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HIP

Hip preservation surgery for borderline and frank dysplasia: an overview of systematic reviews

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- *Purpose:* To identify, synthesise, and critically appraise findings of systematic reviews and/or meta-analyses on hip preservation surgeries for borderline and/or frank dysplasia with or without concomitant femoroacetabular impingement (FAI).
- *Methods:* A search, following the PRISMA guidelines, was conducted using Medline and Embase on 19/04/2023. Findings extracted from eligible studies were tabulated and synthesised.
- *Results:* The search identified 477 references. Nineteen were eligible for data extraction: nine reported on arthroscopy, five reported on periacetabular osteotomy (PAO), one reported on shelf acetabuloplasty, and one reported on Chiari osteotomy, while two compared arthroscopy versus PAO, and one compared PAO versus rotational acetabular osteotomy (RAO) versus eccentric acetabular osteotomy (ERAO). The nomenclature and lateral centre edge angle (LCEA) thresholds to define hip dysplasia varied widely across included studies. All hip preservation surgeries provided good outcomes, with the Harris hip score (HHS) being the most commonly reported clinical score. Using the AMSTAR checklist for risk of bias, no systematic reviews were rated as high quality; ten were rated as moderate quality; six were rated as low quality; and three were rated as critically low quality.
- *Conclusions:* Most published systematic reviews on hip preservation surgery are of moderate or low quality, and there is high heterogeneity among them regarding outcomes reported, follow-up periods, and definitions of dysplasia. The authors recommend the following thresholds and nomenclature for dysplasia: LCEA < 20° for frank dysplasia, 20°–25° for borderline dysplasia, and >25° for no dysplasia. Although all hip preservation surgeries can provide good outcomes, it is challenging to conclude which surgery provides the best outcomes and to determine if treatment options are dependent on LCEA.

Keywords: hip dysplasia; borderline dysplasia; lateral centre edge angle; periacetabular osteotomy; hip arthroscopy

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Introduction

Hip dysplasia is a morphological abnormality of the acetabulum that results in insufficient coverage of the femoral head (1, 2). Patients with hip dysplasia may experience pain, functional limitations, and instability (3, 4) and can develop secondary hip osteoarthritis (5, 6). The severity of dysplasia is determined by the lateral centre edge angle (LCEA), with varying thresholds defining borderline versus frank dysplasia across the literature (7, 8).

Hip preservation procedures for symptomatic hip dysplasia have become increasingly popular as they provide a less invasive alternative to total hip arthroplasty (THA) (9, 10, 11). Periacetabular osteotomy (PAO) consists of reorienting the acetabulum to optimise femoral head coverage and normalise LCEA. It is considered by some surgeons as the gold standard hip preservation surgery (1, 12), and it provides good clinical outcomes, reducing the likelihood of developing osteoarthritis (12, 13). However, it is a technically challenging procedure (14, 15, 16, 17), with complication rates of 5.9–37% (14, 16, 17, 18, 19, 20) and may be limited to a specific patient population (14, 15). Variations of osteotomies such as rotational acetabular osteotomy (RAO) (21) and eccentric acetabular osteotomy (ERAO) (22) have also been introduced in Asia, particularly in Japan (21, 23, 24). They have the same indications as PAO (25) and can also be technically demanding for the surgeon (25, 26). Additionally, the use of arthroscopic surgery is becoming more common for borderline dysplasia; however, its effectiveness remains a subject of controversy (27) because only soft tissue or bone resection can be performed, which does not treat insufficient coverage (28, 29, 30). Furthermore, while it is a minimally invasive surgery (31, 32), it is not suitable for patients with severe dysplasia (33). Other hip preservation surgeries, such as shelf acetabuloplasty and Chiari osteotomy, can also be used (34, 35). Although shelf acetabuloplasty was introduced in France for all types of dysplasia, it is now more common in patients with borderline dysplasia (34); however, it does not create true cartilaginous coverage. Chiari osteotomies are commonly used in young patients with femoral head deformities and/or negative LCEA, although this non-anatomic procedure can result in reduced functional outcomes and a high proportion of limping (39%–52%) (35, 36, 37). Several systematic reviews have summarised outcomes of hip preservation surgeries for borderline and/or frank dysplasia; however, they are mostly non-comparative (9, 11, 35, 38, 39).

It is therefore important to summarise the available literature in a single article to establish (i) a definition of borderline dysplasia, (ii) outcomes of all types of hip preservation surgeries for borderline and/or frank dysplasia, and (iii) whether there is an optimal treatment strategy depending on severity. The purpose of this systematic overview was to identify, synthesise, and critically appraise findings of systematic reviews and/or meta-analyses on hip preservation surgeries for borderline and/or frank dysplasia with or without concomitant femoroacetabular impingement (FAI).

Methods

The search strategy and methodological protocol for this overview of systematic reviews and meta-analyses were registered with PROSPERO (CRD42023411805).

Search strategy

The authors conducted a structured electronic literature search, following the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines, on 19 April 2023 using the Medline and Embase databases, applying the keywords presented in Supplementary Appendix I (see the section on supplementary materials given at the end of this article). After the removal of duplicate records, three reviewers (AK, NV, PM) independently screened the titles and abstracts to determine suitability using the following inclusion and exclusion criteria.

Inclusion criteria

- Systematic reviews and meta-analyses reporting outcomes of hip preservation surgeries for borderline and/or frank hip dysplasia, with or without concomitant FAI.

Exclusion criteria

- Narrative reviews, clinical studies, cadaveric studies, computational studies, conference proceedings, letters to the editor, etc.
- Systematic reviews and meta-analyses reporting only on non-surgical treatments, THA, or resurfacing.
- Systematic reviews and meta-analyses written in languages other than English or French.
- Systematic reviews and meta-analyses that report on paediatric populations.

Full texts were retrieved if the article was deemed relevant or if the title and abstract provided insufficient information to establish eligibility. Screening decisions were compared between the three reviewers (AK, NV, PM) and disagreements were resolved through review and consensus.

Data extraction and quality assessment

Two reviewers (AK, BG) independently extracted the following characteristics from each eligible systematic review and meta-analysis: lead author, year of publication, journal, level of evidence, number of studies included,

EFORT Open Reviews (2024) **9** 1144–1155
https://doi.org/10.1530/EOR-20-23015-2

intervention, number of patients and/or hips, gender, age, follow-up period, type of dysplasia, definition of dysplasia, concomitant indications and/or procedures, preoperative and postoperative LCEA, as well as rates of complications, reoperations, and conversions to THA. Pooled means of preoperative and postoperative clinical outcomes were extracted; if these were not available, ranges of means were recorded instead. The data extracted were compared and disagreements were resolved through review and consensus.

The same two reviewers (AK, BG) assessed the methodological quality of eligible studies according to the 16 domains specified by A MeaSurement Tool to Assess Systematic Reviews (AMSTAR-2) (40). The quality assessment was compared, and any disagreements in the appraisal were resolved through review and consensus.

Interpretation of results

Differences in methodology and reported outcomes across the systematic reviews and meta-analyses made pooling or direct statistical comparison impossible. Therefore, findings extracted from eligible studies were tabulated and synthesised narratively. The quality of results from AMSTAR-2 was interpreted using the following guidelines (40): high, no or one non-critical weakness; moderate, more than one non-critical weakness; low, one critical flaw, irrespective of the presence of non-critical weaknesses; critically low, more than one critical flaw, irrespective of the presence of non-critical weaknesses.

Results

Literature search

The electronic literature search identified 477 references, of which 151 were duplicates, and 286 were excluded based on title and abstract screening, as they did not meet the inclusion criteria (Fig. 1). The remaining 40 articles underwent full-text screening, and a further 21 were excluded because: nine did not specifically focus on patients with dysplasia (10, 24, 41, 42, 43, 44, 45, 46, 47), seven included paediatric patients (18, 48, 49, 50, 51, 52, 53), four were editorials or narrative reviews (54, 55, 56, 57), and one did not report on outcomes (58). This left a total of 19 systematic reviews or meta-analyses (1, 2, 7, 8, 9, 11, 34, 35, 38, 39, 59, 60, 61, 62, 63, 64, 65, 66, 67), published between 2016 and 2023, eligible for data extraction.

Characteristics of the included systematic reviews

Of the 19 systematic reviews included, 16 were non-comparative, of which: nine reported on arthroscopy (7, 8, 9, 11, 61, 62, 63, 65, 67), five reported on PAO (1, 38, 39, 51, 64), one reported on acetabuloplasty (34), and one reported on Chiari osteotomy (35) (Table 1). Furthermore, three were comparative, of which two compared arthroscopy versus PAO (60, 66) and one compared PAO versus RAO versus ERAO (2). Additionally, the systematic review by Lodhia *et al.* (66) also included a clinical study that compared PAO versus combined arthroscopy and PAO. All systematic reviews reported on patients with dysplasia, of which seven did not exclude patients with concomitant FAI (8, 9, 11, 61, 62, 63, 65). Patient characteristics of the systematic reviews are reported in Table 2.

The overlap in clinical studies across the 19 systematic reviews was as follows: 1 clinical study (31) was included in 6 systematic reviews, 3 clinical studies (68, 69, 70) were each included in 5 systematic reviews, 7 clinical studies (32, 71, 72, 73, 74, 75, 76) were each included in 4 systematic reviews, 7 clinical studies (77, 78, 79, 80, 81, 82, 83) were each included in 3 systematic reviews, and 24 clinical studies (14, 16, 76, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104) were each included in 2 systematic reviews.

Definition of dysplasia

The definition of dysplasia varied across the clinical studies included in the systematic reviews, with different LCEA ranges used to classify the severity of dysplasia (Table 1). Of the nine systematic reviews (7, 8, 9, 11, 39, 60, 61, 63, 65) that reported on borderline dysplasia, the included clinical studies provided the following definitions based on LCEA: 18°–25° ($n = 27$), 20°–25° ($n = 36$), and ≤ 25° ($n = 7$). Of the two systematic reviews (7, 8) that reported on moderate dysplasia, the included clinical studies provided the following definitions based on LCEA: < 20° ($n = 5$), 16°–22° ($n = 3$), 15°–22° ($n = 4$), 16°–24° ($n = 1$), 19°–27° ($n = 1$), and <25° ($n = 1$). Additionally, one systematic review reported on mild dysplasia (62), with the included clinical studies providing the following definitions based on LCEA: 18°–25° ($n = 2$), 15°–24° ($n = 1$), and 15°–19° ($n = 1$). It is worth noting that certain clinical studies may have been included in more than one systematic review.

Complications, reoperations, and conversions to THA

Complication rates were reported in six systematic reviews on arthroscopy (0–7.2%), three on PAO (9.8–23.5%), one on RAO (3.1%), one on ERAO (12.6%), one on shelf acetabuloplasty (22.3%), and one on Chiari osteotomy (9.3%) (Table 2). Reoperation rates were reported in eight systematic reviews on arthroscopy (4–18.3%), three on PAO (4.0–22.2%), and one on Chiari osteotomy (2.3%). Conversions to THA were reported in nine systematic reviews on arthroscopy (0.4–9.7%), four on PAO (1.0–12.0%), one on combined arthroscopy and PAO (17.7%), one on shelf acetabuloplasty (17.6%), and

EFORT Open Reviews (2024) **9** 1144–1155
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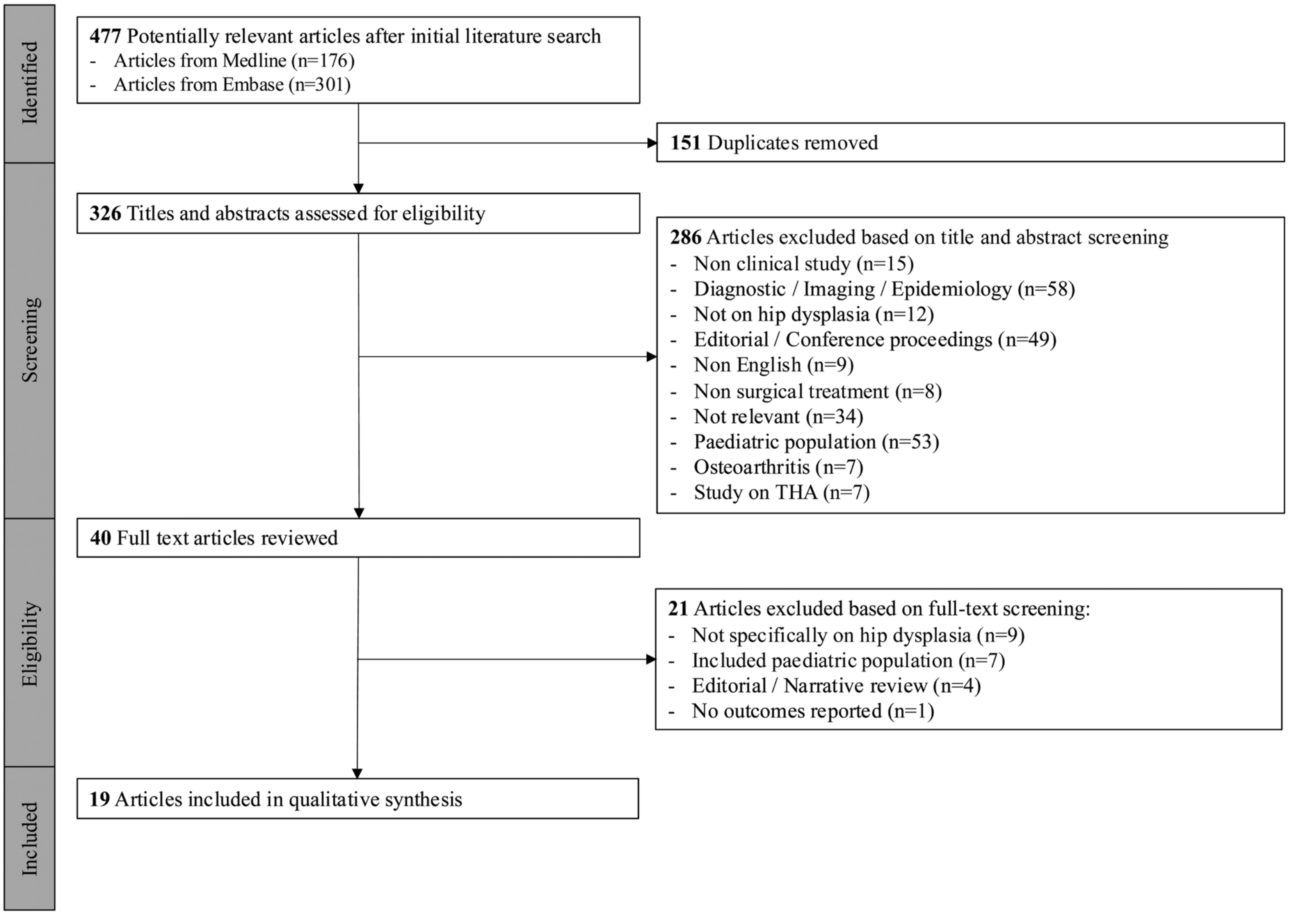

Figure 1

Flowchart of included studies.

one on Chiari osteotomy (18.4%). When considering systematic reviews with mid- to long-term follow-up (pooled mean > 5 years or a minimum mean follow-up of > 5 years), conversion to THA was reported in one systematic review on arthroscopy (4.0%), one on PAO (12.0%), one on shelf acetabuloplasty (17.6%), and one on Chiari osteotomy (18.4%). Furthermore, five systematic reviews reported a combined value for reoperation rates and conversions to THA: two on arthroscopy (5.7% and 29%), one on PAO (1.1%), one on RAO (5.1%), and one on ERAO (4.1%). It is important to note that follow-up greatly varied across systematic reviews.

Postoperative clinical outcomes

The most commonly reported clinical score across all surgeries was the Harris hip score (HHS), followed by pain on the visual analogue scale (VAS) (Supplementary Table 1). Furthermore, the majority of systematic reviews on arthroscopy also reported on hip outcome score (HOS) and non-arthritic hip score (NAHS), while no other clinical scores were consistently reported for the other surgical treatments.

Quality of systematic reviews

Of the 19 systematic reviews, 16 had a level of evidence of IV and three had a level of evidence of III (Table 1). According to the AMSTAR checklist for risk of bias, no systematic reviews were rated as high quality; ten were rated as moderate quality, six were rated as low quality, and three were rated as critically low quality (Supplementary Table 2).

Discussion

The most important findings of this overview of systematic reviews on hip preservation surgeries for borderline and/or frank dysplasia are that most published systematic reviews are of moderate or low quality and that there is high heterogeneity among the literature with regards to definitions of dysplasia and

EFORT Open Reviews (2024) **9** 1144–1155
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Table 1 Study characteristics of the included systematic reviews and definitions of dysplasia in the included clinical studies.

	Overall Characteristics			Systematic Reviews			Dysplasia	
Study	**COI**	**Funding**	**LOE**	**SCR**	**INC**	**Years included**	**Type and definition**	**Surgery performed**
Krivicich *et al.* (11)	Y		III	1434	13	2016–2021	Borderline: ≤ 25°	Arthroscopy
Lee *et al.* (9)	N		IV	175	6	2018–2022	Borderline: 18°–25° (*n* = 1), 20°–25° (*n* = 5)	Arthroscopy
Curley *et al.* (38)	N		IV	141	6	2016–2022		PAO
O'Brien *et al.* (39)	N		IV*	5017	24	2004–2020	Borderline and frank	PAO
Tan *et al.* (51)	N	N	IV	861	24	2003–2020		PAO
Willemsen *et al.* (35)	Y	Y	IV	214	8	1987–2009		Chiari osteotomy alone or with either varus/ valgus osteotomy or trochanter osteotomy
Murata *et al.* (60)	Y	Y	IV	119	10	2016–2019	Borderline: 18°–25° (*n* = 5), 20°–25° (*n* = 5)	Arthroscopy or PAO
Murata *et al.* (61)	Y	Y	III	124	4	2016–2019	Borderline: 18°–25° (*n* = 2), 20°–25° (*n* = 2)	Arthrsocopy
Alrashdi *et al.* (1)	N	Y	IV	631	23	2010–2021		PAO
Beck *et al.* (2)	N	Y	IV	346	47	2002–2017		PAO or RAO or ERAO
Kim & Kim (64)	N	Y	III	222	5	2008–2017		PAO
Willemsen (34)	Y	Y	IV	111	9	1986–2018		Shelf acetabuloplasty with or without varus/ valgus osteotomy
Kuroda *et al.* (63)	Y	Y	IV	124	28	2003–2019	Borderline: 20°–25° (*n* = 13), 18°–25° (*n* = 10), ≤ 25° (*n* = 5)	Arthroscopy
Tang & Dienst (62)	N		IV	620	5	2015–2017	Mild: 18°–25° (*n* = 2), 15°–24° (*n* = 1), 15°–19° (*n* = 1)	Arthroscopy
Shah *et al.* (7)	Y	N	IV	746	13	2003–2018	Borderline: 20°–25° (*n* = 4), 18°–25° (*n* = 2), 22°–28° (*n* = 1); Moderate: < 20° (*n* = 2), 15°–19° (*n* = 1), 16°–22° (*n* = 1)]	Arthroscopy
Ding *et al.* (65)	N		IV	446	9	2012–2018	Borderline: 18°–25° (*n* = 5), 20°–25° (*n* = 3), < 25° (*n* = 1)	Arthroscopy
Jo *et al.* (67)	N	N	IV	5371	6	1998–2013	Borderline and frank	Arthroscopy
Lodhia *et al.* (66)	Y	Y	IV	759	4	2003–2013	Borderline and frank	Arthroscopy and/or PAO
Yeung *et al.* (8)	Y	N	IV	839	18	1998–2015	Borderline: 20°–25° (*n* = 4), 18°–25° (*n* = 2), 22°–28° (*n* = 2), < 25° (*n* = 1); Moderate: < 20° (*n* = 3), 16°–22° (*n* = 2), < 25° (*n* = 1), 16°–24° (*n* = 1), 19°–27° (*n* = 1)]	Arthroscopy

COI, conflict of interest; INC, included; LOE, level of evidence; SCR, screened.
*O'Brien *et al*. classified their systematic review as LOE of I; however, they included case series and therefore their level of evidence is IV.

reported clinical outcomes. Thus, it is challenging to conclude which hip preservation surgery provides the best results to treat borderline or frank hip dysplasia.

The nomenclature surrounding hip dysplasia is confusing, as different studies use the terms 'mild', 'moderate', and 'borderline' to describe the grey zone between non-pathologic hips and frank dysplastic hips (7, 8, 9, 11, 39, 60, 61, 63, 65, 66, 67). Furthermore, there is no consensus regarding LCEA thresholds to characterise the severity of dysplasia (7, 8, 9, 11, 39, 60, 61, 62, 63, 65), with some clinical studies considering the grey zone as an LCEA between 18°–25°, while others consider it as 20°–25° or ≤25°. The historical definition of frank dysplasia was an LCEA <20°, with LCEA >25° considered as normal (non-pathological), and an LCEA between 20°–25° considered uncertain (105, 106). However, several American studies (31, 81, 107) have performed arthroscopic procedures in patients within an LCEA range of 18°–25°, which they considered uncertain dysplasia, and have reported good outcomes. This suggests that using a more inclusive LCEA range to describe non-frank dysplasia may be appropriate. Finally, dysplasia is a continuous spectrum with 3D implications that may explain why some patients develop dysplastic symptoms with an LCEA between 20° and 25° (or 18° and 25°) and others do not. It is important to note that LCEA is a 2D assessment of hip morphology and does not consider 3D anatomy, which is of paramount importance to understanding the morphology and

EFORT Open Reviews (2024) **9** 1144–1155
https://doi.org/10.1530/EOR-20-23015-2

Table 2 Patient characteristics as well as complications, reoperations, and conversions to THA of the included systematic reviews.

Study	Patients, n (range)	Hips, n (range)	Age (years), mean (range)	Females, % (range)	LCEA, mean (range) Pre	LCEA, mean (range) Post	Follow-up (m), mean (range)	CR, %	RR, %	THA-CR, %
Arthroscopy										
Krivicich *et al.* (11)		315 (21–112)	27.5 (16–34)	62.2 (48–81)	22–23		37 (22–68)	7.2	5.7†	
Lee *et al.* (9)		413 (36–162)	31–41	58.8 (45–79)	22–24		60–144		4.1	4.0
Murata *et al.* (60)	581 (21–115)	601	16–39				24–69		6.1	2.2
Murata *et al.* (61)	224 (21–112)		16–34				24–31		1.8	0.4
Kuroda *et al.* (63)		1502 (9–305)	16–49	48–100				1.7	11.1	2.1
Tang & Dienst (62)	218 (8–100)	233 (8–102)	30–50	53.3	18–23		24–42	0.0	5.2**	5.2
Shah *et al.* (7)	712 (19–166)	773 (20–201)	34.2 (11–65)	74.1 (43–90)	20.6 (1–37)		45.6 (5–100)		29†	
Ding *et al.* (65)	425 (21–102)		28.2* (16–38)				36.5* (25–69)		8.9**	9.7
Jo *et al.* (67)	183 (10–50)	186 (10–50)		58–93			24–96		18.3	2.7
Lodhia *et al.* (66)		114 (10–48)	31.3 (20–34)	58–100	0–25*		38.4 (28–98)			4.8
Yeung *et al.* (8)	889 (7–166)	949 (7–201)	35.4 (20–48)	50–100			32.2 (6–168)		14.1	9.5
PAO										
Curley *et al.* (38)	341 (29–161)	420 (29–183)	20–42	88–100	8–18	23–41	29–100		4.0	2.4
O'Brien *et al.* (39)	2190 (9–1051)		16–39				2–102			
Tan *et al.* (51)	3471	3655	32.6 (12–63)	84.9			54.2 (1–336)	23.5		6.0
Alrashdi *et al.* (1)	2355 (21–359)		16–34	75.5 (58–100)						
Beck *et al.* (2)	3649 (17–643)	3838 (29–391)	27.1 ± 5.9 (16–39)	83.9	10.4	29	12–204	14.1	1.1†	
Murata *et al.* (60)	93 (44–49)		27–34				24–26		22.2	1.0
Kim & Kim (64)		235 (14–100)	29–51				48–94	9.8	4.0	
Lodhia *et al.* (66)		703 (12–228)	31.1 (24–35)	69–100	10.5 (−1.5 to 17)*	27–32*	78 (29–114)			12.0
Arthroscopy + PAO										
Lodhia *et al.* (66)		17	31	100	10	28				17.7
RAO										
Beck *et al.* (2)	1489 (17–351)	1681 (19–420)	35.9 ± 7.1 (17–45)	81.5	3.7	36.9	60–270	3.1	5.1†	
ERAO										
Beck *et al.* (2)	1383 (15–530)	1426 (16–530)	36.1 ± 4.1 (30–42)	91.2	4.8	32.6	192–240	12.6	4.1†	
Shelf acetabuloplasty										
Willemsen *et al.* (34)	453 (17–113)	507 (17–124)	25–34	91.0 (79–100)	−12 to 16	30–50	120–312	22.3		17.6
Chiari osteotomy										
Willemsen *et al.* (35)	603 (11–130)	652 (11–130)	18–37	89.6 (81–96)	−10 to 10	26–50	156–384	9.3	2.3	18.4

*Reported as median instead of mean; **Includes conversions to PAO; †Value across RR and THA-CR.
BMI, body mass index; CR, complication rate; ERAO, eccentric acetabular osteotomy; PAO, periacetabular osteotomy; RAO, rotational acetabular osteotomy; RR, reoperation rate; THA, total hip arthroplasty; THA-CR, THA conversion rate.

EFORT Open Reviews (2024) **9** 1144–1155
https://doi.org/10.1530/EOR-20-23015-2

orientation of the acetabulum and femur, which may lead to instability or extra-articular impingement (77, 107). Therefore, the authors of the present overview recommend the use of the following thresholds and nomenclature: an LCEA <20° to describe frank dysplasia, 20°–25° to describe borderline dysplasia, and >25° to describe no dysplasia, in addition to a 3D analysis of hip morphology.

The present overview revealed that the most common hip preservation surgeries for dysplasia are arthroscopy and PAO, while few studies report on RAO, ERAO, shelf acetabuloplasty, and Chiari osteotomy. All hip preservation surgeries provided satisfactory outcomes, although these outcomes were reported inconsistently across the literature, except for HHS which was reported across most systematic reviews. Furthermore, mean follow-up periods greatly varied across surgeries, ranging from 5 to 168 months for arthroscopy, 1 to 336 months for PAO, 60 to 270 months for RAO, 192 to 240 months for ERAO, 120 to 312 months for shelf acetabuloplasty, and 156 to 384 months for Chiari osteotomy. Older studies showed good outcomes for both shelf acetabuloplasty and Chiari osteotomy, including at long-term follow-up (37); however, there is a recent trend for surgeons to prefer PAO when treating adults with frank dysplasia. Currently, shelf acetabuloplasty and Chiari osteotomy are considered good salvage procedures (35), which can also be used successfully for very specific indications, although these are predominantly performed in younger patients during growth and/or very young adolescents, which was an exclusion criterion in the present overview. Arthroscopy has recently become popular for the treatment of borderline dysplastic hips and therefore its long-term outcomes are not yet well investigated. Additionally, arthroscopic procedures such as labral treatments (repair or debridement), capsular treatments (repair or capsulotomy), or femoroplasty cannot change the orientation of bony anatomy, but can only treat soft tissues or resect bone (9). Furthermore, of the 19 systematic reviews included, preoperative LCEA was only reported in 10 and the clinical studies within these reviews reported varying ranges of LCEA to define borderline dysplasia. Hence, due to differences in outcomes reported, follow-up periods, and definitions of dysplasia, it was not possible to make direct comparisons to conclude which hip preservation surgeries provided the best outcomes and to determine if treatment options were dependent on LCEA. Moreover, the lack of details on the radiological and clinical characteristics of patients for each type of treatment, combined with the absence of comparisons between these treatments, makes it difficult to define potential indications for one treatment compared with another in a patient with severe or borderline dysplasia.

Compared to patients who underwent arthroscopy, patients who underwent PAO had higher complication rates (0–7.2% vs. 9.8–23.5%), higher reoperation rates (1.8–18.3% vs. 4.0–22.2%), but similar rates of conversions to THA (0.4–9.7% vs. 1.0–12.0%). It is important to note, however, that the follow-up times varied across studies and interventions, and there may have been differences in patient characteristics with more severe dysplasia in the osteotomy series. The types of minor and major complications also vary between surgeries. Arthroscopy is often associated with the following minor complications: mild heterotopic ossification (Brooker grades I–II), and labral and chondral injuries; and the following major complications: deep vein thrombosis, extra-articular fluid extravasation, and severe heterotopic ossification (Brooker grades III–IV) (108). PAO is often associated with the following minor complications: mild heterotopic ossification (Brooker grades I–II), snapping psoas, and wound infection; and the following major complications: acetabular migration, and posterior column non-union. It is in some rare cases associated with necrosis of the acetabular fragment (20, 108). Additionally, over-correction during PAO can induce secondary FAI, which can lead to iatrogenic acetabular retroversion or pincer-type impingement (108, 109).

A recent systematic review (43) reported on three studies that evaluated the outcomes of PAO after a failed hip arthroscopy in patients with dysplasia and found that clinical and functional scores improved following PAO. Since arthroscopy does not address the underlying pathology (insufficient coverage) in dysplastic hips, withholding or delaying a more efficient treatment, such as PAO, could lead to the development of osteoarthritis and compromise the goal of preserving the native hip. A matched cohort study (ANCHOR) on dysplastic patients found that, compared to patients with no previous arthroscopy, patients who had a failed arthroscopy had lower mHHS (62 vs 57, $P = 0.04$), WOMAC pain (60.5 vs 53.5, $P = 0.04$), SF-12 physical component (40 vs 34, $P = 0.001$), and UCLA activity scores (7 vs 5, $P = 0.001$). Furthermore, at the latest follow-up, compared to patients who underwent only PAO, patients with a previously failed arthroscopy followed by PAO had lower mHHS (87 vs 78, $P = 0.003$) including a lower proportion of patients with an excellent mHHS (>90) outcome (54% vs. 31%, $P = 0.01$).

Clinical studies have shown that the survivorship of arthroscopy in patients with borderline dysplasia, considering THA as the endpoint, is 87% at 5 years and 79% at 10 years (110). The survivorship of combined arthroscopy and PAO in patients with dysplasia, considering reoperation as the endpoint, is 90% at 2 years and 86% at 3 years (111). The survivorship of PAO in patients with frank dysplasia, considering THA as the endpoint, is 96% at 5 years, 91% at 10 years, 85% at 15 years, and 68% at 20 years (58). The findings of these clinical studies suggest that PAO has a longer survivorship compared to arthroscopy; however, the present overview of systematic reviews was not able to compare the survivorship of these two techniques, as

EFORT Open Reviews (2024) **9** 1144–1155
https://doi.org/10.1530/EOR-20-23015-2

this outcome was not widely reported in the included articles. Nonetheless, the present overview found no differences in THA conversion rates between PAO and arthroscopy. Furthermore, a failed PAO may increase the prevalence of complications after conversion to THA. Parvizi *et al.* (112) evaluated 41 patients who underwent THA after PAO with an average follow-up of 6.9 years and found that four patients had heterotopic ossification (Brooker grades I–III), one had a dislocation, three had reoperations, and two had revisions after THA. However, more recent studies with greater cohort sizes have shown no differences in outcomes between primary THA and THA following PAO (113, 114).

The present study has several limitations. First, there is a bias in the over-representation of certain clinical studies that have been included in multiple systematic reviews. Additionally, it was not possible to overcome inter-study pooling and variability. Second, it is not possible to compare outcomes of hip preservation surgeries across systematic reviews due to differences in follow-up and inconsistency in reported outcomes, making it difficult to determine the efficacy of various treatment approaches. Furthermore, the diversity in concomitant indications and surgical procedures used adds to this heterogeneity. Third, the results of the overview did not allow for sub-group analysis of borderline dysplastic patients with and without FAI, to determine the effect of concomitant FAI on clinical outcomes. Fourth, although some systematic reviews reported complication rates, they did not include their treatments or resolutions. Fifth, nine of the 19 eligible systematic reviews were rated low or even critically low quality, which may have an impact on the presented data.

Conclusions

This overview of systematic reviews on hip preservation surgeries for borderline and/or frank dysplasia found that most published systematic reviews are of moderate or low quality and that there is high heterogeneity among the literature with regard to outcomes reported, follow-up periods, and definitions of dysplasia. The authors of the present overview recommend the use of the following thresholds and nomenclature for dysplasia: an LCEA < 20° to describe frank dysplasia, 20°–25° to describe borderline dysplasia, and >25° to describe no dysplasia, in addition to a 3D analysis of hip morphology, without forgetting that dysplasia remains a continuous spectrum. Although all hip preservation surgeries can provide good outcomes, it is challenging to conclude which surgery provides the best outcomes and to determine if treatment options are dependent on LCEA.

Supplementary materials

This is linked to the online version of the paper at https://doi.org/10.1530/EOR-23-0152.

ICMJE Conflict of Interest Statement

PM receives consulting fees from Newclip Technics and SERF, royalties from XNov, and is an advisory board member of DePuy Synthes. NV receives consulting fees from B. Braun. JM, AK, SRP, and BB report no conflicts of interest.

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