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

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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...
were searched on September 19, 2020, using the search strategy
ance [12]. The search strategy was designed in accordance with Cochrane guid-

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.

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 Titanimplant 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.

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   |

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.
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 sub-optimal 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.  | First article to describe the technique                | Follow-up not specified; small numbers; no control                        | Retrospective; uncontrolled                                                          | High                 | Low                      |
| Güngör and Hallin | First article with specific follow-up                 | Lacking clinical data; uncontrolled; small numbers (13)                   | Retrospective; uncontrolled                                                         | High                 | Low                      |
| Bradbury et al.| 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); heterogenous implants | High                 | Low                      |
| Nicholl et al. | Reasonable follow-up; adequate data completeness       | No control; heterogenous augments; heterogenous implants                  | Retrospective; uncontrolled; 2 different augment types used (different experimental interventions); heterogenous implants | High                 | Low                      |
| Charwood et al.| Comparative study; complete data; detailed outcome measures | Short follow-up (2 y); low numbers (n = 20)                              | Retrospective                                                                         | High                 | Low                      |
| Madan et al.   | Relatively large numbers at n = 68; homogenous group   | Uncontrolled; no specific follow-up                                         | Retrospective; uncontrolled; no specific follow-up                                   | High                 | Low                      |
| Bottner et al. | 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.  | Comprehensive data; homogenous                        | Uncontrolled; short follow-up at 2 y                                      | Low numbers; uncontrolled                                                           | High                 | Low                      |
| McConway et al.| Long follow-up (4.5 y); homogenous                    | Uncontrolled; small numbers                                               | Uncontrolled; small numbers                                                        | High                 | Low                      |
| Bottner et al. | Reasonable follow-up                                   | Uncontrolled; retrospective                                                | Uncontrolled; retrospective                                                          | High                 | Low                      |
| Gholve et al.  | Long follow-up                                         | Uncontrolled; incomplete data                                              | Uncontrolled; retrospective                                                          | High                 | Low                      |
| Encocon et al. | Long follow-up                                         | Small; incomplete data                                                     | Uncontrolled; retrospective                                                          | High                 | Low                      |
| McConway et al.| Long follow-up                                         | Retrospective; different durations of follow-up; unmatched comparisons     | 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.  | 1985 | Olerud sector  | Charnley    | 4                 | 6           | 6       | 2       | 4         | 62 (45 to 82)       | N/A (9 to 36)              |
| Güngör and Hallin | 1990 | Olerud sector  | Charnley    | 4                 | 13          | 13      | 6       | 7         | 71 (57 to 81)       | 12 (all 12)               |
| Bradbury et al. | 1994 | Olerud sector  | Charnley    | 4                 | 16          | 16      | 2       | 14        | 73 (45 to 86)       | 36 (12 to 70)             |
| Nicholl et al.  | 1999 | Olerud sector  | Wroblewski  | 13                | 20          | 20      | 4       | 16        | 75 (54 to 89)       | 24 (all 24)               |
| Charwood et al. | 2002 | PLAD (DePuy)  | Charnley    | 4                 | 20          | 20      | 4       | 16        | 75 (54 to 89)       | 24 (all 24)               |
| Madan et al.   | 2002 | Wroblewski    | Charnley    | 4                 | 68          | 68      | 14      | 54        | 79 (74 to 76)       | 35 (24 to 95)             |
| Bottner et al. | 2005 | Multiple types | Charnley    | 4                 | 18          | 18      | 7       | 11        | 65 (44 to 78)       | 35 (24 to 52)             |
| Gholve et al.  | 2006 | PLAD (DePuy)  | Charnley    | 4                 | 21          | 21      | 8       | 13        | 76 (62 to 88)       | 23 (12 to 36)             |
| Encocon et al. | 2006 | Anti-luxation ring | Lubius SPII | 4                 | 12          | 12      | 6       | 6         | 69 (58 to 83)       | 54 (12 to 108)            |
| McConway et al. | 2007 | PLAD (DePuy)  | Charnley    | 4                 | 307         | 310     | 67      | 240       | 75 (39 to 96)       | 48 (0.2 to 132)           |
| Bosker et al.  | 2009 | Antiluxation ring | N/A          | 4                 | 47          | 50      | 12      | 35        | 75 (58 to 94)       | 74 (12 to 178)            |
| Schmidt et al. | 2016 | PLAD (Link)   | EndoMark III/SP2 | 4           | 27          | 27      | 12      | 15        | 82 (70 to 94)       | 69 (30 to 103)            |
| Hoggott et al. | 2020 | PLAD (DePuy)  | Charnley    | 3                 | 54          | 55      | 11      | 43        | 77 (53 to 103)      | 86 (45 to 128)            |
| Overall        |      | All devices   | PLAD (DePuy) |                  | 636         | 644     | 156     | 480       | 75 (39 to 103)      | 49 (0.2 to 132)           |

N/A, not described in the article.

* 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) | LOQ, min (range) | Blood loss, ml (range) | Transfusion, mean | LOS, d (range) | Postoperative dislocation, n (%) | Infection, n (%) | Repeat PLAD, n (%) | Screw breakage, n (%) | Aseptic loosening*, n (%) | Subsequent revision, n (%) |
|------------------------|------|-----------------|---------|---------------------------------|------------------------------------------|--------------------------|-------------------|----------------------|--------------------|----------------|---------------------------------|----------------|----------------------|--------------------------|---------------------------|--------------------------|
| Olerud et al.          | 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      | 1990 | Olerud sector   | 13      | N/A                             | N/A                                      | N/A                      | N/A               | N/A                  | N/A                | 1 (7.7)       | 0 (0)                          | 0 (0)                     | 0 (0)                | 6 (46)                  | N/A                      | 0 (0)                     |
| Bradbury et al.        | 1994 | Olerud sector   | 16      | 2.7 (1 to 3)                    | 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.         | 1999 | Olerud sector   | 28      | 1.8 (1 to 5)                    | 2.25 (0 to 8)                            | 29 (0 to 240)            | N/A               | N/A                  | N/A                | 5 (18)        | 0 (0)                          | 1 (3.6)                   | 1 (3.6)               | 5 (18)                  |                          |                          |
| Charlwood et al.       | 2002 | PLAD (DePuy)    | 20      | 2 (2 to 6)                      | N/A                                      | N/A                      | N/A               | N/A                  | N/A                | 7 (5 to 8)     | 0 (0)                          | 0 (0)                     | 0 (0)                | 0 (0)                   | 0 (0)                     |                          |
| Madan et al.           | 2002 | Wroblewski      | 68      | 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)                   |                          |
| Botner et al.          | 2005 | Beck            | 18      | 2.9 (2 to 5)                    | 4.9 (0 to 20)                            | 8.4 (0 to 60)            | N/A               | N/A                  | N/A                | 6 (33)        | 3 (17)                         | 0 (0)                     | 0 (0)                | 4 (22)                  | 10 (56)                   |                          |
| Gholve et al.          | 2006 | PLAD (DePuy)    | 21      | N/A                             | 72 (12 to 144)                          | N/A                      | 130 (80 to 280)   | 0                   | 4 (3 to 8)          | 2 (9.5)       | 0 (0)                          | 0 (0)                     | 0 (0)                | 0 (0)                   | 0 (0)                     |                          |
| Enocson et al.         | 2006 | Antiluxation ring | 12    | 2.7 (1 to 7)                    | 24 (0 to 48)                            | N/A                      | N/A               | N/A                  | N/A                | 5 (1.6)       | 4 (1.3)                         | 31 (10)                   | 1 (0.3)               | 4 (1.3)                 |                          |                          |
| McConway et al.        | 2007 | PLAD (DePuy)    | 310     | 5 (1 to 6)                      | 46 (0 to 270)                           | N/A                      | N/A               | N/A                  | N/A                | 12 (2 to 124)| 5 (1.6)                         | 4 (1.3)                   | 0 (0)                | 0 (0)                   | 0 (0)                     |                          |
| Bosler et al.          | 2009 | Antiluxation ring | 50      | 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)                    |                          |
| Schimidt et al.        | 2016 | PLAD (Link)     | 27      | 2.6 (2 to 4)                    | 10 (IQR: 13)                           | 41 (25 to 60)            | N/A               | N/A                  | N/A                | 2 (7.4)       | 0 (0)                          | 1 (3.7)                   | 0 (0)                | 2 (7.4)                 |                          |                          |
| Hoggett et al.         | 2020 | PLAD (DePuy)    | 55      | N/A                             | 43 (21 to 84)                           | N/A                      | N/A               | 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)| 66 (10)                         | 18 (2.8)                  | 17 (2.6)             | 58 (9)                  | 7 (1.1)                   | 35 (5.4)                 |
|                        |      | PLAD (DePuy)    | 406     | 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; LOQ, length of operation; LOS, length of stay; N/A, not available within the text of the article.

* Requiring reoperation.
which yields a stable hip joint in 96%. For those who continue to may offer a less morbid undertaking in this typically-frail cohort, total PLAD (DePuy) failures reported in the literature. bias. In addition, this relatively small study accounted for 9 of 16 groups without randomization and with high risk of confounder months). However, this study used asynchronous, uncontrolled mobility cup with a shorter follow-up period (mean follow-up, 55 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 contributory 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 superseded 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.

References

[1] Masonis JL, Bourne RB. Surgical approach, abductor function, and total hip arthroplasty dislocation. Clin Orthop Relat Res 2002:46.
[2] Woo RY, Morrey BF. Dislocations after total hip arthroplasty. J Bone Joint Surg Am 1982;64:1295.
[3] Turner RS. Postoperative total hip prosthetic femoral head dislocations. Incidence, etiologic factors, and management. Clin Orthop Relat Res 1994:196.
[4] Joshi A, Lee CM, Markovic L, Vlatis G, Murphy JC. Prognosis of dislocation after total hip arthroplasty. J Arthroplasty 1998;13:17.
[5] Nickoll JE, Koka SR, Bintcliffe HV, Addison AK. Acetabular augmentation for the treatment of unstable total hip arthroplasties. Ann R Coll Surg Engl 1999;81:127.
[6] Hedlund U, Karlsson M, Ringsberg K, Besjakov J, Fredin H. Muscular and neurologic function in patients with recurrent dislocation after total hip arthroplasty: a matched controlled study of 65 patients using dual-energy X-ray absorptiometry and postural stability tests. J Arthroplasty 1999;14:319.
[7] Jolles BM, Zanger P, Leyvraz PF. Factors predisposing to dislocation after primary total hip arthroplasty: a multivariate analysis. J Arthroplasty 2002;17:282.
[8] Stewart KD. The hip cast-brace for hip prosthesis instability. Ann R Coll Surg Engl 1983;65:404.
[9] Berend KR, Sporer SM, Sierra RJ, Glassman AH, Morris MJ. Achieving stability and lower-limb length in total hip arthroplasty. J Bone Joint Surg Am 2010;92:2737.
[10] Charissoux JL, Asloum Y, Marcheix PS. Surgical management of recurrent dislocation after total hip arthroplasty. Orthop Traumatol Surg Res 2014;100:525.
[11] Charlwood AP, Thompson NW, Thompson NS, Beverland DE, Nixon JR. Recurrent hip arthroplasty dislocation: good outcome after cup augmentation in 20 patients followed for 2 years. Acta Orthop Scand 2002;73:902.
[12] Cochrane Effective Practice and Organisation of Care (EPOC). How to develop a search strategy for an intervention review. London, UK: Cochrane; 2017.
[13] Olerud S, Karlstrom G. Recurrent dislocation after total hip replacement. Treatment by fixing an additional sector to the acetabular component. J Bone Joint Surg Br 1985;67:402.
[14] Güngör T, Hallin G. Cup re-enforcement for recurrent dislocation after hip replacement. J Bone Joint Surg Br 1990;72:325.
[15] Bradbury N, Milligan GF. Acetabular augmentation for dislocation of the prosthetic hip. A 3 (1-6)-year follow-up of 16 patients. Acta Orthop Scand 1994:65:424.
[16] Madan S, Sekhar S, Fiddian NJ. Wroblewski wedge augmentation for recurrent posterior dislocation of the Charnley total hip replacement. Ann R Coll Surg Engl 2002:84:399.
[17] Bottner F, Steinbeck J, Winkelmann W, Gotze C. Acetabular augmentation ring for recurrent dislocations in revision arthroplasty. Clin Orthop Relat Res 2005:151.
[18] Gholve PA, Lovell ME, Naqui SZ. Minimal surgical approach for recurrent hip dislocation using the posterior lip augmentation device for the Charnley hip arthroplasty. J Arthroplasty 2006:21:853.
[19] Enoсон AG, Minde J, Svensson O. Socket wall addition device in the treatment of recurrent hip prosthesis dislocation: good outcome in 12 patients followed for 4.5 (1-9) years. Acta Orthop 2006;77:87.
The use of a posterior lip augmentation device for a revision of recurrent dislocation after primary cemented Charnley/Charnley Elite total hip replacement: results at a mean follow-up of six years and nine months. J Bone Joint Surg B 2007;89:1581.

Bosker BH, Ettema HB, Verheyen CC, Castelein RM. Acetabular augmentation ring for recurrent dislocation of total hip arthroplasty: 60% stability rate after an average follow-up of 74 months. Int Orthop 2009;33:49.

Schmidt S, Jakobs O, Guenther D, et al. Effective prevention of recurrent dislocation following primary cemented Endo-MarkII/SP2 total hip arthroplasty using a posterior lip augmentation device. Archives of Orthopaedic and Trauma Surgery. Arch Orthop Trauma Surg 2016;136:579.

Hoggett L, Cross C, Helm T. Experience of the posterior lip augmentation device in a regional hip arthroplasty unit as a treatment for recurrent dislocation. J Orthopaedics 2017;14:512.

Hoggett L, Cross C, Helm A. Acetabular revision using a dual mobility cup as treatment for dislocation in Charnley total hip arthroplasty. Bone Joint J Bone 2020;102 B:423.

Charnley J. Total hip replacement by low-friction arthroplasty. Clin Orthop Relat Res 1970;72:7.

Berry DJ, von Knoch M, Schleck CD, Harmsen WS. The cumulative long-term risk of dislocation after primary Charnley total hip arthroplasty. J Bone Joint Surg Am 2004;86:9.

Warth LC, Callaghan JJ, Liu SS, Klaassen AL, Goetz DD, Johnston RC. Thirty-five-year results after Charnley total hip arthroplasty in patients less than fifty years old. A concise follow-up of previous reports. J Bone Joint Surg Am 2014;96:1814.

Blakeney WG, Epinette JA, Vendittoli PA. Dual mobility total hip arthroplasty: should everyone get one. EFORT Open Rev 2019;4:541.

Noyer D, Caton JH. Once upon a time. Dual mobility: history. Int Orthop 2017;41:611.

Neri T, Philippot R, Klasan A, et al. Dual mobility acetabular cups for total hip arthroplasty: advantages and drawbacks. Expert Rev Med Dev 2018;15:835.

Reina N, Pareek A, Krych AJ, Pagnano MW, Berry DJ, Abdel MP. Dual-mobility constructs in primary and revision total hip arthroplasty: a systematic review of comparative studies. J Arthroplasty 2019;34:594.

Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016;355:i4919.