ($n = 1$). None of the three patients required further revision surgery. In type IV defects, acetabular reconstructions failed in 9 out of 20 patients due to aseptic loosening ($n = 4$), deep infection ($n = 3$), and non-union of the pelvic ring ($n = 2$). These hips were revised to a Ganz reinforcement ring ($n = 6$), Burch–Schneider cage ($n = 1$), or a Girdlestone situation ($n = 2$).

Univariate Cox regression revealed that the type of acetabular defect (AAOS III vs. AAOS IV; HR 0.168, 95% CI 0.044;0.637, $p = 0.004$), age at surgery in years (HR 0.941, 95% CI 0.887;0.998, $p = 0.041$), and duration of the surgical procedure (HR 1.007, 95% CI 1.001;1.012, $p = 0.021$) present risk factors for failure of the Ganz reinforcement ring. Gender, previous hip surgery, co-morbidities, complications, and implant retaining revision surgery after the index procedure were not associated with increased risk of failure. In multivariate Cox regression, only the type of the acetabular defect (AAOS III vs. IV; HR 0.217, 95% CI 0.054; 0.880, $p = 0.032$) remained an independent risk factor determining failure.

Time to revision of the acetabular reconstructions ranged from 26 months to 41 months in AAOS type III and from 2 to 99 months in AAOS type IV defects, respectively.

Mean estimated survival of acetabular reconstructions was 139 months (95% CI 122;157) in type III defects and 64 months (95% CI 45;84) in type IV defects, respectively (Kaplan–Meier survival, $p = 0.003$, Fig. 1). With revision of the acetabular component for any reason as the endpoint, the estimated 5-year survival was 86% in type III defects and 57% in type IV defects, respectively.

All 32 living patients (AAOS III: $n = 20$, AAOS IV: $n = 12$) underwent clinical and radiographic evaluation at final follow-up (Table 1). In 4 of the 20 patients with AAOS type III defects, a revision of the acetabular construct was performed during the follow-up period. In 14 of the remaining 16 type III defects with the ring in place, implants were not loose, while one implant was probably loose according to the classification of Gill et al. [15]. Among pelvic discontinuity patients, 10 out of 12 patients showed well-fixed acetabular components. Six of the 12 patients underwent revision of the acetabular component. Thus, only six of the Ganz ring reconstructions of AAOS type IV defects were neither been revised nor did they show loosening at final follow-up. In patients with pelvic discontinuity, acetabular defects were definitely healed in nine cases, possibly healed in two cases, and not healed in one case according to the classification of Berry et al. [7].

Functional evaluation using the Harris hip score and Merle d'Aubigné score showed similar results between both groups at the final follow-up (Table 1). Mean HSS was 76.1 ± 20.6 and 74.8 ± 17.8 in type III and type IV defects ($p = 0.854$), respectively. The mean Merle d'Aubigné score was 13.8 ± 3.1 and 13.7 ± 2.3 in type III and type IV defects ($p = 0.882$), respectively.

Table 1 Clinical and radiographic outcome

Parameter	AAOS III	AAOS IV
Overall implant survival	23/26 (89%)	11/20 (55%)
Alive at FU	21/26 (81%)	12/20 (60%)
Final FU evaluation	$n = 21$	$n = 12$
Harris Hip Score		
Mean	76.1 ± 20.6	74.8 ± 17.8
80–100	11	5
71–79	3	2
<70	7	5
Merle d'Aubigné score		
Mean	13.8 ± 3.1	13.7 ± 2.3
14–18	13	7
<14	8	5
Fixation acetabular components (overall)	$n = 21$	$n = 12$
Not loose	20	10
Probably loose	1	0
Definitely loose	0	2
Fixation acetabular components (unrevised)	$n = 17$	$n = 6$
Not loose	16	6
Probably loose	1	0
Definitely loose	0	0
Acetabular reconstruction (overall)	$n = 21$	$n = 12$
Definitely healed	17	9
Possibly healed	3	2
Not healed	1	1
Acetabular reconstruction (unrevised)	$n = 17$	$n = 6$
Definitely healed	13	5
Possibly healed	3	1
Not healed	1	0

Discussion

The study aimed at investigating whether reconstruction with the Ganz reinforcement ring would provide a durable construct in large acetabular defects.

The results of this study indicate that Ganz ring-reconstructed acetabular defects of AAOS type III and IV have an 84 and 53% likelihood of surviving 5 years, respectively. The difference in survivorship could be attributed to the type of defect, i.e., the presence of pelvic discontinuity.

A previous report of the Ganz ring published by Gerber et al. [14] demonstrated a 10-year survivorship of 81% for types II–IV acetabular defects. However, it would be fair to mention that the cohort of 61 patients only included two cases of pelvic discontinuity; therefore, the general figure would have to be considered less representative of larger defects with pelvic discontinuity. More recently, Schmolders et al. [27] reported an 85% survival rate of the MRS® modular reinforcement ring in Paprosky 3A and 3B defect reconstructions after a mean follow-up of 31 months. Five out of six failures were associated with deep infection, whereas only one failure was due to aseptic loosening. However, the authors did not provide information of whether the acetabular defects were associated with pelvic discontinuity [19].

At this juncture, highlighting the outcome of the variety of available implants utilized for AAOS type III

Table 2 Revision THA associated with large acetabular defects and pelvic discontinuity. Overview of the current literature

First author	Year	n	Type of defect	Reconstruction	Mean FU (months)	Overall construct survival (n/pts. with FU, %)	Revision due to aseptic loosening (n/pts. with FU, %)	Remarks
Abolghasemian	2014	45	Pelvic discontinuity	Reinforcement ring/APC ($n = 19$)	69	7 (37%)	4 (15%)	
				TM cup–cage ($n = 26$)	82	22 (85%)	*n*.s.	
Abolghasemian	2013	34	Gross III (18)	TM cup and augment	70	30 (88%)	3 (9%)	
			Gross IV (14)					
			Gross V (2)					
Amenabar	2016	67	Gross IV ($n = 26$)	TM cup–cage	74	Gross IV: 24 (92%)	Gross IV: 0 (0%)	
			Gross V ($n = 41$)			Gross V: 37 (90%)	Gross V: 4 (10%)	
Ballester Alfaro	2010	19	Paprosky 3A ($n = 13$)	TM cup and augment	26	19 (100%)	0 (0%)	
			Paprosky 3B ($n = 6$)	TM cup–cage				
Barlow	2015	63	Paprosky 3B	Custom triflange cup	52	56 (88%)	6 (10%)	
Berasi	2015	28	Paprosky 3B	Custom triflange cup	57	26 (93%)	0 (0%)	
Berry	1999	31	AAOS IV	Porous coated cup	36	18 (67%)	4 (15%)	Follow-up: $n = 27$
				APC				
Berry	1992	42	AAOS III	APC	60	32 (76%)	5 (12%)	
Christie	2001	78	AAOS III ($n = 39$)	Custom triflange cup	53	67 (100%)	0 (0%)	Follow-up: $n = 67$
			AAOS IV ($n = 39$)					
Colen	2012	6	AAOS III ($n = 3$)	Custom triflange cup	29	6 (100%)	0 (0%)	
			AAOS IV ($n = 3$)					
Davies	2011	46	Paprosky 2C ($n = 10$)	TM cup	50	45 (98%)	0 (0%)	
			Paprosky 3A ($n = 21$)	TM cup and augment				
			Paprosky 3B ($n = 15$, $n = 4$ with PD)	TM cup–cage				
DeBoer	2007	30	Pelvic discontinuity	Custom triflange cup	123	20 (100%)	0 (0%)	Follow-up: $n = 20$
Friedrich	2014	18	Paprosky 3B (all with PD)	Custom triflange cup	30	16 (89%)	0 (0%)	
Gerber	2003	61	AAOS II ($n = 24$)	Reinforcement ring	108	46 (92%)	4 (8%)	Follow-up: $n = 50$
			AAOS III ($n = 24$)					100% failure in AAOS IV
			AAOS IV ($n = 2$)					
Gill	1998	63	AAOS I ($n = 13$)	APC	102	58 (92%)	3 (5%)	
			AAOS II ($n = 36$)					
			AAOS III ($n = 14$)					
Goodman	2004	61	AAOS II ($n = 13$)	APC	55	46 (84%)	7 (13%)	Follow-up: $n = 55$
			AAOS III ($n = 38$)					AAOS IV: 5/10 rated successful
			AAOS IV ($n = 10$)					

Table 2 continued

First author	Year	*n*	Type of defect	Reconstruction	Mean FU (months)	Overall construct survival (*n*/pts. with FU, %)	Revision due to aseptic loosening (*n*/pts. with FU, %)	Remarks
Grappiolo	2015	55	Paprosky 3A ($n = 42$) Paprosky 3B w/o PD ($n = 13$)	TM cup and augment	54	51 (93%)	3 (5%)	
Gunther	2014	46	Paprosky 3A Paprosky 3B	TM augment and cage	39	41 (89%)	0 (0%)	
Haddad	1999	48	AAOS I ($n = 10$) AAOS II ($n = 11$) AAOS III ($n = 27$)	Reinforcement ring/ APC	64	48 (100%)	0 (0%)	
Holt	2004	26	AAOS III/IV	Custom triflange cup	54	23 (88%)	3 (12%)	2/3 failures in PD
Joshi	2002	27	AAOS III	Custom triflange cup	58	25 (93%)	1 (4%)	
Kmiec	2015	69	Paprosky 2B ($n = 5$) Paprosky 2C ($n = 20$) Paprosky 3A ($n = 27$) Paprosky 3B ($n = 17$)	APC	86	64 (92%)	4 (6%)	4/4 aseptic failures in PD
Kosashvili	2009	26	Pelvic discontinuity	TM cup–cage	45	23 (88%)	3 (12%)	
Paprosky	2006	16	Paprosky 2C ($n = 2$) Paprosky 3A ($n = 6$) Paprosky 3B ($n = 8$)	Reinforcement ring/ APC	60	11 (69%)	4 (25%)	All defects associated with PD
Peters	1995	28	AAOS I ($n = 1$) AAOS II ($n = 5$) AAOS III ($n = 22$)	APC	33	28 (100%)	0 (0%)	
Philippe	2012	95	AAOS II ($n = 5$) AAOS III ($n = 84$) AAOS IV ($n = 6$)	Reinforcement ring/ APC	96	87 (92%)	2 (2%)	
Regis	2012	18	Pelvic discontinuity	APC	162	15 (83%)	2 (11%)	
Saleh	2000	13	Gross IV	Reinforcement ring/ APC	126	10 (77%)	1 (8%)	
Schlegel	2006	161	No defect ($n = 20$) AAOS I ($n = 11$) AAOS II ($n = 33$) AAOS III ($n = 92$) AAOS IV ($n = 8$)	Reinforcement ring	72	149 (93%)	6 (4%)	

Table 2 continued

First author	Year	*n*	Type of defect	Reconstruction	Mean FU (months)	Overall construct survival (*n*/pts. with FU, %)	Revision due to aseptic loosening (*n*/pts. with FU, %)	Remarks
Schlegel	2008	295	No defect ($n = 26$) AAOS I ($n = 24$) AAOS II ($n = 69$) AAOS III ($n = 164$) AAOS IV ($n = 15$)	Reinforcement ring/ APC	48	277 (94%)	9 (3%)	
Schmolders	2015	39	Paprosky 3A ($n = 15$) Paprosky 3B ($n = 24$)	Reinforcement ring	31	33 (85%)	1 (3%)	
Siegmeth	2008	34	Paprosky 2 ($n = 7$) Paprosky 3A ($n = 19$) Paprosky 3B ($n = 8$, $n = 2$ with PD)	TM cup and augment	34	32 (94%)	2 (6%)	
Sporer	2012	20	Paprosky 2C ($n = 4$) Paprosky 3A ($n = 3$) Paprosky 3B ($n = 13$)	TM cup and augment	54	19 (95%)	1 (5%)	All defects associated with PD
Steno	2015	81	Paprosky 1 ($n = 9$) Paprosky 2 ($n = 44$) Paprosky 3A ($n = 15$) Paprosky 3B ($n = 13$)	TT cup and augments	38	80 (99%)	1 (1%)	
Taunton	2012	57	AAOS IV	Custom triflange cup	65	54 (95%)	1 (2%)	
Whitehouse	2015	56	Paprosky 2 ($n = 17$) Paprosky 3A ($n = 28$) Paprosky 3B ($n = 11$, $n = 3$ with PD)	TM cup and augments	110	52 (93%)	3 (5%)	
Wind	2013	19	AAOS III ($n = 16$) AAOS IV ($n = 3$)	Custom triflange cup	31	17 (90%)	1 (5%)	
Zehntner	1994	27	AAOS I ($n = 1$) AAOS II ($n = 14$) AAOS III ($n = 12$)	Reinforcement ring	86	22 (81%)	1 (3%)	
Current study		46	AAOS III ($n = 26$) AAOS IV ($n = 20$)	Reinforcement ring	74	AAOS III: 23 (89%) AAOS IV: 11 (55%)	AAOS III: 3 (11%) AAOS IV: 4 (20%)	

APC antiprotrusio cage, *PD* pelvic discontinuity, *TM* Trabecular Metal™, *TT* trabecular titanium defects (Table 2) would allow for the statement that the Ganz reinforcement ring provides for survival rates that are consistent with previous reports of the Burch Schneider antiprotrusio cage [6, 15, 16] or Trabecular Metal™ cup and augments [1, 17, 31, 35]. This, however, differs for larger defects with pelvic discontinuity (AAOS type IV), where the survival rate of 53% is clearly inferior to the rates reported for trabecular metal implants, especially when used as a cup–cage reconstruction together with an antiprotrusio cage that have been shown to well exceed 85% for similar follow-up intervals [1, 4, 17, 21, 31, 32, 35]. Sporer et al. [32] demonstrated an excellent survival rate of 95% over 4.5 years using trabecular metal in a small series of 20 patients with Paprosky 2C–3A defects, all of which were associated with pelvic discontinuity. Triflange acetabular components have similarly demonstrated superior success, with a survival rate of 89–100% over 3–10 years [9, 11, 13, 34].

Surviving constructs generally showed similar functional results independent of the type of the acetabular defects treated. Thus, the final function is not associated with the severity of acetabular defects per se but with the successful reconstitution of the functional integrity of the acetabulum.

Based on the results of this study, the presence of pelvic discontinuity was identified as the one independent predictive factor of failure of the Ganz ring, regardless of previous surgeries, co-morbidities, complications, and implant retaining revisions. This emphasizes the need for narrowing indications. The statement is, however, confined to the Ganz reinforcement ring based on the results of this cohort and cannot be generalized to different types of similar constructs at this juncture.

The study has its limitations. First, preoperative CT scans were available for 33 out of 46 patients to re-assess and classify the acetabular defects. In the other 13 cases the image-based classification of the defects relied on conventional radiographs. The evaluation of a three-dimensional problem on two-dimensional projections is limited and includes the risk of under- or overrating the defects. However, the operative reports describing bone loss and the integrity of the anterior and posterior columns were available for all patients. We, therefore, believe that the acetabular defects have been classified correctly. Second, the number of patients available in the study was limited. This small number renders subgroup analysis and the interpretation of predictive risk factors and subgroup analysis difficult. Available evidence is limited to reports of small case series. This emphasizes the need for more clinical research activity in the field. Multicenter studies would be necessary to address the problem of low per-center caseload.

Conclusion

The results of this study indicate that acetabular defects with pelvic discontinuity demonstrate limited survival with the Ganz reinforcement ring compared to Trabecular Metal™ or custom-made triflange components. The utility should, therefore, be confined to defects not associated with pelvic discontinuity. In our clinical practice, Trabecular Metal™ implants have become the favored option in defects with pelvic discontinuity.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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