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HIP ARTHROPLASTY

Acetabular custom-made implants for severe acetabular bone defect in revision total hip arthroplasty: a systematic review of the literature

Francesco Chiarlone[1] · Andrea Zanirato[1] · Luca Cavagnaro[2] · Mattia Alessio-Mazzola[1] · Lamberto Felli[1] · Giorgio Burastero[2]

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Abstract

Purpose The management of acetabular bone loss is a challenging problem in revision total hip arthroplasty (rTHA). The aim of this systematic review is to summarize and critically analyze indications, complications, clinical and radiological outcomes of custom-made acetabular components in rTHA.

Methods A systematic review of English literature was performed on Medline. Retrospective or prospective studies with minimum 2 years of follow-up (FU) were included. The PRISMA 2009 flowchart and checklist were considered to edit the review. Rates of intra- or post-operative complications, aseptic loosening (AL), periprosthetic joint infection (PJI), reoperations and re-revisions rates were extrapolated.

Results 18 articles with a level of evidence of IV were included. Six hundred and thirty-four acetabular custom components (627 patients) with a mean FU of 58.6 ± 29.8 months were analyzed. The studies showed good clinical and functional outcomes. Custom-made acetabular components allowed a stable fixation with 94.0 ± 5.0% survival rate. The estimated rate of re-operations and re-revisions were 19.3 ± 17.3% and 5.2 ± 4.7%, respectively. The incidence of PJI was 4.0 ± 3.9%.

Conclusions The acetabular custom-made implants represent a reliable solution for pelvic discontinuity and particular cases of bone loss classified as Paprosky Type IIIA-B or type III–IV according to American Academy of Orthopaedic Surgeons system where the feature of the defect cannot be handled with standard implants. This strategy allows to fit the implant to the residual host bone, bypassing the bony deficiency and restoring hip biomechanics. Satisfactory clinical and radiological outcomes at mid-term follow-up are reported in literature.

Keywords Revision total hip arthroplasty · Acetabular bone defects · Paprosky classification · Pelvic discontinuity · Custom-made acetabular implants · Triflanged acetabular custom-made component

Introduction

Primary total hip arthroplasty (THA) is one of the most successful and common procedure in orthopedic surgery. A commiserate burden of revision surgery is expected to rise in the future [1]. Acetabular bone loss is a common finding during revision total hip arthroplasty (rTHA) and it represents a real challenge for orthopedic surgeon [2–4].

Different approaches have been proposed for bone defects management but a real consensus is far to be reached [5]. The reported incidence of Paprosky type III B bone defects and pelvic discontinuity is between 1 and 5% in patients undergoing rTHA [6–8].

The goals of acetabular revision for severe bone defect are a stable pelvic fixation with implant stability and restoration of bone stock, ischium and ilium continuity and reconstitution of hip biomechanics [9].

In literature, multiple treatment options have been proposed for management of severe acetabular defects, including porous tantalum acetabular components with early implant integration [10, 11], with or without structural allograft or metal augments [12, 13], standard cage reconstruction with iliac or ischial screw fixation [7, 13], cup-cage

✉ Andrea Zanirato
dott.zanirato@gmail.com

[1] Clinica Ortopedica, Ospedale Policlinico San Martino, Largo Rosanna Benzi 10, 16132 Genoa, GE, Italy

[2] Clinic Ortopedia e Traumatologia 2, Joint Replacement Unit, Ospedale Santa Corona, Viale 25 Aprile, 38, 17027 Pietra Ligure, SV, Italy

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construct [14–16], cup on cup construct and custom-made acetabular implants.

Cages, rings or cup-cages construct with acetabular structural allograft are commonly used techniques with unsatisfactory results and high rates of short and mid-term mechanical failures (from 12.5 to 37.5%) [17, 18].

Norwegian Arthroplasty Register reported that the failure rate of revision hip arthroplasty is 25.6% versus 11.4% for primary THA at 10 years follow-up, especially for acetabular component revision [19].

The best surgical technique has not been established and none of the previously mentioned solutions has been shown to be predictable and has satisfactory clinical and radiological outcomes in the management of severe periacetabular bone loss.

For this reason, the use of custom acetabular implants has gained popularity in the last years.

The purpose of this systematic review is to summarize and critically analyze indications, complications, clinical and radiological results of custom acetabular implants for the management of bone defects during rTHA.

Materials and methods

A systematic review of the literature was performed with a primary search on Medline through PubMed used the following strategy: ((revision[All Fields] AND ("arthroplasty, replacement, hip"[MeSH Terms] OR ("arthroplasty"[All Fields] AND "replacement"[All Fields] AND "hip"[All Fields]) OR "hip replacement arthroplasty"[All Fields] OR ("total"[All Fields] AND "hip"[All Fields] AND "arthroplasty"[All Fields]) OR "total hip arthroplasty"[All Fields])) AND (("bone and bones"[MeSH Terms] OR ("bone"[All Fields] AND "bones"[All Fields]) OR "bone and bones"[All Fields] OR "bone"[All Fields]) AND defect[All Fields])) OR (((((("culture"[MeSH Terms] OR "culture"[All Fields] OR "custom"[All Fields]) AND acetabular[All Fields] AND implants[All Fields]) OR (("culture"[MeSH Terms] OR "culture"[All Fields] OR "custom"[All Fields]) AND triflange[All Fields] AND acetabular[All Fields] AND component[All Fields])) OR (("culture"[MeSH Terms] OR "culture"[All Fields] OR "custom"[All Fields]) AND triflanged[All Fields] AND acetabular[All Fields] AND ("reconstructive surgical procedures"[MeSH Terms] OR ("reconstructive"[All Fields] AND "surgical"[All Fields] AND "procedures"[All Fields]) OR "reconstructive surgical procedures"[All Fields] OR "reconstruction"[All Fields]))) OR (custom-made[All Fields] AND components[All Fields])) OR (triflange[All Fields] AND acetabular[All Fields] AND implant[All Fields])) OR (3D-printed[All Fields] AND acetabular[All Fields] AND component[All Fields])) OR (("culture"[MeSH Terms] OR "culture"[All Fields] OR "custom"[All Fields]) AND acetabular[All Fields] AND cages[All Fields]).

The inclusion criteria were: retrospective and prospective studies including randomized controlled trials, nonrandomized trials, cohort studies, case–control studies and case series providing clinical, radiological results and complications with the use of custom-made implant for acetabular bone defects reconstruction; an average follow-up (FU) ≥ 2 years; papers in English without any restriction on publication date.

The exclusion criteria were: case reports, reviews, conference abstracts or surgical techniques papers; studies concerning predominately management of acetabular bone loss in primary total hip arthroplasties; an average follow-up < 2 years.

One reviewer applied the previously determined criteria to select potentially relevant papers. Articles were initially identified based on title and abstract; full text versions of relevant papers were then obtained and evaluated. References of the identified articles were checked in order not to miss any relevant articles.

The following data, when available, were extracted from the articles: authors and year of publication, level of evidence, number of patients, number of treated hips, mean age population (years), mean number of previous surgeries and revisions, indications for surgery, classification and types of acetabular bone defects, implants features, post-operative clinical and radiological outcomes, intraoperative and post-operative complications rate, rate and reason of re-operation and re-revision, dislocation rate, periprosthetic joint infections (PJI) rate, pelvic discontinuity healing rate, custom acetabular implant survival rate, mean follow-up (months).

Every new surgery was considered as re-operations, re-revisions instead included only custom-made acetabular components revision excluded liner exchange.

The studies that did not declare a specific datum were excluded by the global evaluation of that parameter.

The level of evidence (LOE) of the studies was assigned based on the 2011 Oxford Centre for Evidence-based Medicine Levels of Evidence [20].

The PRISMA 2009 flowchart and checklist were considered to edit our review. Categorical variables were expressed as number of cases or percentage. Continuous variables were reported as mean ± standard deviation (SD).

Results

A total of 18 articles were finally included in this systematic review [21–38]. The PRISMA 2009 diagram illustrates the studies that have been identified, included and excluded as well as the reason for exclusion (Fig. 1). All studies were

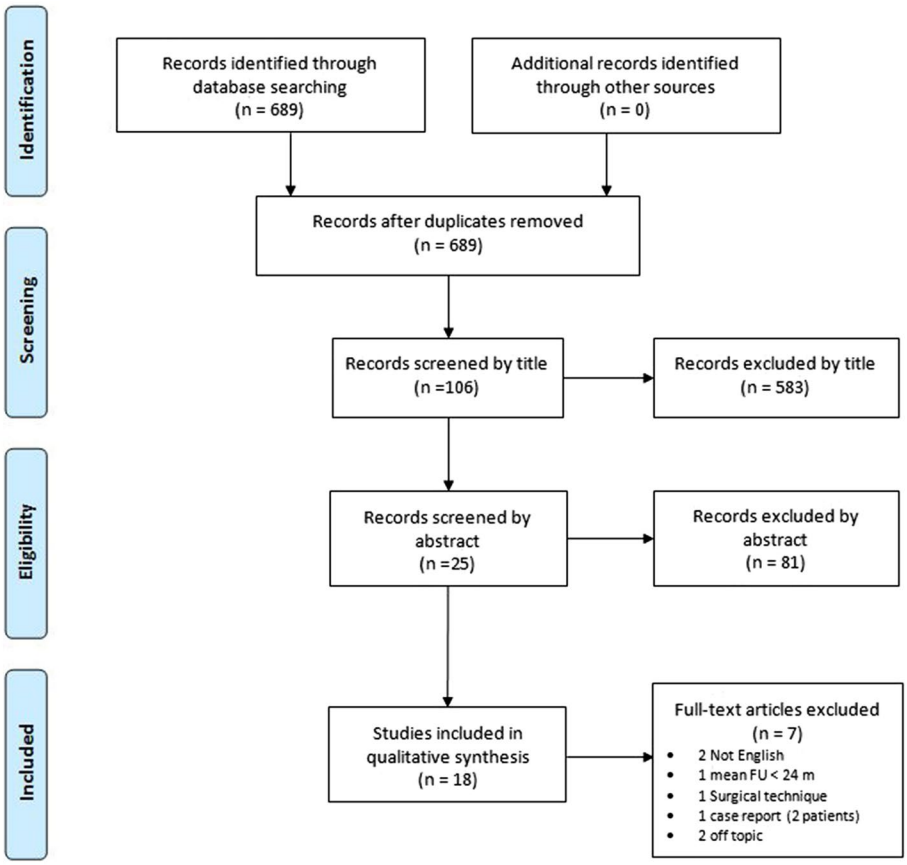

Fig. 1 The PRISMA flow diagram illustrates the studies that have been identified, included and excluded as well as the reason for exclusion

rated as level IV according to the 2011 Oxford Center for Evidence-based Medicine Levels of Evidence.

Demographic data

Pooling the available data from the included studies, 627 patients (634 hips), with a mean age 63.8 ± 4.3 years, underwent rTHA with custom-made acetabular component. The average follow-up was 58.6 ± 29.8 months.

In 17 studies [21–37], the pre-operative acetabular bone loss was classified according Paprosky system [6] or American Academy of Orthopaedic Surgeons (AAOS) system modified by Berry [7, 39]. One article did not declare the type of classification of bone defects used and grade of bone loss [38]. In most cases, the bone defects were classified as Paprosky type IIIA-IIIB, AAOS III–IV or more simply as pelvic discontinuity. Only one study included minor bone defects such as Paprosky type IIA and IIB [37].

Acetabular aseptic loosening (AL) was the main indication for rTHA with custom implant in the series. Other indications for revision surgery were: implant failure, osteolysis, PJI, multiple dislocations, instability, metallosis, dysplasia, Girdlestone, tumor, acetabular fractures and peri-prosthetic femoral fractures.

One study did not declare the indications for rTHA [23].

Implant features

In all cases, acetabular custom-made components, sometimes with a porous-plasma spray or a hydroxyapatite coating to the backside of the implants to facilitate bone ingrowth, were implanted. These features allowed to accommodate and bypass acetabular host bone loss providing for biologic fixation.

The majority of the authors [21–30, 33–38] used a custom triflanged acetabular component with multiple screws placed into iliac and ischial flanges to facilitate initial as well as long-term fixation, while typically the pubic flange, smaller than other, did not contain screws holes.

The polyethylene liner was cemented or trialed and snapped into the triflanged cage as a primary shell, with good restoration of the center of rotation.

The majority of the authors, at the time of the indexed surgery, used standard snap-in or cemented polyethylene liners, sometimes replaced with constrained liners as an additional safeguard against implant dislocation. Only three authors declared to use dual mobility cup cemented in the custom cage [26, 33, 36]. Two studies did not declare the features about the liner used [35, 38]. Not all patients had concomitant revision of the prosthesis femoral component.

Clinical and radiological outcomes

In all studies, a clinical evaluation was performed. Harris Hip Score (HHS) was the most adopted evaluation toll with high rate of results variability. Pooling the data, the mean postoperative HHS was 76.1 ± 8.6. Oxford Hip Score (OHS), Western Ontario and McMaster Universities Arthritis Index (WOMAC), Short Form-36 (SF-36), Hip disability and Osteoarthritis Outcome Score (HOOS), Visual Analogue Scale (VAS) or modified Merle d'Aubigne and Postel scale were other clinical evaluation systems employed.

The authors radiologically evaluated custom-made implant stability, osseointegration or migration, periprosthetic radiolucency and screw breakage. Only four authors [23–25, 28] reported pelvic discontinuity healing rate.

Complications

The mean complications rate of the series was 29.0 ± 16.0%. The mean rate of custom acetabular AL was 2.6 ± 4.0%, with an implant survivorship rate of 94.0 ± 5.0%. The global rate of PJI was 4.0 ± 3.9%.

The mean rate of re-operations and re-revisions were 19.3 ± 17.3% and 5.2 ± 4.7%, respectively.

The main indication for re-operation was dislocation (11.5 ± 10.7%). Other causes of re-operation were: implant instability, nerve palsy, acetabular or femoral fracture, hematoma, polyethylene exchange, trauma and wound infection.

AL (41%) and PJI (59%) were predominant indications for revision of acetabular custom-made implant.

Tables 1 and 2 summarized data extracted from the included studies.

Discussion

The primary goals of acetabular reconstruction are to provide implant stability on residual host bone and to reconstruct hip biomechanics. In rTHA, pre-operative planning with X-rays and CT scan is mandatory. In case of severe bone loss, the reconstruction method should impose to "bridge" the defect. In those cases, several reconstruction techniques have been proposed with different and unpredictable results. In this tangled panorama, the body of literature and interest surrounding custom-made reconstruction techniques has grown [40].

The acetabular custom-made implants allow the surgeon to fit the implant to the residual host bone, bypassing the bone defect and represent a reliable solution for pelvic discontinuity and particular cases of Paprosky Type IIIA-B, AAOS type III–IV where the feature of the defect cannot be handled with standard implants.

All the included types of implants were the result of a strict collaboration between engineers and surgeons to ensure the most appropriate custom-cage conformation evaluating 3D plastic models of both acetabular bone defect and pelvic anatomy.

Baawn et al. [33] showed how the final implant perfectly matched the patient's anatomy relative to acetabular defect and flanges position on the ilium, ischium and pubic bone in every treated case.

The monoblock structure permit to fill and bridge the extensive bone defect at the same time thus reducing a possible source of failure linked to different interfaces of modular implants [41]. Other theoretical advantages of custom-made acetabular implants rely on the possibility of accurate preoperative planning, preoperative trial surgery, meticulous planification of safe screws insertion zones to avoid injuries to the neurovascular structures [42]. Ideally, these advantages lead to a shorter operative time and limited blood loss. Moreover, the custom-made device allows to manage the problems of bone defects and implant stability separately. The custom acetabular system is primarily oriented for bone loss management while the cemented liner (conventional, constrained or dual mobility) is fundamental for hip stability and good biomechanics restoration [32, 37].

At the same time, this reconstruction philosophy does not allow any intraoperative adjustment of the custom-made device, underlining the importance of pre-operative planning accuracy. Nonetheless, the design process of the custom-cage usually takes several weeks with possible worsening of the bony defect. This involves a possible limitation in case of more extensive or complex bone defect respect to the preoperative planning [26].

Some authors stated that overall costs of the procedure with custom made devices could be higher than other reconstruction techniques [21, 24–26, 29, 43]. Although production costs of the implants are more expensive than other off the shelf devices, little is known about a complete cost-effectiveness analysis of custom-made implants [43]. Considering the reduction in blood loss, the complication rate and the operative time, further studies related to cost-effectiveness analysis of custom-made systems are requested.

The flanged component, with iliac and ischial screws or obturator hook, safeguards the initial stability of the acetabular cage [23, 25, 27]. Secondary stability is obtained with biological bone ingrowth and the large surface with hydroxyapatite or porous coating allows osseointegration with long-term fixation [44].

In this systematic review, the mean rate of custom acetabular AL was 2.6 ± 4.0%, with an implant survivorship rate of 94.0 ± 5.0%. Moreover, the triflanged component offers

Table 1 Summary and main features of the included studies

Author (year)	LOE	Patients/hips at last FU[a]	Mean age (years)	Previous surgeries	Indication for revision	Bone defects	Custom implant features	Liner type	Post-operative clinical outcomes	Mean FU (months)	Limitations of the study
Christie MJ (2001) [1921]	IV	65/67	59 (29–87)	–	Failed THA, 8 primary implants	AAOS III–IV	Ti triflanged—porous and hydroxyapatite coatings	Standard snap-in PE/constrained liners	HHS 82.1	53 (24–107)	R case series; 2 surgeons Mid-term FU; Previous surgeries not declared
Joshi AB (2002) [2022]	IV	27/27	68 (55–77)	At least 2 (2–5)	Failed THA	AAOS III	Ti triflanged	Standard and constrained liners	Modified Merle d'Aubigne and Postel score 5.3	58 (48–72)	R case series; mid-term FU`
Holt GE (2005) [2123]	IV	26/26	69.2 (44–82)	Min. 1 (1–4)	Not specified-	P. IIIB AAOS III–IV	Triflanged porous coated	Standard PE	HHS 78	54 (24–85)	R case series; mid-term FU; indication for revision not declared
De Boer DK (2007) [2224]	IV	18/20	55.8 (30–77)	Min. 1 (1–7)	Failed THA	AAOS IV	Triflanged—hydroxyapatite and porous coatings	Standard snap-in PE + 2 constrained liners	HHS 80	123 (89–157)	P case series; 2 surgeons
Taunton MJ (2012) [2325]	IV	57/57	61 (35–81)	Min. 1 (–)	Failed THA	AAOS IV	Triflanged—porous coating	Standard liner + 12 constrained	HHS 74.8	76 (24–215)	R case series; mid-term FU; multicenter study
Colen S (2012) [2426]	IV	6/6	69 (63–78)	3.8 (2–7)	Failed THA	AAOS III–IV	Ti triflanged—porous coating	Dual mobility cup cemented	HHS 61.2 VAS 3.8	28.5 (10–58)	R case series; small sample size; short-term FU
Wind MA (2013) [2527]	IV	19/19	58 (42–79)	2 (0–5)	Lysis with mechanical failure, PJI, multiple dislocations	P. IIIA–IIIB AAOS III–V	Ti triflanged—porous coating	Standard snap-in liners	HHS 63 WOMAC 26	31 (16–59)	R case series; 2 surgeons Short-term FU
Friedrich MJ (2014) [2628]	IV	18/18	68 (26–79)	2.4 (1–10)	AL, PJI	P. IIIB AAOS III–IV	Ti triflanged—hydroxyapatite coating	Cemented polyethylene liner	HHS 69	30 (17–62)	R case series; short-term FU

Table 1 (continued)

Author (year)	LOE	Patients/hips at last FU[a]	Mean age (years)	Previous surgeries	Indication for revision	Bone defects	Custom implant features	Liner type	Post-operative clinical outcomes	Mean FU (months)	Limitations of the study
Berasi CC (2015) [2729]	IV	23/24	67 (47–85)	Min. 1 (–)	Component migration AL, lysis, PJI, acetabular fracture, dislocation	P. IIIB	Ti triflanged—porous plasma spray-coated	16 constrained liners	HHS 65	57 (28–108)	R case series; 2 surgeons; mid-term FU
Barlow BT (2015) [2830]	IV	63/63	62.7 (–)	2 (1–11)	Aseptic or septic failure	P. IIIB AAOS III–IV	Triflanged/biflange—plasma sprayed hydroxyapatite coating	Standard + 16 constrained liners	WOMAC 71.4	52 (–)	R case series; mid-term FU; dislocation rate and reasons for custom failure not reported
Mao Y (2015) [2931]	IV	22/23	60.9 (38–80)	Min. 1 (–)	AL, PJI	P. IIIA-IIIB	Ti Cage: dome, hook, flange or three braids—porous and hydroxyapatite coatings	Cemented polyethylene liner	HHS 80.9	82 (–)	R case series; mid-term FU
Li H (2016) [3032]	IV	24/24	65 (54–79)	1 (1–2)	AL	P. IIIB AAOS III–IV	Cage with iliac wing/braid, ischial flange or crest or obturator hook	Cemented polyethylene liner	HHS 82	67 (24–120)	R case series; 2 surgeons; mid-term FU
Baauw M (2016) [3133]	IV	12/12	66 (33–79)	2.2 (1–5)	AL, Girdlestone, lysis	P. IIIA/IIIB	Trabecular Ti triflanged	Cemented Dual mobility cup	HOOS PS 33.9 OHS 30.5 VAS rest 0.8 VAS activity 2.2	25 (18–39)	R case series; small sample size; short-term FU
Gladnick BP (2017) [3234]	IV	73/73	58.9 (32–83)	Min. 1 (–)	AL, implant failure, PJI, instability, PPFx, Lysis	P. IIIB	Triflanged	Constrained, face-changing, lipped liner, neutral, other	HOOS 85	90 (60–144)	R case series; mid-term FU; multicenter study
Citak M (2017) [3335]	IV	9/9	66.7 (40–79)	5 (1–8)	Acetabular AL	P. IIIA-IIIB Pelvic discontinuity	Triflanged	–	HHS 58.7 OHS 29.8 SF-36 156	29 (13–47)	R case series; small sample size; Short-term FU; liner type not specified

Table 1 (continued)

Author (year)	LOE	Patients/hips at last FU[a]	Mean age (years)	Previous surgeries	Indication for revision	Bone defects	Custom implant features	Liner type	Post-operative clinical outcomes	Mean FU (months)	Limitations of the study
Berend ME (2018) [3436]	IV	94/95	66 (38–85)	1.6 (1–3)	AL, PJI, lysis, acetabular fracture, cage failure	P. IIC-IIIA-IIIB Pelvic discontinuity	Ti triflanged—porous plasma spray or hydroxyapatite coating	Standard liner or dual mobility components	HHS 75	43 (12–132)	R case series; mid-term FU; multicenter study
Kieser DC (2018) [3537]	IV	36/36	68 (43–89)	2 (0–6)	Lysis, PJI, metallosis, tumor, trauma, dysplasia	P. IIA–IIIB Pelvic discontinuity	Ti triflanged—porous surface	Cemented liner	HHS 79	38 (24–108)	R case series; mid-term FU; multicenter study; various degrees of acetabular defects
Moore KD (2018) [3638]	IV	35/35	60 (47–73)	Min. 1 (–)	AL, post-traumatic	14 Pelvic discontinuity, other	Triflanged	–	HHS 90	> 120 (–)	R case series; no classification of acetabular defect; liner type not specified

AAOS American Academy of Orthopaedic Surgeons, *AL* aseptic loosening, *LOE* level of evidence, *FU* follow-up, *HHS* Harris Hip Score, *HOOS* Hip disability and Osteoarthritis Outcome Score, *Min*. minimum, *N* number, *OHS* Oxford Hip Score, *PJI* periprosthetic joint infection, *PPFx* periprosthetic fracture, *P* Paprosky classification acetabular defects, *Pts* patients, *R* retrospective, *SF-36* Short Form-36, *THA* total hip arthroplasty, *Ti* titanium, *VAS* Visual Analogue Scale, *WOMAC* Western Ontario and McMaster Universities Arthritis Index, (–) not reported

[a]At the last follow-up

Table 2 Rate of complication, dislocation, periprosthetic joint infection, re-operation, acetabular re-revision, acetabular custom survival and reason for custom failure extrapolated from the included studies

Authors (year)	Complication rate (%)	Dislocation rate (%)	PJI (%)	Re-operation rate (%)	Acetabular re-revision rate (%)	Acetabular custom survival rate (%)	Reason for custom failure
Christie MJ (2001) [1921]	27.7	17.9	0	8.9	0	100	/
Joshi AB (2002) [2022]	22	3.7	7.4	13.7	0	100	/
Holt GE (2005) [2123]	26.9	7.7	0	3.8	3.8	88.5	3 AL
De Boer DK (2007) [2224]	40	30	0	30	0	100	/
Tauton MJ (2012) [2325]	47.4	21	7	30.3	5.3	95	2 PJI, 1 AL
Colen S (2012) [2426]	0	0	0	0	0	100	/
Wind MA (2013) [2527]	52.6	26	5.2	32	10.5	89.5	1PJI, 1AL
Friedrich MJ (2014) [2628]	33.3	16.7	11.1	27.8	11.1	88.9	2 PJI
Berasi CC (2015) [2729]	26.1	0	8.3	16.6	8.3	91.7	2 PJI
Barlow BT (2015) [2830]	27	–	3.2	27	13.5	86.5	–
Mao Y (2015) [2931]	21.7	8.7	0	4.3	4.3	91.3	2 AL
Li H (2016) [3032]	16.7	4.2	4.2	8	0	100	/
Baauw M (2016) [3133]	33.3	8.3	0	0	0	100	/
Gladnick BP (2017) [3234]	37	9.6	11	35.6	7.9	90.4	6 PJI, 1 AL
Citak M (2017) [3335]	66.7	33.3	0	66.7	11.1	88.9	1 AL
Berend ME (2018) [3436]	22	6.3	6.3	22	7.3	92.7	1 AL, 1 acetabular fracture, other not specified
Kieser DC (2018) [3537]	11	2.8	2.8	2.8	2.8	97.2	1 PJI
Moore KD (2018) [3638]	11.4	0	5.8	8.5	8.5	91.5	2 PJI, 1AL

AL aseptic loosening, *PJI* periprosthetic joint infection, / not applicable, – not reported

a firm fixation to promote healing of the bone discontinuity through its anatomical load distribution [25, 27].

Another interesting point is the role of flanges and screws fixation in case of pelvic discontinuity. As reported by Christie et al. [21], the ischial screws are placed first and then the iliac screws, seated on the flange, can be used to reduce pelvic discontinuity, because often ischium is poorer and more lytic.

In these series of rTHA, high variability in clinical results was reported in the included studies. The global evaluation performed in this review showed acceptable functional results. Nevertheless, the absence of detailed information about number of previous surgery and/or revision did not allow a strong analysis.

Several authors [25, 26, 29, 32] reported that the conventional radiographic evaluation of custom implants was challenging due to intrinsic design of the devices, showing acceptable rate of radiographic implant loosening or migration, screws breakage and radiolucency lines.

The mean rate of re-operations and re-revisions were $19.3 \pm 17.3\%$ and $5.2 \pm 4.7\%$, respectively.

Pooling the data of included studies, dislocation rate was the first cause of re-operation ($11.5 \pm 10.7\%$). This datum is comparable to other reconstruction techniques. Baauw et al. [45] analyzed the final position of their custom-made acetabular implants in 16 patients. The authors concluded that seven devices were malpositioned in one or more parameters (inclination, anteversion and center of rotation). Recently, Weber et al. [46] showed that custom-made acetabular implants can be positioned with good accuracy in Paprosky III defects when a proper preoperative planning is performed.

Many authors reported the importance helpful of constrained liner or dual mobility cup against the risk of dislocation in patients with abductor mechanism insufficiency secondary to trochanteric bone loss, muscles injury and inadequate soft tissue tension due to previous surgeries and large, extensive surgical approach necessary to custom implantation. Other hypothesis is the possible stretch injury to the superior gluteal nerve [21, 23, 28].

PJI and AL were predominant indications for revision of acetabular custom-made implant. These data compared favorably with other proposed techniques for acetabular reconstruction.

Main limitations of the current review are low level of the included studies (type IV), poor quality evaluation, high amount of biases and methodological inaccuracies, and usually short- to mid-term follow-up. Further high-quality log-term studies would better clarify complications, clinical and radiological results and cost-effectiveness of this technique.

Conclusion

The acetabular custom-made implants represent a reliable solution for severe acetabular defects (pelvic discontinuity and particular cases of Paprosky Type IIIA-B, AAOS type III–IV) where the feature of the defect cannot be handled with standard implants. Accurate pre-operative planning, design and production of custom implants are crucial phases of surgery. This strategy allows to fit the implant to the residual host bone, bypassing the bony deficiency and restoring hip biomechanics. Satisfactory clinical and radiological outcomes at mid-term follow-up are reported in literature.

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Compliance with ethical standards

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

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

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