Primary Hip Arthroscopy in Patients With Acetabular Dysplasia

CME

A Systematic Review of Published Clinical Outcomes at Minimum 5-Year Follow-up

Alexander M. Boos,* BA, Christopher V. Nagelli,* PhD, Kelechi R. Okoroha,* MD, Rafael J. Sierra,* MD, Aaron J. Krych,* MD, and Mario Hevesi,*† MD, PhD
Investigation performed at Mayo Clinic, Rochester, Minnesota, USA

Background: Hip arthroscopy in patients with borderline hip dysplasia has satisfactory outcomes at short-term follow-up; however, the data on midterm outcomes are inconsistent, and failure rates are high in some studies, limiting understanding of the role and utility of hip arthroscopy in this patient cohort.

Purpose: To provide an up-to-date, evidence-based review of the clinical outcomes of primary hip arthroscopy in patients with frank or borderline hip dysplasia at ≥5-year follow-up and report the failure rate and progression to total hip arthroplasty in this cohort.

Study Design: Systematic review; Level of evidence, 4.

Methods: A comprehensive literature search was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Studies were included if they evaluated outcomes of primary hip arthroscopy in patients with lateral center-edge angle (LCEA) <25° at ≥5-year follow-up. Risk of bias assessment was performed using the methodological index for non-randomized studies scoring system. Level of evidence was determined using criteria from the Oxford Centre for Evidence-Based Medicine.

Results: Nine studies were included in this review. Patients with LCEA <25° demonstrated satisfactory clinical outcomes, high patient satisfaction, and significant postoperative improvements in patient-reported outcomes (PROs) at follow-up ranging from a ≥5 to 10 years. Studies comparing patients with dysplasia to those without did not demonstrate significant differences in preoperative, postoperative, or delta PROs or in failure, reoperation, or revision rates. There was no overall significant correlation between outcomes and LCEA stratification.

Conclusion: Hip arthroscopy in carefully selected patients with LCEA <25° can be successful at mid- to long-term follow-up and may provide clinical outcomes and failure rates comparable with patients with normal LCEA, understanding that this is a singular, 2-dimensional radiographic measure that does not differentiate instability from impingement or combinations thereof, warranting future studies delineating these differences. These findings suggest that hip dysplasia may not be an absolute contraindication for isolated hip arthroscopy and may serve as a viable intervention with consideration of staged future periacetabular osteotomy (PAO). Importantly, this review does not suggest that hip arthroscopy alters the natural history of dysplasia; therefore, patients with dysplasia should be counseled on the potential utility of PAO by appropriate hip preservation specialists.

Keywords: arthroscopy; acetabular dysplasia; borderline hip dysplasia; lateral center-edge angle

Significant advancements in arthroscopic technologies and techniques over the past decade have increased the indications for and prevalence of hip arthroscopy, allowing it to become a viable intervention for a range of hip pathologies.[5,16,31,43] Commonly, modern hip arthroscopy is used to address labral tears and atypical bony morphology associated with femoroacetabular impingement. Namely, an abnormally shaped femoral head-neck junction may demonstrate a region of increased radius, forming a bump or a ridge denoted as cam morphology.[11] This, in turn, impinges on the acetabulum and chondrolabral junction in deep hip flexion and internal rotation, resulting in a classically anterosuperior labral tear. Such labral tears and osseous abnormalities are managed with cam resection (Figure 1) and anchor-based labral repair (Figure 2) at the time of hip arthroscopy.

Hip arthroscopy, in general, has demonstrated significant, durable improvements in patient-reported outcomes (PROs), including pain and function scores, high patient

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satisfaction, and low complication rates at short-, mid-, and long-term follow-up.[6,15,23-25,30,33] However, rates of secondary hip preservation surgery or conversion to total hip arthroplasty (THA) after primary hip arthroscopy vary across studies at mid- and long-term follow-up, with multiple studies identifying older age and greater preoperative degenerative changes as risk factors for failure.[23-25] Previous evaluation of hip arthroscopy surgeries reported that unaddressed acetabular dysplasia—a significant contributor to hip osteoarthritis (OA) and labral degeneration—was the second most common cause of failure after untreated femoroacetabular impingement.[4,32,38,40]

Acetabular dysplasia is characterized by insufficient acetabular coverage of the femoral head and is typically defined as patients with a lateral center-edge angle (LCEA) <25°, whereas a "normal" LCEA is 25° to 40° (Figure 3).[37] Other radiographic measures such as Tönnis angle, Femoro-Epiphyseal Acetabular Roof index, and femoral head extrusion index have also been used. Periacetabular osteotomy (PAO) is well-established as the standard treatment for dysplasia in skeletally mature individuals and has shown improvements in long-term outcomes, with low conversion to THA at 30-year follow-up and beyond.[19,26,27] However, PAO is a substantial open procedure associated with significant potential morbidity, leading to ongoing debate regarding the additive benefit of PAO for patients with borderline hip dysplasia.[20,42] A recent systematic review reported that between 12% and 16% of patients with hip pain have hip dysplasia, demonstrating a substantial number of patients for whom a clear plan of treatment has not been defined.[10] Although early research showed that patients with hip dysplasia have worse outcomes, higher rates of iatrogenic instability, and greater risk of THA after arthroscopy than patients without dysplasia, several recent studies have shown significant improvements and satisfactory outcomes in patients with dysplasia at short- and midterm follow-up.[3,7-9,22,27,35,36,41] This improvement appears to be most prominent when labral and capsular repairs are performed at the time of arthroscopy.[9,18] However, failure rates remain high in some studies, highlighting the importance of patient selection and the need for additional investigation given the effect concomitant pathologies and patient characteristics may have on outcomes.[7,9,18,21,22,36]

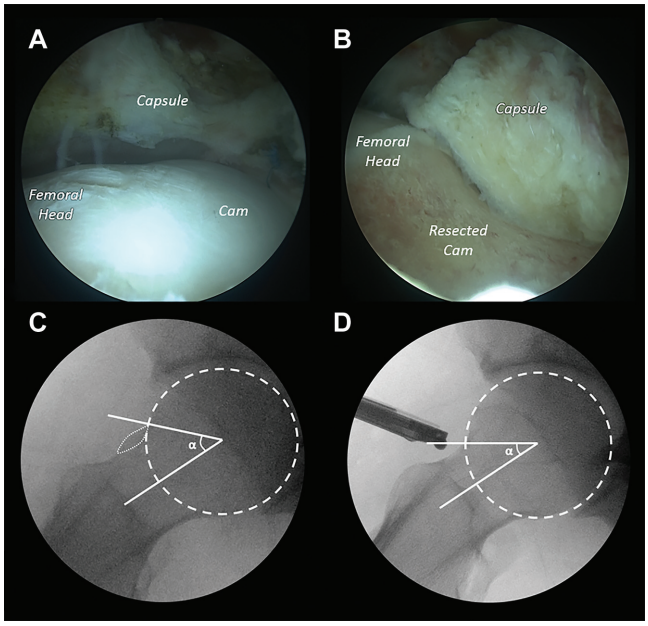

Figure 1. Intraoperative views of (A) cam morphology and (B) after cam resection. Fluoroscopic Dunn views demonstrating (C) preresection cam (fine dotted line) and associated increased α angle (>50°) and (D) subsequent postresection radiographic absence of cam and normalization of α angle. Femoral head marked as coarse dotted line.

To date, there has been no comprehensive evaluation and systematic review of the outcomes and failure rates after primary hip arthroscopy in patients with hip dysplasia at midterm follow-up. Therefore, the purpose of this review is to provide an up-to-date, evidence-based review of the clinical outcomes of primary hip arthroscopy in patients with hip dysplasia at ≥5-year follow-up, as well as report the failure rate and progression to THA in this cohort. Summarizing the outcomes for dysplastic patients after hip arthroscopy in a comprehensive fashion is essential for evidence-based counseling, expectation management, and shared decision-making between providers and patients.

†Address correspondence to Mario Hevesi, MD, PhD, Mayo Clinic, 200 First St SW, Rochester, MN 55905, USA (email: hevesi.mario@mayo.edu).
*Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota, USA.
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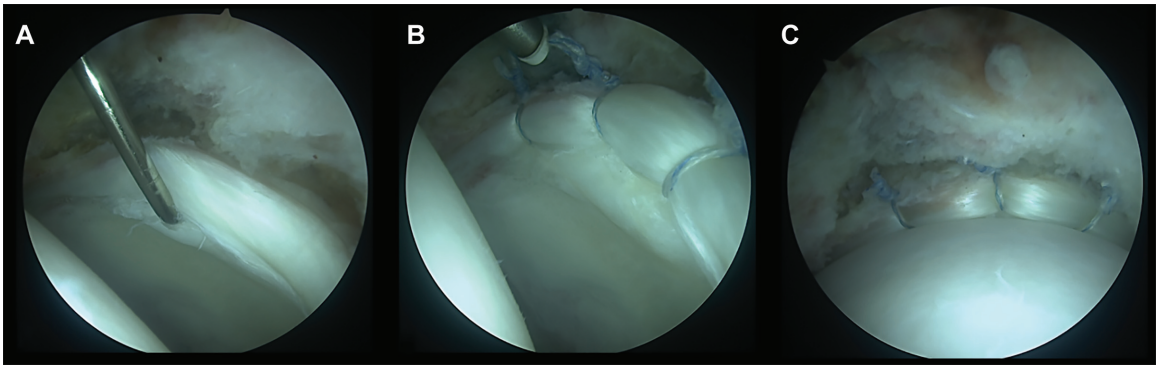

Figure 2. Intraoperative views of (A) labral tear with associated delamination demonstrated by probing of the chondrolabral junction, (B) labrum after 3-anchor repair, and (C) reestablishment of labral suction seal after release of femoral head traction.

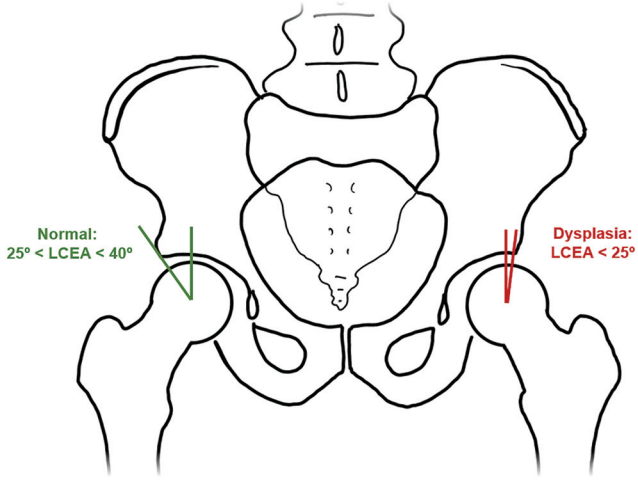

Figure 3. Diagram demonstrating normal femoral head coverage (left), with lateral center-edge angle (LCEA) values of 25° to 40° as well as dysplastic undercoverage of the femoral head (right) with LCEA values of <25°.

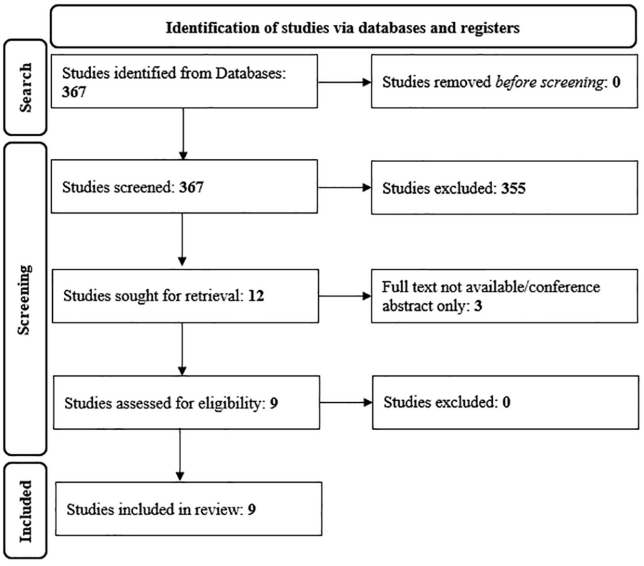

Figure 4. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart demonstrating article selection.

METHODS

Literature Search

A comprehensive search of several databases was performed by the Mayo Clinic Library on September 28, 2022, according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Figure 4). Results were limited to English-language and human studies. No date limits were used. Databases searched (and their content coverage dates) were Ovid MEDLINE 1946 to present and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily, Ovid Embase (1974 +), Ovid Cochrane Central Register of Controlled Trials (1991 +), Ovid Cochrane Database of Systematic Reviews (2005 +), Web of Science Core Collection via Clarivate Analytics (1975 +), and Scopus via Elsevier (1788 +). The search strategies were designed and conducted by a medical librarian with input from the study investigators (A.M.B., C.V.N., M.H.). Controlled vocabulary supplemented with keywords was used. The actual strategies listing all search terms used and how they are combined are available in the appendix (see Appendix 1, available in the online version of this article).

Selection Criteria

In total, 367 articles were identified and screened independently by 2 authors (A.M.B. and C.V.N.). Studies eliminated by both reviewers were removed. Disagreements were resolved between the reviewers and the senior author (M.H.). Articles excluded during screening included nonhip, nonprimary arthroscopies; concomitant PAOs; and nonclinical studies. Twelve remaining studies were manually reviewed for the following inclusion criteria: (1)

TABLE 1
Study Characteristics[a]

Study	Study Type	Level of Evidence	MINORS Score, %	No. of Patients	Mean Follow-up, mo
Beals et al[1] (2022)	Case series	4	81.25	38	NR[b]
Beck et al[2] (2020)	Cohort study	3	87.50	264 (176 controls)	NR[c]
Domb et al[9] (2018)	Case series	4	75	19	68.8
Giordano et al[12] (2020)	Cohort study	3	81.25	419	75.2
Grammatopoulos et al[13] (2017)	Case-control	3	79.16	111	54[d]
Hevesi et al[14] (2018)	Cohort study	3	91.67	144 (96 controls)	68.4
Johannsen et al[17] (2021)	Cohort study	2	75	192	77.9
Maldonado et al[28] (2020)	Cohort study	3	91.67	48 (24 controls)	74.3 (74.7 controls)
Owens et al[34] (2023)	Cohort study	3	87.50	92 (58 controls)	73.6 (73.3 controls)

[a]MINORS, methodological index for non-randomized studies; NR, not reported.
[b]Minimum 10-year follow-up.
[c]Minimum 5-year follow-up.
[d]Five- and 7-year failure rates were reported. Scores with <5-year follow-up were not included in analysis.

TABLE 2
Outcomes Reported[a]

Study	mHHS	NAHS	HOS-ADL	HOS-SS	VAS	iHOT-12	SF-12	VR-12	WOMAC	Satisfaction	Tegner	RTS	MCID/ PASS	Revision/ Reoperation	Conversion to THA
Beals et al[1]	X		X	X			X		X	X	X		X	X	X
Beck et al[2]	X		X	X	X					X			X	X	X
Domb et al[9]	X	X		X	X					X				X	X
Giordano et al[12]	X	X		X	X									X	X
Grammatopoulos et al[13,b]														X	X
Hevesi et al[14]	X			X	X								X	X	X
Johannsen et al[17]	X		X	X			X		X	X				X	X
Maldonado et al[28]	X	X		X	X	X	X	X		X			X	X	X
Owens et al[34]	X	X		X	X							X	X	X	X
Total No.	8	4	3	8	6	1	3	1	2	5	1	1	5	9	9

[a]HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports Subscale; iHOT-12, 12-item international Hip Outcome Tool; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; NAHS, Nonarthritic Hip Score; PASS, Patient Acceptable Symptom State; RTS, return to sport; SF-12, 12-item Short Form Health Survey; THA, total hip arthroplasty; VAS, visual analog scale; VR-12, Veterans RAND 12-Item Health Survey; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[b]Outcome scores reported at <5-year follow-up not included in analysis.

primary hip arthroscopy, (2) patients with LCEA <25°, (3) PROs or subsequent surgery data, and (4) ≥5-year follow-up. Exclusion criteria included not meeting any of the inclusion criteria and studies presented as abstracts at conferences without full text available. Nine studies were ultimately included in this systematic review.

Quality Assessment

Levels of evidence were reported by each study and confirmed using criteria from the Oxford Centre for Evidence-Based Medicine. No randomized controlled trials were identified; therefore, each study was assessed using the methodological index for non-randomized studies (MINORS) scoring system.[39] Noncomparative studies received a score out of 16 total points (8-item rubric scored 0-2), while comparative studies were scored out of 24 points (12-item rubric scored 0-2), with higher scores representing lower levels of bias. Each study was reviewed and scored independently by 2 authors (A.M.B. and C.V.N.). Study characteristics and MINORS score results (displayed as percentages) are detailed in Table 1.

Data Extraction and Analysis

Study characteristics, patient characteristics, surgical interventions, and outcomes were extracted from each study. Capsular repair included patients undergoing side-to-side repair, plication, and/or capsulorrhaphy. Due to the heterogeneity of variables studied and reported, data were not pooled, and meta-analysis could not be performed. The data reported by each study are detailed in Table 2.

RESULTS

Patient Characteristics

Four studies included in this review—Beck et al,[2] Hevesi et al,[14] Owens et al,[34] and Giordano et al[12]—compared

TABLE 3
Patient Characteristics[a]

Study	Age, y	% Female	BMI	LCEA, deg	α Angle, deg
Beals et al[1]	41.0 ± 9.6	39.5	NR	20-25	NR
Beck et al[2]	33.2 ± 11.9	72.7	23.9 ± 3.5	23.2 ± 1.5 (20-25)	*Anteroposterior*: 75.1 ± 15.8 *False profile*: 66.1 ± 13.1 *Dunn*: 66.9 ± 12.2
Domb et al[9]	22.9 ± 8.2	81.0	22.4 ± 4.4	21.7 ± 2.1 (18-24)	NR
Giordano et al[12]	37.67 ± 12.54	50.1	25.9 ± 5.4	30.9 ± 6.5	NR
Grammatopoulos et al[13]	40.9 (16-65)	70.3	NR	18.0 (1.8-25.0)	44.3 (3.4-82.5)
Hevesi et al[14]	31.8 ± 12.7	56.3	24.9 ± 4.9	21.5 (13.0-24.9)	63.7 ± 11.4
Johannsen et al[17]	33.6 (18.2-49.8)	NR	NR	30.3	NR
Maldonado et al[28]	36.2 ± 17.2	70.8	25.2 ± 5.2	22.2 ± 1.9	60.4 ± 8.4
Owens et al[34]	19.5 ± 4.2	55.9	23.3 ± 4.7	22.3 ± 1.9 (19.0-25.0)	NR

[a]Values are presented as mean ± SD, mean ± SD (range), or median (IQR), unless otherwise stated. BMI, body mass index; LCEA, lateral center-edge angle; NR, not reported.

outcomes between a cohort with dysplasia or borderline hip dysplasia (BHD) and a control group (Table 3).[2,12,14,34] An additional study by Maldonado et al[28] also perform a matched-pair controlled study; however, comparison was between patients with and without ligamentum teres tears (LTTs).[28] Notably, all patients in the study by Maldonado et al[28] had dysplasia with LCEA angles ranging from 18° to 25°. There were no significant differences in characteristics between the cohort and control groups or between subgroups in any of these studies other than the feature upon which the cohorts were divided and the matching was based (ie, LCEA or LTT). The remaining 4 studies all investigated outcomes for patients with LCEA <25° (no minimum cutoff) who underwent primary hip arthroscopy.[1,9,13,17]

Surgical Interventions

All studies noted intraoperative labral management; however, Giordano et al[12] reported that labral repair was performed "as indicated" but did not provide rates. In general, most patients underwent labral repair during their hip arthroscopy surgery. Hevesi et al,[14] Beck et al,[2] and Johannsen et al[17] performed labral repairs in 100% of patients, while Domb et al,[9] Beals et al,[1] and Owens et al[34] reported labral repair rates of 95.2%, 92.1%, and 88.3% (86.2% in control group), respectively. The patients in the Domb et al, Beals et al, and cohort group of the Owens et al studies who did not undergo labral repair underwent labral debridement. Six patients in the control group of the Owens et al study underwent labral reconstruction, and 15 underwent selective debridement.[34] Labral repair rates were lower in the studies by Grammatopoulos et al[13] (44%) and Maldonado et al[28] (62.5% vs 50% in control group), with the latter study reporting selective debridement in 37.5% (41.7% in control group) of patients.

Similarly, all studies reported intraoperative capsular management. Grammatopoulos et al[13] reported no capsular repair, and Johannsen et al[17] noted that capsular closure was routinely performed but did not report specific rates. Three studies[1,2,9] reported capsular repair in all patients, and another study[34] reported that all patients without excessive stiffness, adhesive capsulitis, or insufficient capsular tissue underwent capsular repair (93.8% vs 82.7% in control group), while the remaining patients' capsules were left unrepaired. The remaining studies reported lower rates of capsular management based on surgeon discretion. Hevesi et al,[14] Giordano et al,[12] and Maldonado et al[28] reported capsular repair rates of 52.1%, 39%, and 54.2% (50% in control group), respectively. Of note, 61% and 41.7% (50% in control group) of patients in the Giordano et al and Maldonado et al studies underwent capsulotomy or capsular release.

Outcomes

All studies in this review reported that patients had satisfactory postoperative outcome scores, had high satisfaction ratings, and, when applicable, experienced significant improvements in outcome scores irrespective of LCEA at final follow-up of ≥5 years and as far out as 10 years after surgery. In addition, there were no significant differences found in preoperative, postoperative, or delta values for any outcome measures in any cohorts, with the exception of the 12-item Short Form Health Survey (SF-12) mental subscore and Veterans RAND 12-Item Health Survey (VR-12) mental subscores reported by Maldonado et al[28] between the LTT cohort and the matched control group. Notably, Hevesi et al[14] and Johannsen et al[17] both reported that at final follow-up, there were no statistically significant differences in outcome scores between patients with LCEA values of 18° to 25° and those <18°.

Modified Harris Hip Score

In total, 8 studies reported on modified Harris Hip Score (mHHS). Six studies reported both pre- and postoperative mean mHHS at a minimum of 5 years after hip arthroscopy, all of which demonstrated improvements in mean scores. Four studies reported postoperative increases of ≥20 points at final follow-up. Beck et al[2] reported a 24.4-

point postoperative increase across all study participants (54.7 ± 26.1 to 79.1 ± 20.8; P = .001), with 25.2- and 24.8-point increases in the BHD (55.7 ± 15.4 to 80.9 ± 19.6) and non-BHD groups (58.7 ± 13.2 to 83.5 ± 18.0), respectively. Maldonado et al[28] reported 20.4- and 25.4-point postoperative increases in the LTT cohort (63.5 ± 13.6 to 84.0 ± 20.0; P = .0016) and control group (65.0 ± 14.0 to 90.5 ± 8.9; P < .0001), respectively. Owens et al[34] reported a 24.2-point improvement in the dysplasia group (67.6 ± 15.1 to 93.6 ± 11.5; P < .001), compared with a 21.8-point improvement in the control group (66.1 ± 11.5 to 90.6 ± 12.1; P < .001). Finally, Beals et al[1] reported a 25-point increase (58 ± 15 to 83 ± 20; P = .002) at 10-year follow-up in patients with dysplasia who did not require THA or revision.

In the other studies with pre- and postoperative scores, Hevesi et al[14] showed a 15.3-point improvement in mHHS in the dysplasia group (67.2 ± 14.2 to 82.5 ± 18.4) and a 22.0-point improvement in the nondysplasia group (61.2 ± 15.9 to 83.2 ± 17.6), and Domb et al[9] showed a 15.6-point increase (70.3 ± 9.8 to 85.9 ± 12.1; P < .0001) in a cohort with BHD. When further subgrouped, Hevesi et al[14] showed 15.3-point (64.7 ± 12.2 to 80.0 ± 20.5) and 15.4-point (67.6 ± 14.6 to 83.0 ± 18.3) increases in mHHS in the LCEA <20° and LCEA 20° to 25° cohorts, respectively.

Johannsen et al,[17] reported similar postoperative means ranging from 80.3 to 86.5 across all LCEA groups, with no significant difference seen between groups (P = .66). Finally, Giordano et al[12] reported no differences in mHHS based on LCEA as a continuous variable. When provided, all studies showed statistically significant improvements in mean mHHS at time of follow-up and no significant preoperative and postoperative differences or increases between the cohort and control groups.

Nonarthritic Hip Score

Four studies published on Nonarthritic Hip Score (NAHS) outcomes. Domb et al[9] reported a 19.2-point increase (68.3 ± 13.2 to 87.5 ± 9.8; P < .0001) in mean NAHS at 5-year follow-up in patients with dysplasia, and Maldonado et al[28] reported a 30-point postoperative increase in the LTT cohort (58.8 ± 18.9 to 88.8 ± 12.0; P < .0001), compared with a 27.5-point increase in the control group (62.6 ± 17.2 to 90.1 ± 9.9; P < .0001). Owens et al[34] reported 21- and 24.8-point postoperative increases in the dysplasia group (71.2 ± 17.9 to 92.2 ± 13.3; P < .001) and the control group (64.7 ± 15.5 to 89.5 ± 11.3; P < .001), respectively. Of note, Giordano et al[12] reported no differences in the NAHS based on LCEA as a continuous variable. As with the mHHS, there were no significant differences in mean preoperative, postoperative, or delta values for the NAHS between groups in any of these 4 studies.

Hip Outcome Score Activities of Daily Living and Sports Subscales

Three studies reported mean Hip Outcome Score (HOS)–Activities of Daily Living (ADL) and 8 reported mean HOS–Sports Subscale (SS). Beals et al,[1] Beck et al,[2] and Johannsen et al[17] each reported the HOS-ADL and HOS-SS; however, Johannsen et al reported only postoperative HOS-ADL and HOS-SS scores. Johannsen et al showed postoperative HOS-ADL scores ranging from 86.4 to 90.3 and HOS-SS scores ranging from 67.4 to 82.5 across all LCEA subgroups, with no statistically significant difference between groups. Beck et al[2] demonstrated significant improvements in both the HOS-ADL and the HOS-SS for the entire study group (P < .001). In the dysplasia group, there was a 20.9-point increase (64.8 ± 19.2 to 85.7 ± 19.9) in the HOS-ADL and a 29.3-point increase (45.3 ± 22.6 to 74.6 ± 30.7) in the HOS-SS. The control group demonstrated 19.5-point (69.2 ± 18.1 to 88.7 ± 19.9) and 32.8-point (46.8 ± 23.9 to 79.6 ± 23.9) increases in the HOS-ADL and HOS-SS, respectively.[2] Although Beck et al[2] ultimately showed lower final scores in the dysplasia group, this difference was not significant. Last, Beals et al reported a significant increase in the HOS-ADL (70 ± 11 to 87 ± 16; P = .003) and HOS-SS (47 ± 18 to 76 ± 27; P = .004) at 10-year follow-up in patients with dysplasia who did not require THA or revision surgery.

The remaining studies each only reported the HOS-SS. Domb et al[9] reported a significant increase in the HOS-SS at 5-year follow-up (52.1 ± 15.9 to 70.8 ± 19.5; P = .0002) in a cohort patients with dysplasia. Owens et al[34] also reported statistically significant postoperative improvements of 43.2 points in the dysplasia cohort (46.7 ± 26.4 to 89.9 ± 16.4; P < .001) and 36.4 points in the control group (48.0 ± 19.9 to 84.4 ± 22.2; P < .001) on the HOS-SS (P = .245). Similarly, Maldonado et al[28] reported statistically significant improvements in the HOS-SS of 33.4 points in the LTT cohort (38.1 ± 24.2 to 71.5 ± 28.2; P = .0017) and 31.9 points in the control group (46.6 ± 24.3 to 78.5, 19.0; P < .0001) (P > .243). Finally, Hevesi et al[14] reported a 27.3-point increase in the dysplasia group (45.2 ± 20.3 to 72.5 ± 23.3) and a 29.9-point increase in the nondysplasia controls (41.1 ± 25.0 to 71.0 ± 26.6) on the HOS-SS. Notably, the authors observed a 34.9-point increase in the HOS-SS in the subgroup with LCEA <20° (36.1 ± 24.4 to 71.0 ± 23.9), compared with a 26.1-point increase in the LCEA 20° to 25° subgroup (46.7 ± 19.6 to 72.8 ± 23.5).[14]

Hevesi et al[14] did not report significant differences in pre- or postoperative HOS-SS between the dysplasia and nondysplasia groups or between the LCEA subgroups, and again, there were no statistically significant differences reported in any preoperative scores, postoperative scores, or score changes between comparison groups in any of the applicable studies. Of note, Giordano et al[12] similarly reported no differences in the HOS-SS based on LCEA.[12]

Visual Analog Scale for Pain

Six studies reported visual analog scale (VAS) and demonstrated improvements at 5-year follow-up. Five of these studies used a 10-point scale. Domb et al[9] showed a 3.8-point reduction (5.6 ± 2.5 to 1.8 ± 1.3; P < .0001) in patients with dysplasia, and Owens et al[34] showed ≥3-

point reductions in both the dysplasia cohort (4.7 ± 2.5 to 1.3 ± 2.2; $P < .001$) and the control group (5.5 ± 2.3 to 1.7 ± 2.0; $P < .001$), with no significant difference between preoperative, postoperative, or improvements between groups ($P > .154$). Similarly, Maldonado et al[28] demonstrated ≥3-point decreases in VAS in both the LTT group (5.2 ± 2.4 to 1.3 ± 1.3; $P < .0001$) and the control group (5.9 ± 2.8 to 2.3 ± 2.3; $P = .0005$), with no significant difference between groups at any time point ($P > .085$). Finally, Hevesi et al[14] showed similar improvements from pre- to postoperative VAS in the dysplasia cohort (5.0 ± 2.5 to 2.0 ± 2.1) as in the nondysplasia control group (5.7 ± 2.0 to 2.0 ± 2.2). When further subdivided, the cohort with LCEA <20° experienced a 3.3-point decrease in VAS (5.3 ± 2.9 to 2.0 ± 2.2), while the LCEA 20° to 25° cohort experienced a 2.9-point decrease (4.9 ± 2.4 to 2.0 ± 2.1).[14] Neither preoperative nor postoperative VAS scores were significantly different between the dysplasia and nondysplasia groups or between the subgrouped dysplasia cohorts ($P > .11$).[14]

One study, Beck et al,[2] reported an overall decrease of 39.8 points in mean VAS on a 100-point scale for the entire cohort (69.9 ± 17.8 to 30.1 ± 31.5; $P < .001$), as well as 39.1- and 40.9-point decreases in the dysplasia cohort (67.7 ± 19.2 to 28.6 ± 30.7) and control group (70.4 ± 16.5 to 29.5 ± 27.8), respectively. There was no significant difference in pre- or postoperative scores between groups.[2] Finally, Giordano et al[12] reported that there were no differences in VAS based on LCEA.

SF-12 and VR-12

Three studies reported mean SF-12 scores, and 1 study reported a mean VR-12 score. Beals et al[1] reported improvements in both the SF-12 Physical Component Summary ($P = .256$) and mental component summary (MCS) ($P = .347$) in patients with dysplasia who did not require THA or revision surgery at 10-year follow-up; however, neither of these improvements reached statistical significance. Maldonado et al[28] did not record preoperative SF-12 MCS but did find that the LTT cohort had significantly lower postoperative scores at final follow-up than patients in the control group (56.3 ± 5.2 vs 59.0 ± 3.3; $P = .042$). This finding was also true for the postoperative VR-12 mental scores (60.8 ± 5.3 vs 63.7 ± 4.4; $P = .041$).[28] Johannsen et al[17] reported on the complete SF-12 form and recorded postoperative scores of 50.0, 51.5, 52.4, 49.0, and 51.6 in the <20°, 20°-24.9°, 25°-34.9°, and >35° LCEA cohorts, respectively. These scores were not statistically significantly different ($P = .80$).[17]

Western Ontario and McMaster Universities Osteoarthritis Index

Two studies reported mean Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores at final follow-up. Beals et al[1] showed a significant improvement of 21 points (31 ± 9 to 10 ± 11; $P = .001$) in patients with dysplasia who did not require THA or revision surgery, and Johannsen et al[17] found that when patients were subgrouped by resection depth, there was a statistically significant difference in scores, with a mean score of 15.9 ± 14.8 in the 5° to 10° resection cohort, compared with 9.4 ± 11.4 and 8.8 ± 8.7 in the <5° and >10° cohorts, respectively ($P = .03$). Notably, this finding did not persist when patients were subgrouped by LCEA.[17] Similarly, Johannsen et al reported similar WOMAC scores across all postoperative LCEA cohorts on average, with the highest score in the LCEA <20° group (13.3 ± 12.2) and the lowest score seen in the LCEA 25° to 34.9° group (9.5 ± 11.3), but there was no statistically significantly difference in WOMAC scores across the groups ($P = .57$).[17]

Satisfaction

Postoperative satisfaction was recorded on a 10-point scale in 4 studies, which all demonstrated high patient satisfaction scores. Domb et al[9] reported a mean score of 7.9 ± 1.7 in patients with dysplasia. Maldonado et al[28] reported similarly high satisfaction scores in both the LTT cohort (8.3 ± 2.2) and the control group (8.6 ± 1.4). Beals et al[1] reported a median score of 10 at ≥10-year follow-up, and Johannsen et al[17] reported median satisfaction scores of 9 or 10 for all 5 LCEA subgroups at ≥5-year follow-up. In their respective studies, neither Maldonado et al or Johannsen et al found any significant differences between groups ($P = .587$ and $P = .62$, respectively). In 1 other study, Beck et al[2] reported postoperative satisfaction scores of 75.5 ± 30.6 in the dysplasia cohort and 77.8 ± 29.8 in the control group ($P = .593$) using the VAS for satisfaction.[2] Notably, the 3 comparative studies showed no significant differences in scores between cohorts.

Return to Sport

The primary aim of Owens et al[34] was to evaluate return to sport (RTS) rates after primary hip arthroscopy. They reported that 90.0% of athletes with dysplasia and 87.2% of athletes in the control group who attempted to RTS were able to do so successfully.[34] There was not a significant difference in RTS rates between these 2 groups ($P = .713$). The authors noted that 4 athletes with dysplasia were able to return at a higher level than before surgery, compared with 2 athletes without dysplasia.

Minimal Clinically Important Difference and Patient Acceptable Symptom State

In total, 5 studies described minimal clinically important difference (MCID) and Patient Acceptable Symptom State (PASS) achievement rates in some capacity. Three of the included studies reported on MCID and PASS as it related to LCEA. In their study, Beck et al[2] found no statistical difference in the rates of achieving MCID or PASS for any outcome measure between the dysplasia cohort and matched control groups. The dysplasia cohort achieved MCID at rates of 69.7% to 86.6% across all outcome scores

(compared with 60.2%-85.2% in the control group) and achieved PASS at rates of 60.9% to 76.0% (compared with 60.4%-73.7% in the control group).[2] However, the group did report that the PASS logistic regression model showed that having a larger preoperative LCEA was a statistically significant predictor of achieving PASS on ≥1 outcome measure (odds ratio = 2.3; P = .001).[2] Beals et al[1] similarly reported MCID achievement rates ≥80% and PASS achievement rates ≥69% for all outcome scores in patients who did not undergo THA or revision surgery but at ≥10 years postoperatively. Finally, Owens et al[34] found that >90% and 86% of patients with dysplasia met or exceeded PASS and MCID, respectively, for mHHS. For HOS-SS, the achievement rates were 75.4% and 90.8% for PASS and MCID in the dysplasia cohort.[34] There were no statistically significant differences in rates of PASS or MCID between the dysplasia cohort (LCEA 18°-25°) and the control group (LCEA >25°) in this study (P > .332).[34]

Three of the studies reported on MCID and PASS for outcome scores unrelated to LCEA. Both Beals et al[1] and Hevesi et al[14] noted older age as a risk factor for failing to achieve MCID and/or PASS. Beals et al reported that a greater percentage of younger patients reached MCID and PASS compared with older patients; however, this difference was not statistically significant. Hevesi et al[14] similarly reported that age >35 years was associated with a 3.17-fold increased relative hazard of failure to reach the MCID when compared with patients ≤35 years old in the dysplastic group; however, this trend did not reach significance for mHHS (P = .06). In regard to LTT, Maldonado et al[28] demonstrated that patients in the LTT cohort were significantly less likely to achieve the PASS for mHHS than the control group (75.0 vs 100.0; P = .022), but there was no significant difference in rates of MCID (70.8 vs 91.7; P = .14). In addition, there was no difference in achieving PASS (41.7 vs 58.3; P > .39) or MCID (58.3 vs 70.8; P = .55) for HOS-SS between groups.[28]

Revision, Reoperation, and Conversion to THA

All studies reported on subsequent operations (Table 4). Three studies performed survivorship analysis for patients with LCEA <25°, which showed 73% survivorship at 3 years, 71% to 98.9% at 5 years, 68% at 7 years, and 79% at 10 years (Table 5).[1,13,14] The overall rate of conversion to THA at time of final follow-up for these patients in 8 studies ranged from 0% to 29% at ≥5 years after surgery, with 1 other study reporting a 56% conversion rate in 9 patients with LCEA <18°, which was significantly higher than the 13% rate in control patients with LCEA >25° (P < .001).[12] Notably, in this study, patients with LCEA values between 18° and 25° did not demonstrate the same increased risk of conversion to THA compared with patients without dysplasia (12% vs 13%; P = .93).[12] The study with the longest follow-up reported a 21% rate of conversion to THA at ≥10 years after arthroscopy.[1] Revision rates were also reported for each study, ranging from 0% to 19.0% in patients with LCEA <25°. The highest revision rate in any study was 20.4% in the LCEA 25° to 35° cohort in the Johannsen et al[17] study. Multiple studies investigated the relationship between LCEA and rates of revision or conversion to THA, and other than the finding by Giordano et al[12] of higher THA rates in 9 patients with LCEA <18°, there were no other differences in revision rates or conversion to THA across LCEA subgroups or between dysplastic and nondysplastic patients.[14,17,34]

TABLE 4
Revision Rates[a]

Study	%
Beals et al[1,b]	7.0
Beck et al[2]	
LCEA 20°-25°	2.3
LCEA 25°-40°	0.0
Domb et al[9]	19.0
Giordano et al[12]	9.5
LCEA <18°	11.0
LCEA 18°-24.9°	9.8
LCEA 25°-40°	8.9
Grammatopoulos et al[13]	0.0
Hevesi et al[14]	
LCEA <25°	16.7[c]
LCEA 25°-40°	18.8
Johannsen et al[17]	
LCEA <20°	0.0
LCEA 20°-24.9°	9.4
LCEA 25°-34.9°	20.4
LCEA >35°	0.0
Maldonado et al[28]	4.2
Owens et al[34]	
LCEA 18°-24.9°	11.8
LCEA 25°-40°	13.8

[a]LCEA, lateral center-edge angle.
[b]Ten-year follow-up.
[c]Revision hip arthroscopy + periacetabular osteotomy.

Some studies also reported failure rates, although the definition of "failure" was not consistently defined across all studies. Hevesi et al[14] also reported an overall failure rate of 18.8% in the dysplastic group (LCEA <25°) and 22.9% in the control group. The failure rates of both the dysplastic and the nondysplastic groups were not significantly different from that of the general population of hip arthroscopies (16.6%) from which the groups were selected (P = .39 and P = .06, respectively). Finally, when patients with LCEA <25° were subgrouped into severe dysplasia (LCEA <20°) and LCEA values of 20° to 25°, there was no significant difference in rates of revision surgery (P = .60) or survival trends (P = .60) between the 2 cohorts.[14] Johannsen et al[17] reported a similar failure rate of 16.1%, which included revision hip arthroscopy and THA, across the entire patient population at ≥5-year follow-up.

DISCUSSION

Isolated hip arthroscopy for patients with dysplasia remains controversial. PAO has become the current standard of care to treat patients with severe dysplasia (LCEA <18°), with early studies showing hip arthroscopy

TABLE 5
Survivorship From Total Hip Arthroplasty[a]

Study	3 Years, %	5 Years, %	7 Years, %	10 Years, %
Beals et al[1]		87.0		79.0
Beck et al[2]				
LCEA 20°-24.9°		98.9		
LCEA 25°-40°		100.0		
Domb et al[9]		100.0		
Giordano et al[12]		86.0		
LCEA <18°		44.0		
LCEA 18°-24.9°		88.0		
LCEA 25°-40°		87.0		
Grammatopoulos et al[13]	73.0	71.0	68.0	
Hevesi et al[14,b]				
LCEA <25°		83.3		
LCEA 25°-40°		78.1		
Johannsen et al[17]				
LCEA <20°				
LCEA 20°-24.9°				
LCEA 25°-34.9°				
LCEA >35°				
Maldonado et al[28]		100.0		
Owens et al[34]		100.0		

[a]LCEA, lateral center-edge angle.
[b]Survival from any subsequent ipsilateral hip surgery.

alone in these patients does not improve long-term outcomes. However, PAO represents a challenging procedure performed by hip preservation specialists that may not always be necessary or clearly indicated for all patients who have hip dysplasia, particularly as LCEA values approach 25°. Furthermore, some patients may choose to stagger their primary hip arthroscopy for intra-articular pathology and subsequent PAO by a substantial time period due to logistical considerations or personal preference. To our knowledge, there are no comprehensive reviews to date reporting clinical outcomes of hip arthroscopy in patients with hip dysplasia at midterm follow-up. Therefore, the purpose of this study was to systematically review the current literature to provide an up-to-date, evidence-based review of the clinical outcomes after primary hip arthroscopy in patients with dysplasia at ≥5-year follow-up. Among the included studies, we found that hip arthroscopy for patients with hip dysplasia had satisfactory outcomes, high patient satisfaction, and significantly improved PROs at final-follow-up, when reported. In addition, outcomes in patients with dysplasia were not significantly different from those with nondysplastic hips when dysplasia was categorized based on LCEA. Finally, the incidence of revision procedures and conversion rates to THA were similar between patients with and without hip dysplasia. These findings suggest that hip arthroscopy in patients with hip dysplasia may produce satisfactory clinical outcomes at ≥5-year follow-up up to 10 years postoperatively.

While this review found satisfactory midterm outcomes of hip arthroscopy for patients with hip dysplasia, it remains unknown how these clinical outcomes relate to long-term joint preservation. Hip dysplasia is a well-known risk factor for early hip osteoarthritis, and while hip arthroscopy likely does not change the natural progression of OA, it may serve as a reasonable intervention to provide satisfactory function for patients for years, allowing for a staged approach for patients currently uninterested or medically limited (ie, due to habitus) from proceeding with PAO. Understanding the body of published clinical outcomes at 5 to 10 years after hip arthroscopy allows for more accurate counseling and expectation management for patients with LCEA <25°, particularly for those who are unwilling to pursue more aggressive surgical treatment at the time of clinical evaluation.

Our findings are highlighted by the comparative studies reviewed in the presented systematic review. The studies by Beck et al,[2] Giordano et al,[12] Hevesi et al,[14] Johannsen et al,[17] and Owens et al[34] classified patients based on LCEA to distinguish clinical outcomes between patients with dysplasia and control patients. These studies found no significant differences in PROs and revision/failure rates among these groups. Interestingly, the Johannsen et al and Hevesi et al[14] studies found the highest point estimate for hip arthroscopy revision rates to be among the control cohorts, although this was not statistically significant. These results indicate that the static measurement of LCEA may not be associated with clinical outcomes. It may be important for future studies to classify patients with hip dysplasia with both static and functional measurements, or with additional radiographic measures, to assist in delineating those patients with hip dysplasia who may not respond to hip arthroscopy. For example, previous literature has demonstrated that ≤84% of patients with dysplasia and a Tönnis angle >10° required a secondary reoperation at a mean 41-month follow-up.[29] However, such measures fall outside the scope of the present review and are inconsistently reported in the currently available literature.

This review article is not without several important and notable limitations. First, the compiled results represent contemporary surgical cohorts by experienced surgeons. Careful capsular management and labral preservation were likely key to successful outcome. As this was a retrospective study, it is also notable that hips that the included surgical groups thought they could not predictably help with isolated hip arthroscopy were likely referred for (and treated with) PAO. For example, while both may have an LCEA <25°, there is likely a key clinical distinction between a male patient with a stiff dysplastic hip and massive cam morphology who may benefit from isolated arthroscopy and a young, hyperlax female patient with subtle loss of femoral head neck offset who may be better served with PAO or a combined PAO and arthroscopy procedure. This is highlighted by the fact that the included studies had a majority of female patients and average α angle of 62.75°, which is overall enriched in male patients and increased α values as compared with the general dysplasia population. In addition, only 4 of the 9 studies included a control group in their studies, which made it difficult to compare all the outcomes with patients without hip dysplasia. Finally, among the studies that were eligible for inclusion, 6 were level 3, 2 were level 4, and 1 was level 2, resulting in an overall level 4

systematic review. This further highlights the fact that additional well-designed, randomized controlled trials are needed in this important patient population.

CONCLUSION

Hip arthroscopy in carefully selected patients with LCEA <25° can be successful at mid- to long-term follow-up and may provide clinical outcomes and failure rates comparable with patients with normal LCEA, understanding that this is a singular, 2-dimensional radiographic measure that does not differentiate instability from impingement or combinations thereof, warranting future studies delineating these differences. These findings suggest that hip dysplasia may not be an absolute contraindication for isolated hip arthroscopy and may serve as a viable intervention with consideration of staged future PAO. Importantly, this review does not suggest that hip arthroscopy alters the natural history of dysplasia; therefore, patients with dysplasia should be counseled on the potential utility of PAO by appropriate hip preservation specialists.

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ORCID iDs

Alexander M. Boos https://orcid.org/0000-0002-5241-9191
Aaron J. Krych https://orcid.org/0000-0003-3248-8007

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