Rate of Revision Hip Arthroscopy for Pediatric Femoroacetabular Impingement: A Systematic Review

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Abstract

Femoroacetabular impingement (FAI) can cause pain, dysfunction, and early arthritic progression in young patients. The purpose of this study was to systematically review the evidence in literature to determine patient-reported outcomes and failure rates as defined by the need for revision surgery, following hip arthroscopy for pediatric patients with FAI. The literature search was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Clinical studies evaluating the outcomes following primary hip arthroscopy for pediatric patients with FAI were included. Clinical outcomes evaluated included revisions, complications, functional outcome scores (modified Hip Harris Score [mHHS], Non-Arthritis Hip Score, and Visual Analogue Score), and return to play. Statistical analysis was performed using GraphPad Prism version 7. This study is a level IV systematic review. Overall, 20 clinical studies with 1,136 patients (1,223 hips) were included in this review, with an average age of 16.3 years. Overall, 8.6% patients experienced revision surgery. The mHHS was the most widely used metric, present in 17 of the 20 studies. The mHHS was reported as excellent (> 90) in six of these studies and good (80–89) in 11. The weighted mean of the post-operative mHHS found across reporting studies was 84.3, from a baseline score of 58.1. The overall return to play rate was 91%. This study reports excellent post-hip arthroscopy clinical outcomes for FAI and labral tears in the pediatric population. However, revision rates for this surgical procedure are higher than previously documented.

Keywords
- FAI
- pediatric
- systematic review
- revision

Femoroacetabular impingement (FAI) can cause pain, dysfunction, and early arthritic progression in young patients. FAI refers to the morphological abnormality of the bone on the acetabular rim (pincer lesion) and the femoral neck (cam lesion) or a combination of the two.[1–4] Labral tears are common in FAI due to repetitive abnormal contact between the bone and the chondrolabral junction, occurring in up to 55% of patients with mechanical symptoms.[5] FAI can affect pediatric patients, with youth sports being a risk factor in its development due to excessive stress on the growing hip.[6,7]

Hip arthroscopy, while technically challenging, is increasingly being performed to treat FAI and correct the pathological morphology.[8–10] However, the evidence supporting the use of hip arthroscopy for FAI in pediatric patients is limited, with prophylactic surgery in the asymptomatic hip being contraindicated, even in the context of predisposing anatomy.[11] Additionally, many patients in the pediatric

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population can be managed non-operatively quite successfully.[12] Despite this, there is a bias not only in the clinic but also in the literature toward the surgical management of FAI, with further bias toward older demographics. The majority of the literature consists of retrospective case series and studies focusing primarily on surgical management of adult patients.

Chen et al[13] performed a systematic review looking at adolescent return to play following hip arthroscopy for FAI. They found 10 studies that included 618 patients, demonstrated a return to play rate of 84.9%, and had a 3.1% revision rate. However, multiple other studies that did not report the rate of return to play were excluded in that review. This must be considered when evaluating overall outcomes and failure rates for this population. Additionally, Migliorini and Maffulli[14] found among 10 studies and 406 pediatric patients that there was a 4.7% revision rate in their systematic review; however, this study failed to include many of the available studies in the literature.

The purpose of this study was to systematically review the current published evidence to determine patient-reported outcomes and failure rates following hip arthroscopy for pediatric patients with FAI. Our hypothesis was that there would be excellent patient-reported outcomes with a low failure rate.

Methods

Search Strategy and Study Selection

Two independent reviewers conducted the literature search based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The MEDLINE, EMBASE, and Cochrane Library databases were queried in March 2021 using the following search terms: (femoroacetabular or FAI or hip or coxa or acetabulofemoral joint) and (impingement) and (repair or refixation or preservation or reattachment or debridement or resection). The independent authors reviewed articles from the search for the relevance of this particular study, with the lead author deciding upon inclusion in cases of disagreement. Upon reviewing the abstract, papers that were deemed relevant to the research question were then thoroughly reviewed. The reference lists of articles considered suitable for this study were then manually screened for additional works that did not arise in the primary search.

Eligibility Criteria

The inclusion criteria for this analysis were as follows: (1) study analyzing outcomes of patients undergoing hip arthroscopy for FAI who are less than 18 years of age, (2) published in a peer-reviewed journal, (3) published in English, (4) full text assessment of studies available, and (5) having a minimum follow-up time of 6 months. Study designs including randomized controlled trials, prospective cohort studies, retrospective cohort studies, and case-control studies were considered for inclusion. The exclusion criteria included (1) review studies, (2) cadaver studies, (3) biomechanical studies, and (4) conference abstract only.

Data Extraction/Analysis

Information was pulled from the selected studies using a data sheet predetermined by the research team. Data included study design, level of evidence (LOE), the methodological quality of evidence (MQOE), patient population and demographics, and outcomes, including patient-reported and surgical measures. The modified Coleman scale was used to compute the MQOE for each study.[15] The modified Coleman score is scaled from 0 to 100 points, with an increasing score denoting a study that better avoids chance, biases, and confounding factors. The Coleman score components are modeled after the Consolidated Standards of Reporting Trials statement, with modifications to allow for the analysis of various study types.

The reasons for revision were also collected across the various studies analyzed. As the reasons were reported with different verbiage depending on the author of study, several factors were selected by the authors as agreed upon after the review of the literature. These factors included: FAI recurrence, capsulolabral adhesions, overuse, continuous pain, re-injury, snapping hip, heterotopic ossification, and inability to return to the same level of activity. A frequently encountered term was "recurrence of FAI symptoms," which was decided by the authors to be synonymous with continuous pain.

Statistical Analysis

Statistical analysis was performed using GraphPad Prism version 7. Qualitative analysis was performed for each study, and quantitative analysis was performed across all groups.

Results

Literature Search

The initial literature search resulted in 2,607 total studies. Once duplicates were removed and the articles were screened for inclusion and exclusion criteria, 1,384 studies were included, and full texts were assessed for eligibility. Overall, 20 clinical studies with 1,136 patients (1,223 hips) were included in this review (►**Fig. 1**).[13,16–35]

Study Characteristics and Patient Demographics

Overall, 20 studies (LOE II: 2, LOE III: 5, and LOE IV: 14) reported the outcomes of hip arthroscopy for FAI in the pediatric population. The mean modified Coleman's was 56.1. The mean age of the studied population was 16 years (12–18 years). Patients undergoing FAI surgery had a mean α angle of 61.0 ± 10.4 and a mean lateral center edge angle (LCEA) of 30.3 ± 8.5. The study characteristics and patient demographics are shown in ►**Table 1**.

Patient-Reported Outcomes

Overall, weighted means of patient follow-up demonstrated a range from 11.5 to 47.3 months, with a weighted average follow-up of 38.2 months. In the studies analyzed, modified Hip Harris Score (mHHS), Non-Arthritis Hip Score (NAHS), and Visual Analogue Score (VAS) were the most commonly reported.

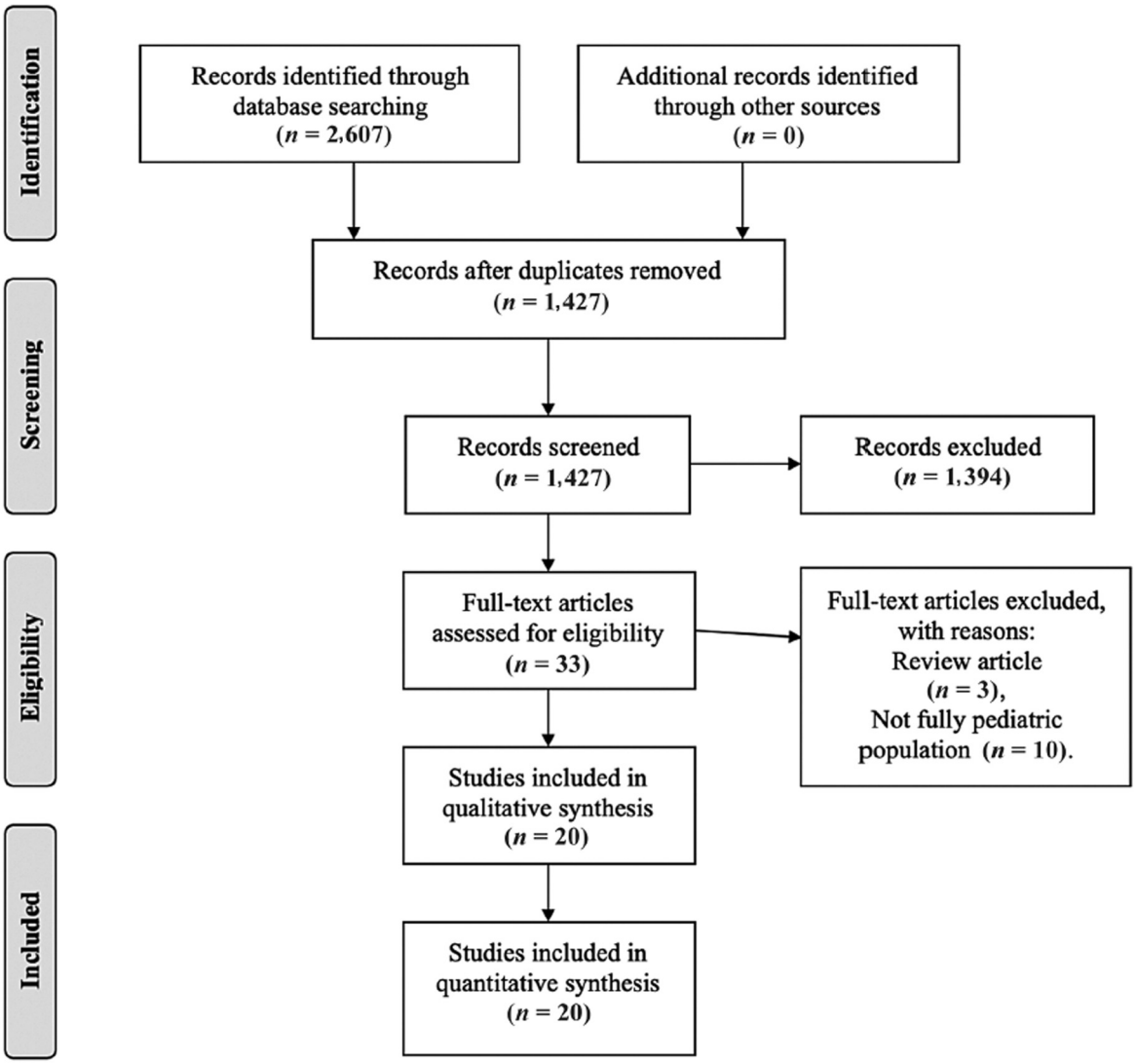

Fig. 1 PRISMA study selection flow diagram.

The mHHS was the most widely used metric, present in 17 of the 20 studies. The mHHS was reported as excellent (> 90) in six of these studies and good (80–89) in 11. The weighted mean of the postoperative mHHS found across reporting studies was found to be 84.3 from a baseline score of 58.2. In all of these reporting studies, there was a significant increase in pre-operative values, meeting minimal clinically important difference (MCID) and patient acceptable symptomatic state for the values reported in the literature.[36] Although the average patient studied reached the threshold of change in mHHS that qualifies for MCID at final follow-up, Beck et al, Cvetanovich et al, and Larson et al further quantify the rate at which the studied patient population achieved MCID at 88.4, 84.0, and 81.2% of their population meeting the threshold, respectively.

NAHS was also reported in five studies, with three studies reporting excellent outcomes (> 90) and two studies reporting good outcomes (80–89). Baseline score for NAHS through weighted means was found to be 71, rising to 95 upon final follow-up. VAS was reported in six studies, with all studies demonstrating a significant decrease in pain post-operatively. VAS was found to have a weighted mean baseline score of 5.9, recovering to 1.8 upon final follow-up. These results are further illustrated in ►**Table 2**.

Return to Sport

Return to sport among adolescents undergoing hip arthroscopy was investigated in six of the analyzed studies. Upon final follow-up, the return to play rate was determined to be 91%. Additionally, Willimon et al studied the amount of time it took for the pediatric population to return to school, finding a mean length of 10.8 days (standard deviation 5.1). These results are further illustrated in ►**Table 3**.

Complications and Revisions

The most common complication reported after FAI surgery was a neurological deficit. Transient numbness and nerve paresthesia most frequently occurred along the perineal and

Table 1 Study characteristics

Author	LOE	Coleman	Patients (*n*)	Hips (*n*)	LCEA (degrees)	Alpha angle (degrees)	Age (y)	Follow-up (mo)
Arashi et al	3	61	33	36	32	63	16.7 (12–17)	40 and 60
Ashberg et al	2	75	157	157	29.2	58.3	16.6 (13.2–17.9)	38.5 (24–89.9)
Beck et al	4	59	85	85	30.1 ± 6	63.6 ± 12.2	17.60	60
Byrd et al	4	72	104	116		59.9	16.00	38 (24–120)
Chandrasekaran et al	4	61	90	90	31.6	59.5	16.30	30.6 (24.1–60)
Cvetanovich et al	4	62	37	37	32.2 ± 4.8	59.4 ± 7.5	17 (12.8–18.3)	28.3
Degen et al	3	43	34	38	33 ± 5.1	65.2 ± 7.1	15.9 (10.8–18.0)	36.1
Fabricant et al	4	54	21	27		64 ± 16	17.60	18 (12–30)
Larson et al	4	52	28	37	30.7	60.9	15.90	39.8 (12.1–86.5)
Litrenta et al	4	64	69	81	28.5 ± 18.4	57.7 ± 11.6	15.9 (14–18)	45.2
McConkey et al	2	69	24	36			15.70	24
Menge et al	4	75	60	70	38 ± 5	67 ± 14	16.00	120
Mohan et al	4	37	50	57	31	54	17 (13–23)	34 (24–77)
Newman et al	3	51	42	42	33 ± 9	68 ± 14	16 (10–19)	43
Nwachukwu et al	4	37	47	47	31.2 ± 6.5	57 ± 12.4	16.5 (11–18)	12
Philippon et al	4	66	60	65	36	64	15.00	36 (24–60)
Richard et al	2	49	58	58			15.53 (10.4–20.5)	6
Tran et al	4	57	34	41			15.70	14 (12–24)
Willimon et al	4	26	17	17			15.30	
Youngman et al	3	48	86	86	31.6	61.7	16.50	37 (12–121)

Abbreviations: LCEA, lateral center edge angle; LOE, level of evidence.

Table 2 Patient-reported outcomes

Author	Pre-op mHHS	Post-op mHHS	*p*-Value	MCID for mHHS	Pre-op NAHS	Post-op NAHS	*p*-Value	Pre-op VAS	Post-op VAS	*p*-Value
Arashi et al		98				97				
Ashberg et al	64.8	84.1	**$p < 0.001$,**		65.9	99.4	**$p < 0.001$,**	5.80	1.9	**0.001**
Beck et al	58.9	85.1	**$p < 0.001$,**	88.40%			**$p < 0.001$,**	6.79	2.44	**0.001**
Byrd et al	69	94	**$p < 0.001$,**							
Chandrasekaran et al	64.5	89.6	**$p < 0.001$,**		65.3	89.9	**$p < 0.001$,**	6.07	2.16	**0.001**
Cvetanovich et al	58.1	86.9	**$p < 0.001$,**	84.00%						
Degen et al	63.8	86	**$p < 0.001$,**							
Fabricant et al	67	88	**$p < 0.001$,**							
Larson et al	66.8	94.5	**$p < 0.001$,**	81.20%				5.90	1.2	**0.001**
Litrenta et al	64.6	88.1	**$p < 0.001$,**		66.8	89.8	**$p < 0.001$,**	5.50	1.6	**0.001**
McConkey et al										
Menge et al	56	88	**< 0.0001**							
Mohan et al	64	85	**0.04**							
Newman et al	57.5	84.2								

Table 2 (*Continued*)

Author	Pre-op mHHS	Post-op mHHS	*p*-Value	MCID for mHHS	Pre-op NAHS	Post-op NAHS	*p*-Value	Pre-op VAS	Post-op VAS	*p*-Value
Nwachukwu et al	61.6	90	< **0.0001**							
Philippon et al	57	91	**0.005**							
Richard et al										
Tran et al	77.39	94.15	< **0.0005**		76.34	93.18	< **0.0005**			
Willimon et al										
Youngman et al	62.8	86.5	< **0.0001**							

Abbreviations: MHHS, modified Hip Harris Score; NAHS, Non-Arthritis Hip score; post-op, postoperative; pre-op, preoperative; VAS, Visual Analogue Score.
Note: Bold values highlight statistical significance.

Table 3 Return to play of selected studies

Author	Athletes (*n*)	RTP total—return to play (%)
Cvetanovich et al	29	29 (100)
Larson et al	28	26 (93)
Litrenta et al	69	58 (84)
McConkey et al	24	24 (100)
Mohan et al	50	46 (92)
Tran et al	32	29 (91)

lateral femoral cutaneous nerves. Litrenta et al described four cases of temporary unspecified numbness occurring in 81 of the operated upon hips. McConkey et al and Byrd et al reported two transient left femoral cutaneous and two transient perineal nerve paresthesias, respectively. There were few infections, with Litrenta et al reporting two minor infections. There were a total of 82 revisions in the literature. Therefore, 8.6% of the 959 hips in those studies investigating revision rates experienced revision surgery, at a mean time of 23.7 months. Revision procedures were qualified as labral repair, capsular release/plication, lysis of adhesions, and removal of loose bodies most commonly, although they were scarcely specified upon in the studies analyzed. The revisions and complications are further reported in ►**Table 4**.

The most common reasons for revision surgery were continuous pain and re-injury of the hip, with incidences of 14 (17%) and 17 (21%), respectively. Additionally, 5.0% of those that underwent revision surgery for the recurrence of FAI morphology, such as cam regrowth. These revisions are further illustrated in ►**Table 5**.

Table 4 Complications and revisions

Author	Complications	Revision	Time until revision (mean[range])
Arashi et al	0	6	19.5
Ashberg et al		20	
Beck et al	Two transient nerve paresthesia along perineal nerve	2	
Byrd et al	0	4	17.8 (6.9–41.5)
Chandrasekaran et al	One case of pudendal neuropraxia; one wound dehiscence	5	13.4 (8.2–22.1)
Cvetanovich et al	0		
Degen et al	0	2	
Litrenta et al	Two transient nerve paresthesia along lateral cutaneous nerve	6	37.3 (7.9–74.2)
McConkey et al		0	
Menge et al		7	
Mohan et al		3	
Newman et al		6	
Philippon et al		8	26 (10–46)
Tran et al	0		
Youngman et al	0	10	

Note: Time until revision given in months.

Table 5 Reasons for revisions

Reason for revision	*n* (%)
FAI recurrence	4 (5)
Capsulolabral adhesions	9 (11)
Overuse	3 (4)
Continuous pain	14 (17)
Re-injury	17 (21)
Snapping hip	4 (5)
Heterotopic ossification	3 (4)
Inability to return to the same level	3 (4)
Instability	3 (4)
Unknown	22

Discussion

The most important finding in this review is a revision rate of 8.6% for hip arthroscopy of the pediatric patient, which is higher than previous systematic reviews.[13,37] However, while revision rates were noted to be higher, the pediatric patient demonstrated good, if not excellent, outcomes, as reported by mHHS and NAHS. These outcomes were shown to be significantly improved throughout all 17 studies that looked at baseline and post-operative scores for mHHS and in the five studies that reported NAHS. Similarly, six studies found both a significant decrease in VAS scores and a high return-to-play rate among the athletes that were observed. Nonetheless, it is important to note that while reported outcomes favor arthroscopy, the technical demands of this procedure present various theoretical risks.

Hip arthroscopy in the pediatric population is known to be a particularly challenging procedure, mainly due to anatomical variation in the skeletally immature patient.[2,8,37] A significant decrease in the neck–shaft angle and anteversion must be kept in mind when positioning the patient and care must be taken to respect the open physes. Additionally, due to the immaturity of the acetabulum, theoretical risks of slipped capital femoral epiphysis (SCFE), avascular necrosis, and infection do exist. However, a systematic review by de Sa et al reported no violation of the physes resulting in premature closures, SCFE, or other theoretical and feared complications of arthroscopy of the pediatric hip. This postulates the idea that these risks might solely be theoretical. Furthermore, of the 435 hips studied, only 13 (3.0%) went on to require revision surgery, primarily for lysis of adhesions. Outcomes demonstrated across the review also favored the use of arthroscopy, with significant improvements in patient-reported outcomes among the six studies analyzed.

The findings of this paper are in accordance with the previous literature and continue to affirm good clinical outcomes. Similar to the review by de Sa et al, Chen et al[13] conducted a systematic review focusing on return to sport and also found high post-operative outcome scores. Additionally, of 194 hips analyzed, a return-to-sport rate of 84.9% was reported upon final follow-up, demonstrating tangible results in addition to reported good outcomes. Despite good scores, there seems to be a difference in percentages of the pediatric population achieving MCID as compared with the adult population. Overall, 97% of the adult population was found to reach MCID for mHHS in a systematic review by Levy et al,[38] leaving the rates in the 80s found by this study to be relatively low. This is perhaps due the adolescent population having less severe disease, and therefore, it being more difficult to achieve a significant increase from baseline than their older peers. However, Chen et al reported a revision rate of 3.1%, drawn from six separate studies, which is in line with the findings from de Sa et al. Additionally, Migliorini and Maffulli[14] found among 10 studies and 406 patients that there was a 4.7% revision rate in their systematic review; however, this study failed to include many of the available studies in the literature. The revision rate presented in our paper (8.6%) is higher than rates previously documented, resulting from data including a larger number of hips studied, and thus is more indicative of the population and literature as a whole.

As documented by Litrenta et al and Chandrasekaran et al,[20,25] the primary reasons for revision were recurrence of pain and re-injury. Pediatric populations who undergo surgery are less likely to rest their hip and can do subsequent damage to the vulnerable hip. This was commented on by Ashberg et al[17] who discussed the pediatric populations proclivity toward revision surgery may be due to early return to unrestricted activity. Byrd et al[19] made a similar observation, noting that athleticism in the pediatric population may correlate with the incidence of FAI, in general, reporting that 96% of those patients in their adolescent group were athletes compared with 61% of adults. While adolescents tend to be more active than adults, Menge et al compounded on this rationale stating that of the seven revision surgeries observed all were female and athletes, theorizing that increased athleticism in the pediatric population may lend itself to the need for revision surgery due to re-tear of the labrum or aggravation of the joint. They also documented that hypermobility as reported by Beighton score ($\geq$ 4) was associated with revision surgery ($p = 0.045$), warranting further studies.[27] Increased return to unrestricted activity may contribute to this high revision rate reported, especially, in the context of 4% of adults going back for secondary surgery.[39]

Interestingly, while re-injury and overuse seem to be the primary cause of revisions throughout the investigated literature, Arashi et al.[16] documented four of their six revisions due to cam regrowth in the male population. Although a rare cause of the need for revision in this review, it has been theorized that cam regrowth is a theoretical risk in the skeletally immature patients, due to bony growth potential inherent in this younger population, and was indeed observed in 5% of the studied population.[6,7] At risk for this pathology are those with initial cam morphology, seen in pediatric patients with borderline α angles of 60.1 ± 10.4, as well as more commonly in males.[3,7,16] These at-risk populations become important when determining ideal patient selection, as outcomes seem to correlate.

There are various risk factors that predispose to poorer outcomes, such as dysplasia, older age, and abnormal femoral version. However, the most significant risk factor is the need for revision surgery.[3,9,29,40,41] Newman et al[29] demonstrated in a retrospective cohort study that patients undergoing revision hip arthroscopy for labral tears and FAI had significantly lower improvement and post-operative mHHS scores. These patients also demonstrated poorer sports function (as evaluated by Hip Outcome Score , sports) during the final post-operative visit. This suggests that while pediatric hip arthroscopy indicated for labral tears has excellent clinical outcomes, the need for revision surgery can easily jeopardize the operation's success and is typically triggered with early return to unrestricted activity. Furthermore, as this is a pediatric population, studies with longer-term follow-up are needed to ascertain the true failure rate over time, specifically evaluating if these patients suffer from premature arthritic hip degeneration.

Limitations

This study has several limitations and biases, largely due, in part, to the variable studies reviewed themselves. First, the age range was 12 to 18 years and some patients may be skeletally mature, which may impact the procedure outcomes and it was not possible to sub-stratify by this. While this study revolved around revision rate, certain studies did not report revision rates due to exclusion criteria and others still did not report why the revision was performed. Additionally, studies were included that had less than 1 full year of follow-up. The heterogeneity of the studies was also not evaluated because of the lack of comparative groups. Furthermore, apart from mHHS, there was a lack of consistency in the outcomes used making it difficult to compare across the different studies.

Conclusion

Our study established that clinical outcomes following hip arthroscopy for FAI and labral tears in the pediatric population are excellent. However, revision rates for this surgical procedure might be higher than previously documented. While hip arthroscopy overall is safe and effective in this population, the potential need for revision surgery should be discussed pre-operatively.

Conflict of Interest
None declared.

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