Outcomes After Concomitant Hip Arthroscopy and Periacetabular Osteotomy

A Systematic Review

Michael S. Lee,* BA, Scott Fong,† BA, Jade S. Owens,‡ BS, Ronak J. Mahatme,§ BS, David N. Kim,‖ BS, Stephen M. Gillinov,‖ AB, Jay Moran,‖ BS, Jacquelyn Simington,¶ BS, Wasif Islam,‖ BS, Seyi Abu,‖ and Andrew E. Jimenez,‖# MD

Investigation performed at the Department of Orthopaedics and Rehabilitation, Yale School of Medicine, New Haven, Connecticut, USA

Background: Despite several studies' reports on outcomes of concomitant hip arthroscopy and periacetabular osteotomy (PAO), there is a paucity of aggregate data in the literature.

Purpose: To evaluate outcomes and survivorship after concomitant hip arthroscopy and PAO.

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

Methods: The PubMed, Cochrane, and Scopus databases were searched in April 2022 using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The following keywords were used: (hip OR femoroacetabular impingement) AND (arthroscopy OR arthroscopic) AND (periacetabular osteotomy or rotational osteotomy) AND (outcomes OR follow-up). Of 270 articles initially identified, 10 studies were ultimately included. The following information was recorded for each study if available: publication information; study design; study period; patient characteristics; follow-up time; indications for hip arthroscopy; patient-reported outcomes (PROs); rates of secondary hip preservation surgeries; and rates of conversion to total hip arthroplasty (THA). Survivorship was defined as nonconversion to THA.

Results: The study periods for the 10 included articles ranged from 2001 to 2018. Three studies were level 3 evidence, and 7 studies were level 4 evidence. This review included 553 hips with a mean follow-up of 1 to 12.8 years. All 10 studies listed dysplasia as an indication for surgery. Of 9 studies that reported PRO scores, 7 reported significant improvement after surgery. Studies with a <5-year follow-up reported conversion to THA rates of 0% to 3.4% and overall secondary surgery rates of 0% to 10.3%. Similarly, studies with >5-year follow-up reported conversion to THA rates of 0% to 3% and overall secondary surgery rates of 0% to 10%.

Conclusion: Patients who underwent concomitant hip arthroscopy and PAO reported favorable outcomes, with 7 of the 9 studies that provided PRO scores indicating significant preoperative to postoperative improvement.

Keywords: concomitant; dysplasia; hip arthroscopy; outcomes; periacetabular osteotomy

Acetabular dysplasia has been established as a common diagnosis for hip pain.[19] Hip dysplasia has been associated with microinstability and poor outcomes when treated with hip arthroscopy alone.[27,29] Periacetabular osteotomy (PAO) has demonstrated reliability and durability in treating patients with hip dysplasia at short-, mid-, and long-term follow-ups.[4,5,17] A 2019 study by Ziran et al[39] reported favorable outcomes even 20 years after surgery. The authors reported that of the 302 hips in the study, 86% and 60% were able to survive at 10- and 20-year follow-ups, respectively.

Despite the success of isolated PAO for the treatment of hip dysplasia, some question the method of treating the high frequency of intra-articular pathology often accompanying hip dysplasia. A study by McCarthy and Lee[28] reporting on dysplastic hips found that 112 of the 170 hips (72%) had a labral tear. More recently, Haene et al[12] reported that among the radiographs of 128 patients with arthroscopically diagnosed labral tears, 59 of the hips had dysplasia. To address this problem, recent literature has described the use of combined hip arthroscopy and PAO to comprehensively address intra-articular pathology (labral tears,[11] bony impingement,[6,26] ligamentum teres damage,[22] capsular laxity,[16] and cartilage damage[8,24,32]) and hip dysplasia with promising outcomes. Whether in the active or general population, the 2 procedures in conjunction have demonstrated excellent short-term outcomes.[15,33]

The Orthopaedic Journal of Sports Medicine, 11(4), 23259671231160559
DOI: 10.1177/23259671231160559

The purpose of this study was to perform a systematic review to evaluate outcomes and survivorship of patients undergoing concomitant hip arthroscopy and PAO. It was hypothesized that patients undergoing concomitant hip arthroscopy and PAO would demonstrate significant improvement after surgery and low rates of secondary surgeries.

METHODS

Study Search and Identification

A systematic review was performed on the current literature with the following keywords: (hip OR femoroacetabular impingement) AND (arthroscopy OR arthroscopic) AND (periacetabular osteotomy or rotational osteotomy) AND (outcomes OR follow-up). PubMed, Cochrane, and Scopus databases were queried in April 2022 using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Articles were included if they reported outcomes of patients undergoing concomitant hip arthroscopy and PAO. The following types of articles were excluded from this review: studies with <15 patients; non-English articles; <1-year follow-up; case reports; opinion articles; review articles; and technique articles.

Articles underwent thorough analysis by 2 independent reviewers (M.S.L., A.E.J.; A.E.J. is a board-eligible orthopaedic surgeon attending who specialized in hip preservation). For full-text review, the senior author (A.E.J.) and independent reviewer (M.S.L.) re-reviewed articles. The reviewers discussed the inclusion and exclusion criteria for articles that were not unanimously agreed on before the senior author made the final decision on whether articles should be included in the study. Duplicate studies were removed during the initial title/abstract screening. All included articles underwent an additional review of references to determine whether additional studies could be added to the review.

Quality Assessment

Two authors (M.S.L.) and (A.E.J.) evaluated the quality of the included articles using the methodological index for non-randomized studies criteria.[35] Articles were scored and those articles with 2 different scores were re-reviewed and discussed until an agreement was reached. The level of evidence was assigned using the criteria set by Hohmann et al.[14]

Data Extraction

The following information was recorded for each study if available: title; author; publication date; study design; demographic characteristics; number of hips; follow-up time; study period; indications for hip arthroscopy; radiologic findings; intraoperative findings; surgical procedures; patient-reported outcomes (PROs); rates of secondary hip preservation surgeries; and rates of conversion to total hip arthroplasty (THA). The latest PROs were used for postoperative PRO outcomes. Survivorship was defined as nonconversion to THA.

RESULTS

Study Identification and Quality

The initial query on the PubMed, Cochrane, and Scopus databases resulted in 270 articles. After removing duplicates, a total of 176 articles were left. Titles and abstracts were reviewed for the remaining articles to assess preliminary relevancy and 16 remained. The remaining articles underwent full-text review; 10 articles[**] met the inclusion criteria and were included in the study. The article-selection process is shown in Figure 1.

Study Characteristics

Descriptive information, including study period, number of hips, sex, mean follow-up time, and mean age, are recorded in Table 1. The 10 studies in this review were from 5 different institutions, with study periods ranging from[18] 2001 to[15] 2018. Overall, 553 hips were included, with the mean follow-ups ranging from 1 year[38] to 12.8 years.[3] Seven studies were case series, representing level 4 evidence,[3,7,9,15,18,25,34] and the remaining 3 articles[31,33,38] were level 3 cohort studies.

All 10 studies listed dysplasia as an indication for PAO. All 10 studies reported radiologic measurements, 8 studies[3,7,9,15,18,25,33,34] reported intraoperative findings, and 9 studies[3,7,9,15,18,25,33,34,38] reported surgical procedures. Surgical indications and radiologic measurements are shown

** References 3, 7, 9, 15, 18, 25, 31, 33, 34, 38.

#Address correspondence to Andrew E. Jimenez, MD, Department of Orthopaedics and Rehabilitation, Yale School of Medicine, 800 Howard Avenue, First Floor, New Haven, CT 06519, USA (email: andrew.jimenez@yale.edu).
*Medical College of Wisconsin, Milwaukee, Wisconsin, USA.
†Advanced Orthopaedics & Sports Medicine, San Francisco, California, USA.
‡Keck School of Medicine of the University of Southern California, Los Angeles, California, USA.
§University of Connecticut School of Medicine, Farmington, Connecticut, USA.
‖Department of Orthopaedics and Rehabilitation, Yale School of Medicine, New Haven, Connecticut, USA.
¶University of Connecticut, Storrs, Connecticut, USA.
Final revision submitted December 9, 2022; accepted January 19, 2023.
One or more of the authors has declared the following potential conflict of interest or source of funding: A.E.J. has received grant support from Arthrex and education payments from Arthrex and Medwest. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

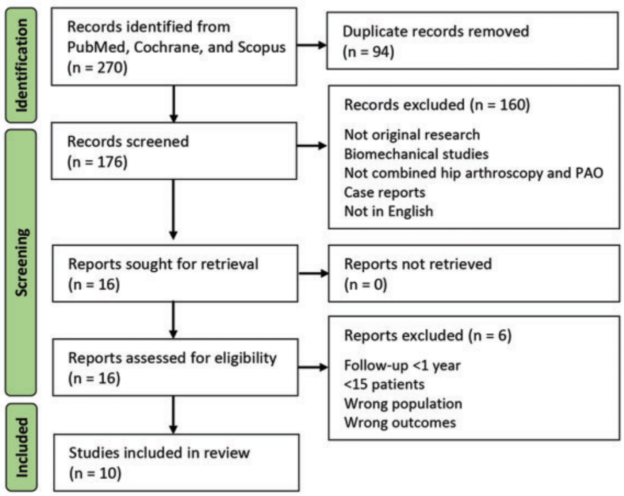

Figure 1. Article-selection flowchart. PAO, periacetabular osteotomy.

in Table 1. Intraoperative findings and surgical procedures are shown in Appendix Table A1.

Surgical Outcome Tools

Nine studies[3,7,9,15,18,25,31,33,38] reported PROs and 7 studies[3,7,9,15,18,25,31] reported significant improvements in PROs after surgery. The modified Harris Hip Score (mHHS) was the most common PRO reported and was cited in 5 studies.[7,9,15,25,33] The mHHS scores ranged from 55 to 63.9 preoperatively[7,9] and 81.6 to 88.3 postoperatively.[15,25] PROs are recorded in Appendix Table A2.

Of the 9 studies reporting PROs, 4 studies[3,15,25,33] reported psychometric thresholds (minimal clinically important difference [MCID], Patient Acceptable Symptom State [PASS], minimally important change, and clinical success); every study reported an 80% achievement of ≥1 threshold. Two studies[15,25] reported that 81.3% and 92.3% of patients achieved the MCID, respectively. Seven studies[3,7,9,15,18,25,31] reported significant improvements after surgery in ≥1 PRO. Although the Edelstein et al[9] study did not report clinical benefit thresholds, the mean postoperative score in the study was 10 points higher than the PASS threshold established for femoroacetabular impingement.[2] The clinical benefit achievement rates are listed in Appendix Table A2.

Survivorship and Secondary Surgeries

Seven studies[3,7,9,15,18,25,34] reported surgery rates on either subsequent hip preservation procedures or conversion to THA. Two of these studies did not report secondary hip preservation rates.[18,25] Secondary hip preservation procedure rates ranged[3,7,9] from 0% to 7%, and conversion to THA rates ranged[7,15,18,25,34] from 0% to 3.4%.Two studies[3,7] reported no secondary hip preservation procedures, and 4 studies[7,18,25,34] reported no conversions to THA. Studies with <5-year follow-up reported conversion to THA ranging from[7,34] 0% to[15] 3.4% and overall secondary surgery rates ranging from[7] 0% to[15] 10.3%. Similarly, studies with >5-year follow-up reported conversion to THA rates ranging from[18,25] 0% to[9] 3% and overall secondary surgery rates ranging from[18,25] 0% to[9] 10%. Survivorship rates are shown in Table 2.

DISCUSSION

The major findings of this review were 3-fold: (1) patients undergoing combined hip arthroscopy and PAO demonstrated favorable outcomes, as all studies reporting *P* values for change in PROs reported significant improvement ($P < .05$) on ≥1 PRO, and all studies reporting clinical benefit reported patients achieving ≥80% in 1 category; (2) the most common indication for surgery was hip dysplasia, as reported in all studies; and (3) survivorship rates (mean follow-up, 2.4-12.8 years) were high, with over 95% survivorship in every included study. Nine studies assessed clinical outcomes in the general population, while 1 study reported results in athletes. The highest rate of conversion to THA was 3.4%, and 4 of the studies reported no conversion to THA.[7,18,25,34] It appears that studies with lower mean age had higher rates of survivorship. Of the 4 studies[7,18,25,34] that had 100% survivorship, the mean age in 3 of the 4 studies was <30 years and ranged from 23.5 to 26.6 years, while 1 study had a mean age of 40 years. Similarly, low rates of secondary hip arthroscopy were reported, with the highest rate being 6.9% in an athletic population.

The overall secondary surgery rate varied[7,15,18,25] from 0% to 10.3%.The highest rate of secondary surgeries and conversion to THA was reported by Jimenez et al[15] in the athlete population at a minimum 2-year follow-up. They reported that all revision hip arthroscopies were due to re-torn labrums and residual femoroacetabular impingement. On the other hand, the lowest rates of secondary surgeries were observed by Domb et al,[7] Kim et al,[18] and Maldonado et al.[25] These 3 studies assessed the general population. These results may imply that although highly active patients can return to sport at high rates, there may be a higher likelihood of subsequent surgery. Despite the considerable literature demonstrating the favorable outcomes in the general population, further literature is needed to describe the outcomes of athletes undergoing combined PAO and hip arthroscopy surgery, return to sport, and durability of the surgery in these patients.

A direct comparison of the outcomes of PAO with concomitant hip arthroscopy to isolated PAO has not been well-established. Combined PAO and hip arthroscopy seems to demonstrate similar rates of survivorship and outcomes to those of PAO alone. Swarup et al[36] reported that 94% and 91% of patients achieved the MCID at a minimum 1-year follow-up for the mHHS and Hip Outcome Score–Sports Specific Subscale (HOS-SSS), respectively, for patients undergoing isolated PAO. Jimenez et al[15] and Maldonado et al[25] reported rates of achieving the MCID for the mHHS and HOS-SSS, ranging from 81.3% to 92.3% and 78.6% to 88.5%, respectively, for patients undergoing combined hip

TABLE 1
Patient Characteristics, Indications, and Radiologic Findings of the Included Studies (N = 10)[a]

Lead Author (Year)	Study Type; LOE	Study Period	MINORS Score	No. of Hips, n (Sex)[b]	Follow-up, y[c]	Age, y[c]	Indications	Radiologic Findings
Domb[7] (2015)	Case series; 4	2010-2013	11	17 (3 M/14 F)	2.4 (0.6-3.3)	24.2 ± 7.1	Acetabular dysplasia	▪ LCEA: 11.15° ± 6.96° ▪ Tönnis grades, n (%) 0: 15 (88.2) 1: 2 (11.8)
Maldonado[25] (2019)	Case series; 4	2010-2012	11	16 (3 M/13 F)	5.5 ± 0.56 (5.05-7.04)	23.5 ± 6.8	Hip dysplasia (LCEA ≤25°)	▪ LCEA: 14.2° ± 6.7° ▪ Alpha angle: 55.7° ± 12° ▪ Tönnis grade, n (%) 0: 15 (93.8) ▪ Tönnis angle: 19.3° ± 5.9°
Jimenez[15] (2022)	Case series; 4	2010-2018	11	29 (2 M/27 F)	2.44 ± 0.42	26 ± 8.7	Acetabular dysplasia	▪ LCEA: 16.5° ± 6.3° ▪ Alpha angle: 55.6° ± 10.1° ▪ Tönnis grades, n (%) 0: 25 (86.2) 1: 4 (13.8)
Sabbag[34] (2019)	Case series; 4	2007-2016	12	248 (33 M/207 F)	3 (1-8)	26.6 ± 9.2	▪ Acetabular dysplasia: 220 (88.7%) ▪ Acetabular retroversion: 17 (6.9%) ▪ Combined: 11 (4.4%)	▪ LCEA: 18.3° ± 6.2° ▪ Tönnis grades, n (%) 0: 150 (62.8) 1: 87 (36.4%) 2: 2 (0.8)
Ricciardi[33] (2016)	Retrospective cohort study; 3	2010-2014	15	24 (21 F)	1.92	27 (12-41)	Acetabular dysplasia (LCEA <25°)	▪ LCEA: 18° (15°-21°) ▪ Tönnis grades, (%) 0: (71) 1: (21) 2 (4) Not documented: (4) ▪ Alpha angle: 54° (44°-62°)
Kim[18] (2011)	Case series; 4	2001-2005	8	43 (7 M/33 F)	6.2 (5-8.1)	40 (20-67)	Acetabular dysplasia (center-edge angle <20°)	▪ Tönnis grades, n (%) 0: 7; (16.3) 1: 23 (53.5) 2: 11 (25.6) 3: 2 (4.7) ▪ Center-edge angle: 7.3° (–10° to 19°)
Edelstein[9] (2021)	Case series; 4	2005-2012	11	70 (5 M/62 F)	6.5 ± 1.6	29 ± 10	Acetabular dysplasia (center-edge angle <20°)	Survivors: (%) ▪ LCEA <20°: (83) ▪ LCEA 20°-38°: (17) ▪ Tönnis grades, n (%) 0: 25 (48) 1: 27(52) Nonsurvivors: (%) ▪ LCEA <20°: (93) ▪ LCEA 20°-38°: (7) ▪ Tönnis grades, n (%) 0: 8 (53) 1: 7 (47)
Cho[3] (2020)	Case series; 4	2002-2005	9	39 (9 M/27 F)	12.8 ± 1.7	36.7 ± 11.3 (16-59)	Acetabular dysplasia (center-edge angle <20°)	▪ Tönnis grades, n (%) 0: 4 (10.3) 1: 24 (61.5) 2: 8 (20.5) 3: 3 (7.7) ▪ LCEA: 8.7° (–9° to 18°)
Wyles[38] (2018)	Retrospective cohort study; 3	2013-2015	13	39 (5 M/34 F)	1	27.1 ± 7.4	Symptomatic developmental dysplasia (LCEA <25°)	▪ LCEA: 17.6° ± 5.8° ▪ Tönnis angle: 14.1° ± 10.6° ▪ Tönnis grades, n (%) 0: 23 (59) 1: 16 (41)

(continued)

Table 1 (continued)

Lead Author (Year)	Study Type; LOE	Study Period	MINORS Score	No. of Hips, n (Sex) [b]	Follow-up, y[c]	Age, y[c]	Indications	Radiologic Findings
Panos[31] (2021)	Retrospective cohort study; 3	2009-2016	13	17 (4 M/13 F)	3.2	20.4 ± 4	▪ Symptomatic developmental dysplasia (LCEA <25°) ▪ Acetabular retroversion	Developmental dysplasia: ▪ Tönnis grades, n (%) 0:13 (76.5) 1: 4 (23.5) ▪ LCEA: 26.4° ± 7° Acetabular retroversion: ▪ Acetabular inclination: 10.1° ± 16.4° ▪ Alpha angle: 54.5° ± 9.9° ▪ Retroversion index: 36.8 ± 6.2

[a]Values are reported as mean ± SD (range) unless otherwise indicated. F, female; LCEA, lateral center-edge angle; LOE, level of evidence; M, male; MINORS, methodologic index for non-randomized studies.
[b]Reported as the number of hips or patients.
[c]Reported as mean ± SD. Values in parentheses are ranges.

TABLE 2
Summary of Survivorship Rates (n = 7 studies)[a]

	Secondary Hip Preservation Procedure			Conversion to THA/THR			
Lead Author (Year)	No. of Procedures	Rate, %	Mean Time to Procedure, mo	No. of Procedures	Rate, %	Mean Time to Procedure, mo	Overall Secondary Surgery Rate, %
Domb[7] (2015)	0	0	—	0	0	—	0
Maldonado[25] (2019)	NR	NR	NR	0	0	—	0
Jimenez[15] (2022)	2	6.9	NR	1	3.4	NR	10.3
Sabbag[34] (2019)	13	5	NR	0	0	—	5
Kim[18] (2011)	NR	NR	NR	0	0	—	0
Edelstein[9] (2021)	5	7	2.8 years	2	3	33	10
Cho[3b] (2020)	0	0	—	1	2.6	7.8 years	2.6

[a]Values are reported as mean unless otherwise indicated. Dashes indicate areas not applicable. NR, not reported; THA, total hip arthroplasty; THR, total hip replacement.
[b]Study did not report secondary surgeries specific to periacetabular osteotomy + hip arthroscopy groups.

arthroscopy and PAO. Further, Okoroafor et al[30] reported on 66 hips undergoing isolated PAO in which there were no conversions to THA at a minimum 5-year follow-up. These low rates of conversion to THA at midterm follow-up are similar to reports in patients undergoing PAO and concurrent hip arthroscopy. Maldonado et al[25] and Kim et al reported no conversions to THA, and Edelstein et al[9] and Cho et al[3] reported rates of conversion to THA ≤3%—all in patients undergoing a combined procedure.

Overall, the addition of the concomitant hip arthroscopy and PAO resulted in favorable clinical outcomes and low revision rates, identifying the procedure as promising to address concurrent labral pathology. Previous literature has reported on high rates of failed hip arthroscopies in the dysplastic population that has been steadily increasing over the years, with a failure rate[13] as high as 12%. Larson et al[21] reported a failure rate of >30% when using hip arthroscopy to treat dysplasia. Combined treatments for dysplasia and labral tears are a necessity, as there is a high incidence of patients diagnosed with both labral tears[1,37] and dysplasia.[10,20] The previous review by Lodhia et al[23] reported on 17 patients with concurrent hip arthroscopy and PAO, whereas the present review included 553 cases of combined hip arthroscopy and PAO.

Strengths and Limitations

This study has several strengths. First, this systematic review provides aggregate outcomes and survivorships in a patient population where data are scarce. Second, outcomes have qualitatively been contextualized with clinical benefits when available. Third, the wide study period accounts for evolution of surgical techniques and labral preservation.

A limitation of this review is that all included studies were retrospective and had level 4 or level 3 evidence. The lack of randomization and quality of the studies may introduce bias and limit the external validity of the review. Second, labral treatment may have evolved over the wide study period captured by included articles, which may influence outcomes. Third, articles included various PROs, which did not allow for accurate comparison. Fourth, some studies did not report clinical benefit markers, which does not allow qualitative evaluation of postoperative outcomes. Fifth, the included studies may be underpowered with small patient populations that may not capture larger trends in outcomes and survivorship. Sixth, 3 studies[7,15,25] were from the same institution, which may disproportionately represent results and practices from specific orthopaedic surgeons. Seventh, some studies had patients with short-term follow-up of <2 years, which may make survivorship difficult to interpret. Eighth, heterogeneity was not analyzed for the studies and the present study did not calculate I^2 values. Last, only 1 article described the outcomes of combined PAO and hip arthroscopy in athletes.[15]

CONCLUSION

Patients who underwent concomitant hip arthroscopy and PAO reported favorable outcomes, with 7 of the 9 studies that provided PRO scores indicating significant preoperative to postoperative improvement.

REFERENCES

1. Bonazza NA, Homcha B, Liu G, Leslie DL, Dhawan A. Surgical trends in arthroscopic hip surgery using a large national database. *Arthroscopy*. 2018;34(6):1825-1830. doi:10.1016/j.arthro.2018.01.022
2. Chahal J, Thiel GSV, Mather RC, Lee S, Salata MJ, Nho SJ. The minimal clinical important difference (MCID) and patient acceptable symptomatic state (PASS) for the modified Harris Hip Score and Hip Outcome Score among patients undergoing surgical treatment for femoroacetabular impingement. *Orthop J Sports Med*. 2014;2(suppl 2):2325967114S00105. doi:10.1177/2325967114S00105
3. Cho YJ, Kim KI, Kwak SJ, Ramteke A, Yoo MC. Long-term results of periacetabular rotational osteotomy concomitantly with arthroscopy in adult acetabular dysplasia. *J Arthroplasty*. 2020;35(10):2807-2812. doi:https://doi.org/10.1016/j.arth.2020.05.045
4. Clohisy JC, Ackerman J, Baca G, et al. Patient-reported outcomes of periacetabular osteotomy from the prospective ANCHOR cohort study. *J Bone Joint Surg Am*. 2017;99(1):33-41. doi:10.2106/JBJS.15.00798
5. Clohisy JC, Schutz AL, St John L, Schoenecker PL, Wright RW. Periacetabular osteotomy: a systematic literature review. *Clin Orthop Relat Res*. 2009;467(8):2041-2052. doi:10.1007/s11999-009-0842-6
6. Curley AJ, Owens JS, Jimenez AE, et al. Arthroscopic subspine decompression is commonly reported in a heterogenous patient population with concomitant procedures: a systematic review. *Arthroscopy*. 2022;38(8):2529-2542. doi:10.1016/j.arthro.2022.01.049
7. Domb BG, LaReau JM, Hammarstedt JE, Gupta A, Stake CE, Redmond JM. Concomitant hip arthroscopy and periacetabular osteotomy. *Arthroscopy*. 2015;31(11):2199-2206. doi:10.1016/j.arthro.2015.06.002
8. Dwyer MK, Tumpowsky C, Boone A, Lee J, McCarthy JC. What is the association between articular cartilage damage and subsequent THA 20 years after hip arthroscopy for labral tears? *Clin Orthop Relat Res*. 2019;477(5):1211-1220. doi:10.1097/CORR.0000000000000717
9. Edelstein AI, Nepple JJ, Abu-Amer W, Pascual-Garrido C, Goss CW, Clohisy JC. What mid-term patient-reported outcome measure scores, reoperations, and complications are associated with concurrent hip arthroscopy and periacetabular osteotomy to treat dysplasia with associated intraarticular abnormalities? *Clin Orthop Relat Res*. 2021;479(5):1068-1077.
10. Engesæter IØ, Laborie LB, Lehmann TG, et al. Prevalence of radiographic findings associated with hip dysplasia in a population-based cohort of 2081 19-year-old Norwegians. *Bone Joint J*. 2013;95-B(2):279-285. doi:10.1302/0301-620X.95B2.30744
11. Groh MM, Herrera J. A comprehensive review of hip labral tears. *Curr Rev Musculoskelet Med*. 2009;2(2):105-117. doi:10.1007/s12178-009-9052-9
12. Haene RA, Bradley M, Villar RN. Hip dysplasia and the torn acetabular labrum: an inexact relationship. *J Bone Joint Surg Br*. 2007;89(10):1289-1292. doi:10.1302/0301-620X.89B10.17319
13. Haynes JA, Pascual-Garrido C, An TW, Nepple JJ; ANCHOR Group; Clohisy JC. Trends of hip arthroscopy in the setting of acetabular dysplasia. *J Hip Preserv Surg*. 2018;5(3):267-273. doi:10.1093/jhps/hny026
14. Hohmann E, Feldman M, Hunt TJ, Cote MP, Brand JC. Research pearls: how do we establish the level of evidence? *Arthroscopy*. 2018;34(12):3271-3277. doi:10.1016/j.arthro.2018.10.002
15. Jimenez AE, Lee MS, Owens JS, Maldonado DR, LaReau JM, Domb BG. Athletes undergoing concomitant hip arthroscopy and periacetabular osteotomy demonstrate greater than 80% return-to-sport rate at 2-year minimum follow-up. *Arthroscopy*. 2022;38(9):2649-2658. doi:10.1016/j.arthro.2022.02.017
16. Jimenez AE, Lee MS, Owens JS, Paraschos OA, Maldonado DR, Domb BG. Competitive athletes who underwent hip arthroscopy with capsular repair showed greater improvement in patient-reported outcome scores compared with those who did not undergo repair. *Arthroscopy*. 2022;38(11):3030-3040. doi:10.1016/j.arthro.2022.04.010
17. Kain MSH, Novais EN, Vallim C, Millis MB, Kim YJ. Periacetabular osteotomy after failed hip arthroscopy for labral tears in patients with acetabular dysplasia. *J Bone Joint Surg Am*. 2011;93(suppl 2):57-61. doi:10.2106/JBJS.J.01770
18. Kim KI, Cho YJ, Ramteke AA, Yoo MC. Peri-acetabular rotational osteotomy with concomitant hip arthroscopy for treatment of hip dysplasia. *J Bone Joint Surg Br*. 2011;93-B(6):732-737. doi:10.1302/0301-620X.93B6.25809
19. Kraeutler MJ, Garabekyan T, Pascual-Garrido C, Mei-Dan O. Hip instability: a review of hip dysplasia and other contributing factors. *Muscles Ligaments Tendons J*. 2016;6(3):343-353. doi:10.11138/mltj/2016.6.3.343
20. LaPrade MD, Melugin HP, Hale RF, et al. Incidence of hip dysplasia diagnosis in young patients with hip pain: a geographic population cohort analysis. *Orthop J Sports Med*. 2021;9(3):2325967121989087. doi:10.1177/2325967121989087
21. Larson CM, Ross JR, Stone RM, et al. Arthroscopic management of dysplastic hip deformities: predictors of success and failures with comparison to an arthroscopic FAI cohort. *Am J Sports Med*. 2016;44(2):447-453. doi:10.1177/0363546515613068
22. Lee JK, Hwang DS, Kim SB, et al. The role and clinical relevance of the ligamentum teres: long-term outcomes after hip arthroscopic surgery of cam-type femoroacetabular impingement. *J Hip Preserv Surg*. 2021;8(4):360-366. doi:10.1093/jhps/hnab080
23. Lodhia P, Chandrasekaran S, Gui C, Darwish N, Suarez-Ahedo C, Domb BG. Open and arthroscopic treatment of adult hip dysplasia: a systematic review. *Arthroscopy*. 2016;32(2):374-383. doi:10.1016/j.arthro.2015.07.022
24. Maldonado DR, Chen JW, Lall AC, et al. Microfracture in hip arthroscopy. Keep it simple! *Arthrosc Tech*. 2019;8(9):e1063-e1067. doi:10.1016/j.eats.2019.05.020
25. Maldonado DR, LaReau JM, Perets I, et al. Outcomes of hip arthroscopy with concomitant periacetabular osteotomy, minimum 5-year follow-up. *Arthroscopy*. 2019;35(3):826-834.
26. Mansor Y, Perets I, Close MR, Mu BH, Domb BG. In search of the spherical femoroplasty: cam overresection leads to inferior functional scores before and after revision hip arthroscopic surgery. *Am J Sports Med*. 2018;46(9):2061-2071. doi:10.1177/0363546518779064
27. Marland JD, Horton BS, West HS, Wylie JD. Association of radiographic markers of hip instability and worse outcomes 2 to 4 years after hip arthroscopy for femoroacetabular impingement in female patients. *Am J Sports Med*. 2022;50(4):1020-1027. doi:10.1177/03635465211073341

28. McCarthy JC, Lee JA. Acetabular dysplasia: a paradigm of arthroscopic examination of chondral injuries. *Clin Orthop Relat Res*. 2002;(405):122-128. doi:10.1097/00003086-200212000-00014
29. Nepple JJ, Graesser EA, Wells J, Clohisy J. Borderline acetabular dysplasia: independent predictors of hip instability versus impingement. *Orthop J Sports Med*. 2019;7(suppl 3):2325967119S0001. doi:10.1177/2325967119S00018
30. Okoroafor UC, Pascual-Garrido C, Schwabe MT, Nepple JJ, Schoenecker PL, Clohisy JC. Activity level maintenance at midterm follow-up among active patients undergoing periacetabular osteotomy. *Am J Sports Med*. 2019;47(14):3455-3459. doi:10.1177/0363546519881421
31. Panos JA, Gutierrez CN, Wyles CC, et al. Addressing intraarticular pathology at the time of anteverting periacetabular osteotomy for acetabular retroversion is associated with better short-term patient-reported outcomes. *J Hip Preserv Surg*. 2021;8(1):90-104. doi:10.1093/jhps/hnab040
32. Perets I, Chaharbakhshi EO, Hartigan DE, Ortiz-Declet V, Mu B, Domb BG. The correlation between arthroscopically defined acetabular cartilage defects and a proposed preoperative delayed gadolinium-enhanced magnetic resonance imaging of cartilage index in hips of patients with femoroacetabular impingement syndrome. *Arthroscopy*. 2018;34(4):1202-1212. doi:10.1016/j.arthro.2017.10.023
33. Ricciardi BF, Mayer SW, Fields KG, Wentzel C, Kelly BT, Sink EL. Patient characteristics and early functional outcomes of combined arthroscopic labral refixation and periacetabular osteotomy for symptomatic acetabular dysplasia. *Am J Sports Med*. 2016;44(10):2518-2525. doi:10.1177/0363546516651829
34. Sabbag CM, Nepple JJ, Pascual-Garrido C, Lalchandani GR, Clohisy JC, Sierra RJ. The addition of hip arthroscopy to periacetabular osteotomy does not increase complication rates: a prospective case series. *Am J Sports Med*. 2019;47(3):543-551. doi:10.1177/0363546518820528
35. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. *ANZ J Surg*. 2003;73(9):712-716.
36. Swarup I, Zaltz I, Robustelli S, Sink E. Outcomes of periacetabular osteotomy for borderline hip dysplasia in adolescent patients. *J Hip Preserv Surg*. 2020;7(2):249-255. doi:10.1093/jhps/hnaa012
37. Westermann RW, Day MA, Duchman KR, Glass NA, Lynch TS, Rosneck JT. Trends in hip arthroscopic labral repair: an American Board of Orthopaedic Surgery database study. *Arthroscopy*. 2019;35(5):1413-1419. doi:10.1016/j.arthro.2018.11.016
38. Wyles CC, Hevesi M, Bartels DW, Larson DR, Sierra RJ, Trousdale RT. Arthroscopy and arthrotomy to address intra-articular pathology during PAO for hip dysplasia demonstrates similar short-term outcomes. *J Hip Preserv Surg*. 2018;5(3):282-295. doi:10.1093/jhps/hny022
39. Ziran N, Varcadipane J, Kadri O, et al. Ten- and 20-year survivorship of the hip after periacetabular osteotomy for acetabular dysplasia. *J Am Acad Orthop Surg*. 2019;27(7):247-255. doi:10.5435/JAAOS-D-17-00810

APPENDIX TABLE A1
Intraoperative Findings and Surgical Procedures (N = 9 studies)[a]

Lead Author (Year)	Labral Tear, n (%)	Cartilage, n (%)	Ligamentum Teres, n (%)	Surgical Procedures, n (%)
Domb[7] (2015)	Chondrolabral pathology: 17 (100)	Chondrolabral pathology: 17 (100)	NR	Labral repair: 12 Labral debridement: 5 Iliopsoas fractional lengthening: 4 Acetabular chondroplasty: 3 Loose body removal: 1
Maldonado[25] (2019)	Seldes: ▪ 0: 1(6.3) ▪ 1: 9 (56.3) ▪ 2: 3 (18.8) ▪ Combined 1 and 2: 3 (18.8)	Acetabular Outerbridge: ▪ 0: 3 (18.8) ▪ 1: 6 (37.5) ▪ 2: 4 (25) ▪ 3: 0 ▪ 4: 3 (18.8) Femoral head Outerbridge ▪ 0: 14 (87.5) ▪ 1: 0 ▪ 2: 2 (12.5) ▪ 3: 0 ▪ 4: 0 ALAD ▪ 0: 0 ▪ 1: 5 (31.3) ▪ 2: 4 (25) ▪ 3: 4 (25) ▪ 4: 3 (18.8)	Partial: 11 (68.8) Complete: 3 (18.8)	Labral repair: 12 (75) Labral debridement: 3 (18.8) Capsular plication/repair: 12 (75) Femoroplasty: 10 (62.5) Acetabular microfracture: 3 (18.8) Acetabular chondroplasty: 5 (31.3) Femoral head chondroplasty: 2 (12.5) Iliopsoas fractional lengthening: 4 (25) Subspine decompression: 6 (37.5)

(continued)

Appendix Table A1 (continued)

Lead Author (Year)	Labral Tear, n (%)	Cartilage, n (%)	Ligamentum Teres, n (%)	Surgical Procedures, n (%)
Jimenez[15] (2022)	Seldes: ▪ 0: 0 ▪ 1: 7 (24.1) ▪ 2: 14 (48.3) ▪ Combined 1 and 2: 8 (27.6)	Acetabular Outerbridge ▪ 0: 1 (3.4) ▪ 1: 12 (41.4) ▪ 2: 9 (31) ▪ 3: 5 (17.2) ▪ 4: 2 (6.9) Femoral head Outerbridge ▪ 0: 26 (89.7) ▪ 1: 0 ▪ 2: 2 (6.9) ▪ 3: 0 ▪ 4: 1 (3.4) ALAD: ▪ 0: 2 (6.9) ▪ 1: 12 (41.4) ▪ 2: 8 (27.6) ▪ 3: 6 (20.7) ▪ 4: 1 (3.4)	LT percentile (Domb)[c] ▪ 0: 12 (41.4) ▪ 1: 9 (31) ▪ 2: 7 (24.1) ▪ 3: 1 (3.4) LT (Villar)[d] ▪ 0: 12 (41.4) ▪ 1: 1 (3.4) ▪ 2: 15 (51.7) ▪ 3: 1 (3.4)	Labral repair: 25 (86.2) Labral selective debridement: 4 (13.8) Capsular repair: 27 (93.1) Femoroplasty: 26 (89.7) Acetabular microfracture: 2 (6.9) Femoral head: 1 (3.4) Microfracture: 1 (3.4)
Sabbag[34] (2019)	Intra-articular chondrolabral pathology: 248 (100)	Intra-articular chondrolabral pathology: 248 (100)	NR	Acetabular chondroplasty: 95 (38.3) Femoral head/neck osteochondroplasty: 175 (70.6) Open arthrotomy: 161 (64.9) Labral repair: 150 (60.5)
Ricciardi[33] (2016)	Labral tear: 24 (100)	NR	NR	Open osteochondroplasty: (9) Anterior inferior iliac spine debridement: (4) Ligamentum teres debridement: (9) Loose body removal: (13) Labral repair (100)
Kim[18] (2011)	Classification: ▪ Degenerative: 17 ▪ Flap: 3 ▪ Radial: 2 ▪ Longitudinal: 1 ▪ Complex: 2 ▪ Fibrillation: 13	NR	NR	Arthroscopic debridement: 38 (100) Limited labral excision: 16 (53.3)
Edelstein[9] (2021)	Labral grade[b] ▪ 1: 11 (16) ▪ 2: 16 (23) ▪ 3: 1 (1) ▪ 4: 42 (60) ▪ 5: 0	Acetabular cartilage grade[b] ▪ 1: 12 (17) ▪ 2: 15 (21) ▪ 3: 22 (31) ▪ 4: 12 (17) ▪ 5: 9 (13) Femoral head cartilage grade[b] ▪ 1: 62 (89) ▪ 2: 5 (7) ▪ 3: 0 ▪ 4: 1 (1) ▪ 5: 2 (3)	Tear: 9 (13) No tear: 61 (87)	Open femoral head-neck osteochondroplasty: 62 (89) Anterior inferior iliac spine decompression with greater trochanteric osteoplasty: 1 (1) Acetabular chondroplasty: 16 (23) Acetabular microfracture: 6 (9) Labral debridement: 29 (41) Labral refixation: 17 (24)
Cho[3] (2020)	Classification ▪ Degenerative: 15 (38.4) ▪ Flap: 3 (7.7) ▪ Radial: 2 (5.1) ▪ Longitudinal: 1(2.6) ▪ Complex: 2 (5.1) ▪ Fibrillation: 12 (30.8) ▪ Intact: 4 (10.3)	Chondral lesion grade Acetabulum ▪ 0: 16 (41) ▪ 1: 11 (28.2) ▪ 2: 4 (10.3) ▪ 3: 8 (20.5) Femoral head: ▪ 0: 15 (38.5) ▪ 1: 10 (25.6) ▪ 2: 8 (20.5) ▪ 3: 6 (15.4)	NR	Arthroscopic debridement: 39 (100)

(continued)

Appendix Table A1 (continued)

Lead Author (Year)	Labral Tear, n (%)	Cartilage, n (%)	Ligamentum Teres, n (%)	Surgical Procedures, n (%)
Wyles[38] (2018)	NR	NR	NR	Major interventions (labral repair, osteochondroplasty): 26 (67) Minor intervention (labral debridement, acetabular or femoral chondroplasty): 12 (30)

[a]Percentages were not calculated in the article. ALAD, acetabular labrum articular disruption; LT, ligamentum teres; NR, not reported.
[b]Modified Beck classification.
[c]Domb classification: 0 = 0%; 1: 0% to <50%; 2 = 50% to <100%; 3 = 100%.
[d]Villar classification: 0 = no tear; 1 = complete tear; 2 = partial tear; 3 = degenerative.

APPENDIX TABLE A2
Preoperative and Latest Follow-up PRO Scores With Achievement Rates of Clinical Benefits (N = 9 studies)[a]

Lead Author (Year)	PRO Score, Pre vs Post	Achievement Rate, n (%)
Domb[7] (2015)	mHHS: 63.9 vs 84.1 ($P < .001$) NAHS: 57.7 vs 79.5 ($P = .001$) HOS-ADL: 65.4 vs 80.1 ($P = .005$) HOS-SSS: 37.7 vs 74.4 ($P < .001$)	NR
Maldonado[25] (2019)[c]	mHHS: 63.5 ± 10.3 vs 81.6 ± 15.1 ($P < .001$) NAHS: 56.8 ± 20.8 vs 79.8 ± 13.3 ($P < .001$) HOS-SSS: 37.6 ± 23.9 vs 68.1 ± 23 ($P = .001$) iHOT-12: NR vs 66.3 ± 22.4 (P = NR) VAS–pain: 5.8 ± 1.9 vs 3.1 ± 2.5 ($P = .007$) Satisfaction: NR vs 8 ± 2.6 (P = NR)	MCID ▪ mHHS: 13 (81.3) ▪ HOS-SSS: 11 (78.6) PASS ▪ mHHS: 12 (75) ▪ HOS-SSS: 7 (50)
Jimenez[15] (2022)	mHHS: 61.3 ± 14.2 vs 88.3 ± 12.3 ($P < .001$) NAHS: 61.2 ± 15.1 vs 90 ± 9.9 ($P < .001$) HOS-SSS: 43.3 ± 20.1 vs 80.2 ± 12.5 ($P < .001$) VAS pain: 5.1 ± 2.5 vs 1.9 ± 2 ($P < .001$)	MCID ▪ mHHS: 24 (92.3) ▪ NAHS: 24 (92.3) ▪ HOS-SSS: 23 (88.5) ▪ VAS–pain: 19 (73.1) PASS ▪ mHHS: 22 (84.6) ▪ NAHS: 19 (73.1) ▪ HOS-SSS: 20 (76.9) RTS: (81.8)
Ricciardi[33] (2016)[c]	mHHS: 58 ± 13 vs 83 ± 14 (P = NR) HOS-ADL: 69 ± 14 vs 91 ± 13 (P = NR) HOS-SSS: 41 ± 20 vs 80 ± 23 (P = NR) IHOT-33: 30 ± 15 vs 84 ± 13 (P = NR)	MIC ▪ mHHS (100) ▪ HOS-ADL (79) ▪ HOS-SSS (79) ▪ iHOT-12 (100)
Kim[18] (2011)	HHS: 72.4 (60-83) vs 94 (76-100) ($P < .0001$)	NR
Edelstein[9] (2021)	mHHS: 55 ± 19 vs 85 ± 17 ($P < .001$) WOMAC: 9.1 ± 4.3 vs 3.2 ± 3.9 ($P < .001$) UCLA: 6.5 ± 2.7 vs 7.5 ± 2.2 ($P = .01$)	NR
Cho[3] (2020)	HHS: 72 (60-83) vs 90 (68-100) ($P < .001$)	Clinical success (HHS >80): 33 (84.6)
Wyles[38] (2018)	UCLA: 6 ± 2.7 vs NR (P = NR) HHS: 59.7 ± 15.8 vs NR (P = NR) HOOS–Pain: 53.8 ± 17.3 vs NR (P = NR) HOOS–Symptoms: 51.3 ± 20 vs NR (P = NR) HOOS-ADL: 66.1 ± 20.3 vs NR (P = NR) HOOS–Sport/Rec: 37.3 ± 22.3 vs NR (P = NR) HOOS-QOL: 28.5 ± 18.5 vs NR (P = NR) WOMAC–Pain: 60.0 ± 18.5 vs NR (P = NR) WOMAC–Stiffness: 51 ± 23.7 vs NR (P = NR) WOMAC–Physical: 66.1 ± 20.3 vs NR (P = NR) WOMAC total: 63.9 ± 19.2 vs NR (P = NR) SF-12 PCS: 35.6 ± 9.4 vs NR (P = NR) SF-12 MCS: 52.9 ± 9.5 vs NR (P = NR)	NR

(continued)

Appendix Table A2 (continued)

Lead Author (Year)	PRO Score, Pre vs Post	Achievement Rate, n (%)
Panos[31] (2021)	UCLA: 6.4 ± 2.9 vs 7 ± 2.2 (P = .55) HHS: 56.3 ± 21.7 vs 78.7 ± 20.8 (P = .023) HOOS–Pain: 57.3 ± 20.1 vs 77.7 ± 22.3 (P = .004) HOOS-ADL: 68.2 ± 22.8 vs 87.3 ± 14 (P = -.006) HOOS–Sport/Rec: 41.3 ± 21.5 vs 70.1 ± 28.8 (P = .004) HOOS-QOL: 31.3 ± 21.1 vs 61.2 ± 25 (P = .005) WOMAC–Pain: 64.3 ± 22.6 vs 81.8 ± 22.8 (P = .015) WOMAC–Stiffness: 51.7 ± 27.5 vs 76.7 ± 18.2 (P = .004) WOMAC–Physical: 68.2 ± 22.8 vs 88.2 ± 13.9 (P = .003) WOMAC total: 66 ± 22.2 vs 85.1 ± 14.8 (P = .005) SF-12 PCS: 35.4 ± 10.6 vs 47.3 ± 13.5 (P = .020) SF-12 MCS: 52.7 ± 10.4 vs 52.5 ± 9 (P = .67)	NR[b]

[a]Values are reported as mean, mean ± SD, or mean (range). N was not reported in the study by Ricciaridi et al.[33]–only percentage was reported. ADL, Activities of Daily Living; HHS, Harris Hip Score; HOS, Hip Outcome Score; iHOT, International Hip Outcome Tool; MIC; minimally important change; MCID, minimal clinically important difference; MCS, Mental Component Summary; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; NR, not reported; PASS, Patient Acceptable Symptom State; PCS, Physical Component Summary; Post, postoperative; Pre, preoperative; PRO, patient-reported outcome; QOL, Quality of Life; RTS, return to sport; SF-12, 12-Item Short Form Health Survey; Sport/Rec, Sport and Recreation; SSS, Sports-Specific Subscale; UCLA, University of California Los Angeles activity scale; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Score.

[b]The MCID was reported, but there was no proportion or number of patients reported that achieved the MCID for the concomitant periacetabular osteotomy and hip arthroscopy group.

[c]Maldonado et al[25]: n = 14 for HOS-SSS; Ricciardi et al[33]: n = 16 for mHHS, n = 14 for HOS-ADL, n = 13 for HOS–Sport, n = 12 for iHOT-33.