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Systematic review

Acetabular Lip Augmentation Devices for the Unstable Total Hip Replacement—A Systematic Review

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ABSTRACT

Background: The optimal management strategy for instability afte total hip arthroplasty remains unclear. Acetabular lip augmentation devices may offer an operative solution for recurrent instability. This systematic review reports the clinical outcomes of acetabular lip augmentation devices in comparison to other treatment options.

Methods: A literature search strategy was performed of Medline, EMBASE, and CENTRAL on September 19, 2020, for all studies reporting outcomes of acetabular lip augmentation devices for recurrent dislocation after total hip arthroplasty. Non-English language articles were excluded. Clinical and survivorship data were collated and analyzed.

Results: Thirteen studies describing acetabular augmentation were included for analysis. A total of 644 hips in 636 patients were augmented with a mean age of 75 years (39 to 103). Five different augmentation devices were used. The posterior lip augmentation device (PLAD, DePuy) was the most used (406 hips). Overall, acetabular lip augmentation devices had a 10% postoperative dislocation rate at a mean follow-up of 49 months (0.2 to 132). The PLAD had a 3.9% subsequent dislocation rate with a mean follow-up of 51 months (0.2 to 132). Only one study compared the PLAD to a dual-mobility cup, which demonstrated shorter operative times with the PLAD but higher rates of dislocation and revision surgery.

Conclusion: The quality of literature on lip acetabular augmentation devices is poor. In these studies, the postoperative dislocation rate after lip acetabular augmentation was relatively high. The PLAD (DePuy) has the most evidence and may offer a therapeutic option for recurrent instability, in very specific clinical situations.

Introduction

Dislocation after primary total hip arthroplasty (THA) has a reported incidence ranging from 0.6% to 4% [1]. Of those, 16% to 36% may sustain recurrent THA dislocation [2-4]. Multiple factors contributing to recurrent instability, including component orientation, femoral head size, impingement, polyethylene wear, patient age, patient gender, and choice of surgical approach, have been described [5-7].

Numerous management strategies have been reported for recurrent THA dislocations. Previously, conservative treatment with an above-knee spica brace or hip cast-brace was considered appropriate. In 1983, Stewart reported a 73% success rate with a hip cast-brace for recurrent THA instability [8].

In the majority of those with recurrent instability, however, operative intervention is required. Revision surgery may be a substantial undertaking in this patient cohort, who are often elderly and frail. Revision surgery has been associated with reported subsequent dislocation rates between 5% and 28% [9,10]. Acetabular lip augmentation devices may be used in this population.

A lip augmentation device (Fig. 1) consists of a stainless steel backing plate and ultra-high-molecular-weight polyethylene bearing

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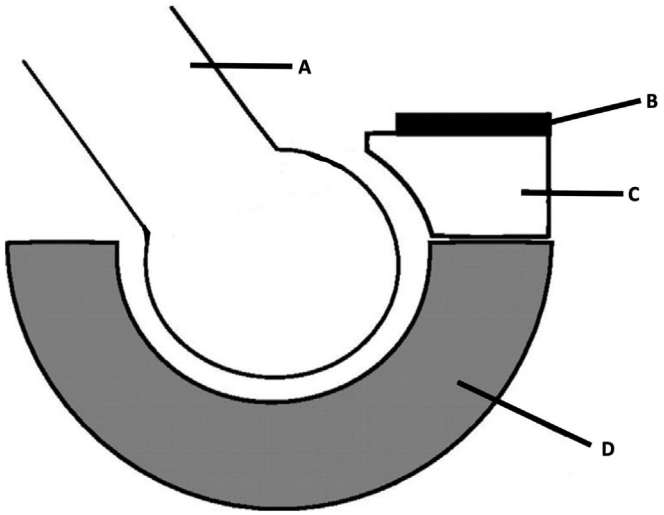

Figure 1. Diagram of a lip augmentation device. A, Femoral stem implant; B, metal backing of device; C, polyethylene component of device; D, acetabular component.

piece which are predrilled to facilitate fixation with 5 screws into the in situ polyethylene cup and contoured for a congruent articulation with the femoral head [11]. Augmentation devices, of which the posterior lip augmentation device (PLAD; DePuy International Limited, Leeds, United Kingdom) is one, may be fixed in whichever direction the hip has a predilection to dislocate.

The aim of this study was to perform a systematic review of the reported clinical outcomes of the acetabular lip augmentation devices for recurrent instability after THA.

Material and methods

This was a systematic review of the outcomes of acetabular lip augmentation devices for recurrent instability after THA. The search strategy was designed in accordance with Cochrane guidance [12].

Medline, EMBASE, Cochrane CENTRAL, and Clinicaltrials.gov were searched on September 19, 2020, using the search strategy outlined in Table 1. Google Scholar was used to perform a cited reference search. Grey literature was assessed through www.opengrey.eu.

Articles that reported clinical outcomes of a lip augmentation device for unstable THA were included. Non-English language articles and studies without full-text results were excluded.

Database results are outlined in Figure 2. Abstracts were screened by two independent reviewers. Articles were reviewed independently, and consensus met. The senior author acted as mediator for instances of reviewer discordance.

Results

Fourteen studies [5,11,13-24] met the inclusion criteria for this review. Two articles [23,24] presented results from the same study and were thus amalgamated for analysis. Each articles was critically appraised, as outlined in Table 2.

Table 1
The literature search strategy used for this systematic review.

Number	Searches
1	(acetabulum* or acetabular or hip or hip joint).mp.
2	(posterior lip augmentation device or PLAD or lip augmentation device or lip augmentation ring).mp.
3	2 or 3

Five types of acetabular lip augmentation devices were used. The PLAD (DePuy International Limited, Leeds, United Kingdom) was used in four studies and accounted for 406 of 644 cases (64%) [11,18,20,24]. Olerud and Karlström's original sector method was reported in four studies [5,13-15]. The other described acetabular augmentation devices were the Wroblewski acetabular stabilizing wedge (DePuy) in three studies [5,15,16], the antiluxation ring (Waldemar Link GmbH, Hamburg, Germany) in three studies, the Beck acetabular augmentation ring segment (Erothitan Titanimplantate AG, Schmalkalden, Germany) in one study [17], and the PLAD (custom-made; Waldemar Link GmbH, Hamburg, Germany) in one study [22]. Two studies assessed more than one augment type [5,15].

There were two studies with level III evidence [11,24], with the remainder having level IV evidence. All studies demonstrated high risk of bias (Table 2). Funding sources were declared in 6 of 13 articles, of which 5 had no funding source and 1 article was funded by a public research institutional grant. There was no declaration of industry funding in the included studies.

The patient demographics within each study are outlined in Table 3. A total of 644 acetabular augmentations were performed in the 13 included studies. The Charnley prosthesis was augmented in nine studies, while the four remaining studies included other arthroplasty devices (Table 3). Two studies augmented different acetabular cup types [5,17], whereas one study did not specify the acetabular cup in situ [21].

Eight of the 13 included studies reported the number of prior dislocations, while four studies reported the mean number of operations performed before acetabular augment. Of those, the average number of prior dislocations was 4.2 (range, 0 to 20). Two patients in the study by Nicholl et al. [5] and one patient in the study by Bottner et al. [17] had an acetabular augment inserted during the index procedure for gross on-table instability. The mean number of previous operations was 2.5 (range, 0 to 8) (Table 4). The mean time from the index THA to insertion of the PLAD was 41 months (range, 0 to 270) (Table 4).

The mean follow-up for all augment types was 49 months (range, 0.2 to 132) (Table 3). Specifically, the mean follow-up for the PLAD (DePuy) was 51 months (range, 0.2 to 132). The clinical outcomes from acetabular lip augmentation are described in Table 4.

The overall postoperative dislocation rate after acetabular lip augmentation was 10% (65 of 644). Postoperative dislocation rate varied by augment type (Table 5). The Beck acetabular augmentation ring had the highest dislocation rate at 33% (1 study, 6 of 18 hips). Comparatively, the PLAD from DePuy had the lowest pooled postoperative dislocation rate at 3.9% (4 studies, 16 of 406 hips). Notably, one study reported the dislocation rate as high as 16% (9 of 55 hips) [24].

Duration of operation was recorded in three studies, with a mean of 46 minutes (range, 21 to 84), while blood loss was recorded in two studies, with a mean of 213 millilitres (range, 80 to 600).

Five studies reported length of stay, with an overall mean of 11.7 days (range, 3 to 124). There were 18 reported cases (2.8%) of deep-wound infection, which was defined as requiring reoperation. Repeat acetabular lip augmentation was performed in 17 cases (2.6%). There were 8 reported cases (1.3%) of aseptic loosening across 12 studies. Screw breakage occurred in 58 cases (9%). Thirty-five patients (5.4%) across 13 studies ultimately progressed to full revision of the THA (Table 5).

The PLAD (DePuy) accounted for most of the acetabular lip augmentation devices assessed (406 of 644, 63%). This device demonstrated lower rates of postoperative dislocation (16 patients, 3.6%) and THA revision (6 patients, 1.5%) than other devices

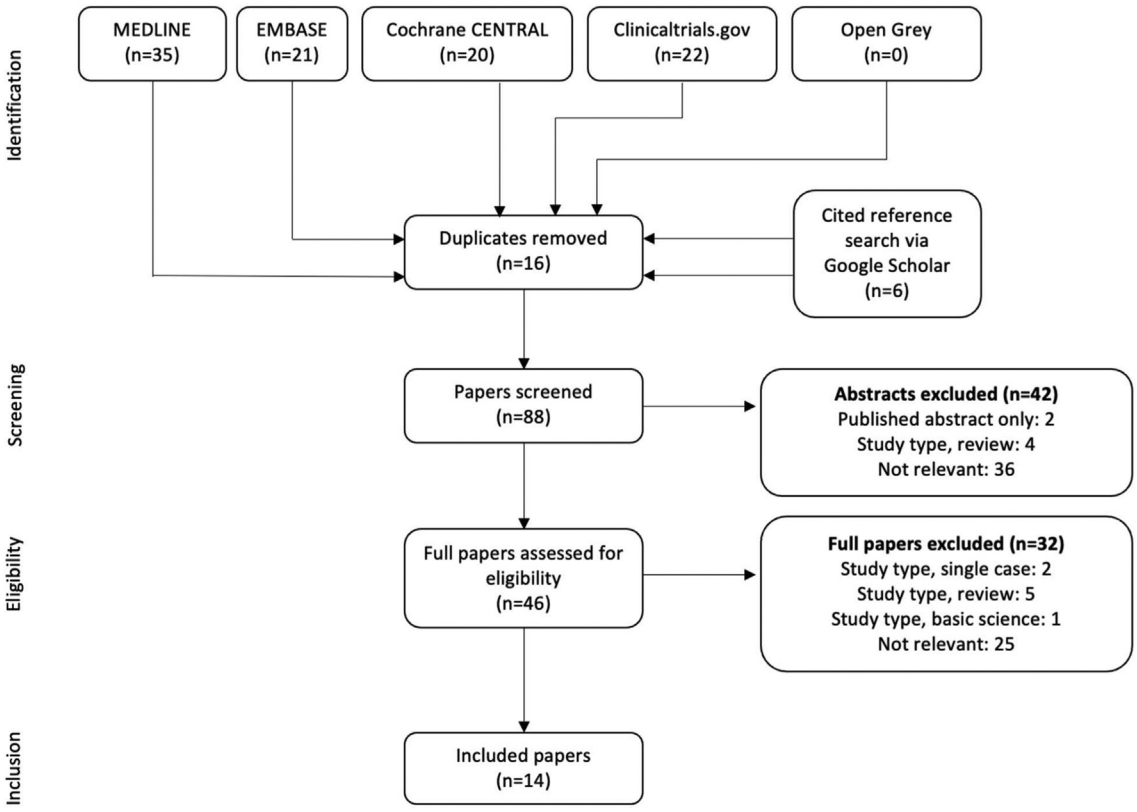

Figure 2. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of the review.

(Tables 4 and 5). Two patients (0.49%) in the PLAD (DePuy) subgroup developed aseptic loosening requiring revision (1 femoral stem, 1 acetabular component).

Two patients in the study by Gholve et al. [18] sustained dislocation after PLAD (DePuy) insertion which was attributed to suboptimal device positioning [18]. In both cases, resiting the device more anteriorly prevented further dislocation. Five patients in the study by McConway et al. sustained a postoperative dislocation [20], although the authors did not describe the proposed modes of failure. One of the five had broken screws. However, 30 patients in the same study developed broken screws without failure [20], implying this was not the causative element.

Discussion

The pooled postoperative dislocation rate of all acetabular lip augmentation devices was 10% in the thirteen included studies. The PLAD (DePuy), accounting for 64% of cases, had a lower pooled postoperative dislocation rate of 3.9%. Furthermore, the PLAD (DePuy) demonstrated a low complication rate and a low rate of progression to full revision (1.5%).

The Charnley low-friction arthroplasty, first implanted in 1962, [25] was the first widespread total hip replacement. To reduce particulate wear, small head sizes of 22.225 mm were used [25]. However, this predisposed the Charnley THA to recurrent instability [26].

The postoperative dislocation rate of a hip prosthesis is cumulative over its lifespan [26]. With survival of nearly 44% at 35 years [27], options for operative management of instability remains important. These options include acetabular augmentation devices or formal revision surgery, including dual-mobility cups.

Olerud and Karlström first described acetabular augmentation in 1985, augmenting the existing acetabular component with a polyethylene wedge cut from another acetabular component [13]. Subsequently, the PLAD (DePuy International Limited, Leeds, United Kingdom) was developed to constrain the femoral head within the acetabular component [5,6]. These devices differ from constrained acetabular implants as they are attached to the in situ acetabular component and resist femoral head subluxation in a specific direction (Fig. 1).

McConway et al reported the largest series of acetabular lip augmentation devices [20]. They described 310 cases of PLAD (DePuy) insertion for THA instability. Their series accounts for 76% of PLAD (DePuy) cases and 48% of all lip augmentation cases described in the literature [20]. They reported only 5 postoperative dislocations (1.6%) at a mean follow-up of 48 months.

Dual-mobility acetabular cups offer an increasingly popular solution to the unstable THA [28]. First devised by Bousqet in 1977 to address the problem of postoperative instability with small head sizes [29], the cups incorporate two advantageous elements: a small head to reduce polyethylene wear, and a large, mobile, polyethylene intermediary cup within a metal-backed cup to increase jump distance and thus reduce dislocation [30]. A recent systematic review found a 2.2% postoperative dislocation rate after revision THA at mean 4.1 years of follow-up [31]. The perceived disadvantages of revision to a dual-mobility cup are increased surgical invasiveness, duration of operation, and blood loss [11,24].

Two studies [11,24] compared the PLAD (DePuy) to formal THA revision for postoperative dislocation. Charlwood et al retrospectively compared 20 patients who underwent PLAD to 20 who underwent revision THA [11]. They found no cases of dislocation in either group and similar Oxford Hip Scores at 2 years of follow-up.

Table 2
Critical appraisal of included studies.

Study	Strengths	Weaknesses	Bias and confounding	Overall risk of bias	Overall grade of evidence
Olerud et al. [13]	First article to describe the technique	Follow-up not specified; small numbers; no control	Retrospective; uncontrolled	High	Low
Güngör and Hallin [14]	First article with specific follow-up	Lacking clinical data; uncontrolled; small numbers (13)	Retrospective; uncontrolled	High	Low
Bradbury et al. [15]	Reasonable follow-up (3 y)	Small series (16); no control; 2 different augment types used	Retrospective; uncontrolled; 2 different augment types used (different experimental interventions)	High	Low
Nicholl et al. [5]	Reasonable follow-up; adequate data completeness	No control; heterogenous augments; heterogenous implants	Retrospective; uncontrolled; 2 different augment types used (different experimental interventions); heterogenous implants augmented	High	Low
Charlwood et al. [11]	Comparative study; complete data; detailed outcome measures	Short follow-up (2 y); low numbers (n = 20)	Retrospective	High	Low
Madan et al. [6]	Relatively large numbers at n = 68; homogenous group	Uncontrolled; no specific follow-up	Retrospective; uncontrolled; no specific follow-up	High	Low
Bottner et al. [17]	Reasonable follow-up	Heterogenous groups; many with multiple previous operations; previous infection in one case; dialysis patient in another—high risk; 6 had proximal femoral replacements	Different implants; heterogenous patient group; heterogenous treatment plans	High	Low
Gholve et al. [18]	Comprehensive data; homogenous	Uncontrolled; short follow-up at 2 y	Low numbers; uncontrolled	High	Low
Enocson et al. [19]	Long follow-up (4.5 y); homogenous	Uncontrolled; small numbers	Uncontrolled; small numbers	High	Low
McConway et al. [20]	Large study (n = 310); long follow-up; comprehensive data; homogenous	Uncontrolled; retrospective	Uncontrolled; retrospective	High	Low
Bosker et al. [21]	Long follow-up	Small; uncontrolled; incomplete data	Uncontrolled; retrospective	High	Low
Schmidl et al. [22]	Long follow up	Small; uncontrolled; incomplete data	Uncontrolled; retrospective	High	Low
Hoggett et al. [24]	Comparative; long follow-up (7 y)	Retrospective; sparse clinical data; historical control; different durations of follow-up (longer in the PLAD)	Retrospective; different durations of follow-up; unmatched comparisons	High	Low

Table 3
Patient demographics of studies assessing acetabular augmentation devices.

Study	Year	Augment device	Cup in situ	Level of evidence	Patients, n	Hips, n	Male, n	Female, n	Mean age, y (range)	Mean follow-up, mo (range)
Olerud et al. [13]	1985	Olerud sector	Charnley	4	6	6	2	4	62 (45 to 82)	N/A (9 to 36)
Güngör and Hallin [14]	1990	Olerud sector	Charnley	4	13	13	6	7	71 (57 to 81)	12 (all 12)
Bradbury et al. [15]	1994	Olerud sector in 3, Wroblewski in 13	Charnley	4	16	16	2	14	73 (45 to 86)	36 (12 to 70)
Nicholl et al. [5]	1999	Olerud sector in 18 Wroblewski in 10	Multiple types[a]	4	27	28	5	22	72 (50 to 99)	26 (3 to 108)
Charlwood et al. [11]	2002	PLAD (DePuy)	Charnley	3	20	20	4	16	75 (54 to 89)	24 (all 24)
Madan et al. [6]	2002	Wroblewski	Charnley	4	68	68	14	54	79 (74 to 76)	35 (24 to 95)
Bottner et al. [17]	2005	Beck	Multiple types[b]	4	18	18	7	11	65 (44 to 78)	35 (24 to 52)
Gholve et al. [18]	2006	PLAD (DePuy)	Charnley	4	21	21	8	13	76 (62 to 88)	23 (12 to 36)
Enocson et al. [19]	2006	Anti-luxation ring	Lubius SPII	4	12	12	6	6	69 (58 to 83)	54 (12 to 108)
McConway et al. [20]	2007	PLAD (DePuy)	Charnley	4	307	310	67	240	75 (39 to 96)	48 (0.2 to 132)
Bosker et al. [21]	2009	Antiluxation ring	N/A	4	47	50	12	35	75 (58 to 94)	74 (12 to 178)
Schmidl et al. [22]	2016	PLAD (Link)	EndoMark III/SP2	4	27	27	12	15	82 (70 to 94)	69 (30 to 103)
Hoggett et al. [24]	2020	PLAD (DePuy)	Charnley	3	54	55	11	43	77 (53 to 103)	86 (45 to 128)
Overall		All devices			636	644	156	480	75 (39 to 103)	49 (0.2 to 132)
		PLAD (DePuy)			402	406	90	312	75 (39 to 103)	51 (0.2 to 132)

N/A, not described in the article.
[a] Multiple types in the study by Nicholl et al.: Stanmore, n = 6; Charnley, n = 5; Howse, n = 4; Ultralock, n = 1; Sheehan, n = 1; Kent, n = 1.
[b] Multiple types in the study by Bottner et al.: Muller Roof Ring, n = 4; LOR oval oversize revision cup, 2; Burch/Schneider cage, n = 1; Allofit press fit cup, n = 1.

Table 4
The clinical outcomes of acetabular augmentation devices in included studies.

Study	Year	Augment device	Hips, n	Mean prior operations, n (range)	Mean preoperative dislocations, n (range)	Time to PLAD, mo (range)	LOO, min (range)	Blood loss, ml (range)	Transfusion, mean	LOS, d (range)	Postoperative dislocation, n (%)	Infection,[a] n (%)	Repeat PLAD, n (%)	Screw breakage, n (%)	Aseptic loosening[a], n (%)	Subsequent revision, n (%)
Olerud et al. [13]	1985	Olerud sector	6	3.7 (1 to 8)	N/A	N/A	N/A	N/A	N/A	10 (3 to 18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Güngör and Hallin [14]	1990	Olerud sector	13	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1 (7.7)	0 (0)	0 (0)	6 (46)	N/A	0 (0)
Bradbury et al. [15]	1994	Olerud sector in 3, Wroblewski in 13	16	2.7 (1 to 3)	N/A	N/A	N/A	N/A	N/A	N/A	3 (19)	0 (0)	1 (6.3)	0 (0)	0 (0)	2 (13)
Nicholl et al. [5]	1999	Olerud sector in 18 Wroblewski in 10	28	1.8 (1 to 5)	2.25 (0 to 8)	29 (0 to 240)	N/A	N/A	N/A	N/A	5 (18)	0 (0)	0 (0)	1 (3.6)	1 (3.6)	5 (18)
Charlwood et al. [11]	2002	PLAD (DePuy)	20	N/A	3 (2 to 6)	N/A	59 (45 to 80)	300 (150 to 600)	0.7	7 (5 to 8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Madan et al. [6]	2002	Wroblewski	68	N/A	4 (1 to 12)	N/A	N/A	N/A	N/A	N/A	16 (24)	3 (4.4)	7 (10)	3 (4.4)	0 (0)	1 (1.5)
Bottner et al. [17]	2005	Beck	18	2.9 (2 to 5)	4.9 (0 to 20)	8.4 (0 to 60)	N/A	N/A	N/A	N/A	6 (33)	3 (17)	0 (0)	0 (0)	4 (22)	10 (56)
Gholve et al. [18]	2006	PLAD (DePuy)	21	N/A	N/A	72 (12 to 144)	N/A	130 (80 to 280)	0	4 (3 to 8)	2 (9.5)	0 (0)	2 (9.5)	0 (0)	0 (0)	0 (0)
Enocson et al. [19]	2006	Antiluxation ring	12	N/A	2.7 (1 to 7)	24 (0 to 48)	N/A	N/A	N/A	N/A	1 (8.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
McConway et al. [20]	2007	PLAD (DePuy)	310	N/A	5 (1 to 6)	46 (0 to 270)	N/A	N/A	N/A	12 (2 to 124)	5 (1.6)	4 (1.3)	0 (0)	31 (10)	1 (0.3)	4 (1.3)
Bosker et al. [21]	2009	Antiluxation ring	50	N/A	2.5 (2 to 5)	N/A	N/A	N/A	N/A	N/A	15 (30)	5 (10)	7 (14)	15 (30)	0 (0)	9 (18)
Schmidl et al. [22]	2016	PLAD (Link)	27	N/A	2.6 (2 to 4)	10 (IQR: 13)	41 (25 to 60)	N/A	N/A	N/A	2 (7.4)	0 (0)	0 (0)	1 (3.7)	0 (0)	2 (7.4)
Hoggett et al. [24]	2020	PLAD (DePuy)	55	N/A	N/A	N/A	43 (21 to 84)	N/A	N/A	15 (3 to 99)	9 (16)	3 (5.5)	0 (0)	1 (1.8)	1 (1.8)	2 (3.6)
Overall		All devices	644	2.5 (1 to 8)	4.2 (0 to 20)	42 (0 to 270)	46 (21 to 84)	213 (80 to 600)	0.34 (0 to 0.7)	8 (2 to 124)	65 (10)	18 (2.8)	17 (2.6)	58 (9)	7 (1.1)	35 (5.4)
		PLAD (DePuy)	406	N/A	4.9 (1 to 6)	48 (12 to 270)	47 (21 to 84)	213 (80 to 600)	0.34 (0 to 0.7)	8 (2 to 124)	16 (3.9)	7 (1.7)	2 (0.49)	32 (7.9)	2 (0.49)	6 (1.5)

IQR, interquartile range; LOO, length of operation; LOS, length of stay; N/A, not available within the text of the article.
[a] Requiring reoperation.

Table 5
Postoperative dislocation rate after acetabular lip augmentation.

Augment	Hips	Dislocations (%)
Beck	18	6 (33)
Waldemar	62	16 (26)
Wroblewski	68	16 (24)
Mixed[a]	44	8 (18)
PLAD (LINK)	27	2 (7.4)
Olerud sector	19	1 (5.3)
PLAD (DePuy)	406	16 (3.9)
Total	644	65 (10)

[a] Mixed: Olerud sector in 21, Wroblewski in 23. No differentiation in dislocation rate by individual device in the original papers.

However, the PLAD demonstrated shorter operative durations (59 vs 171 min), less blood loss (300 vs 1800 ml), shorter length of stay (7 vs 11 days), and lower rates of wound complications (0 of 20 vs 2 of 20). The authors concluded the PLAD was a valid alternative for this patient cohort [11].

In the second comparative study, Hoggett et al. compared a historic cohort of 54 patients who received a PLAD (DePuy) to 28 patients who underwent acetabular revision with a dual-mobility cup for recurrent dislocation after THA [24]. Operative duration was shorter for the PLAD group (43 vs 71 min). The mean length of stay was similar for both groups (15 vs 15 days), but the PLAD had higher rates of deep wound infection (5% vs 0%).

Hoggett et al. found a higher postoperative dislocation rate (16% vs 0%) and revision rate (25% vs 0%) in the PLAD (DePuy) group (mean follow-up, 86 months) than those in revision with a dual-mobility cup with a shorter follow-up period (mean follow-up, 55 months). However, this study used asynchronous, uncontrolled groups without randomization and with high risk of confounder bias. In addition, this relatively small study accounted for 9 of 16 total PLAD (DePuy) failures reported in the literature.

Of the 406 hips augmented with the PLAD (DePuy), 16 (3.9%) sustained a postoperative dislocation. Acetabular lip augmentation may offer a less morbid undertaking in this typically-frail cohort, which yields a stable hip joint in 96%. For those who continue to dislocate after a PLAD, a more significant revision procedure still remains an option.

Lip augmentation devices may only be used where the acetabular component is stable. Their use is contraindicated if component loosening, excess polyethylene wear, or gross malpositioning are present [20].

This review is significantly limited by the quality of studies in the published literature. All but two studies were noncomparative case series. Of the two comparative cohort studies, one comparison used an unmatched historical cohort. One cohort study supported the PLAD (DePuy), [11] while the other did not [24]. All studies in this review had a high risk of bias leading to low quality of evidence. The risk of bias was predominantly driven by the lack of controls and by selection bias on using asynchronous, unmatched controls [32]. Randomized, comparative studies with long follow-up are required to determine the optimal management strategy for recurrent THA instability.

Instability after THA has several contributary factors, most of which are not addressed by a lip augmentation device. With the availability of modular revision implants and dual-mobility cups, lip augmentation devices have been superceded as the operative treatment of instability. Most THA instability cases will be treated with formal THA revision with or without a dual-mobility cup. However, some studies report positive results with lip augmentation devices, particularly with the PLAD (DePuy) implant. Thus, some patient populations, in very specific situations, may be treated with a lip augmentation device.

Conclusions

This systematic review describes outcomes of acetabular lip augmentation for recurrent instability after THA. The assessed studies were of low quality with high risk of bias. Of acetabular augmentation devices, the PLAD (DePuy) has the most evidence. Although the majority will require formal THA revision, lip augmentation devices may offer a therapeutic option in very specific circumstances.

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Conflicts of interest

The authors declare there are no conflicts of interest.

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