Patients With Borderline Hip Dysplasia Achieve Clinically Significant Improvement After Arthroscopic Femoroacetabular Impingement Surgery

A Case-Control Study With a Minimum 5-Year Follow-up

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Background: Hip arthroscopy for the treatment of femoroacetabular impingement syndrome (FAIS) in patients with borderline hip dysplasia (BHD) is becoming a more common practice. However, the literature on achieving meaningful outcomes at midterm follow-up, as well as predictors of these outcomes, is limited.

Purpose: To (1) compare the rates of achieving meaningful clinical outcomes between patients with and without BHD and (2) identify the predictors for achieving clinical success among patients with BHD 5 years after undergoing hip arthroscopic surgery for FAIS.

Study Design: Cohort study; Level of evidence, 3.

Methods: Data from consecutive patients who underwent primary hip arthroscopic surgery with routine capsular closure for the treatment of FAIS between January 2012 and August 2014 were collected and retrospectively analyzed. Patients with BHD (lateral center-edge angle [LCEA] 20°-25°) were matched 1:2 by age (±1 year) and body mass index (BMI; ±5 kg/m^2) to control patients with normal acetabular coverage (LCEA 25°-40°). Data collected included baseline and 5-year postoperative patient-reported outcomes. The minimal clinically important difference (MCID) and patient acceptable symptom state (PASS) were calculated for each patient-reported outcome measure and compared between the 2 groups. A binary logistic regression analysis was used to identify significant predictors of achieving the MCID and PASS in the BHD group.

Results: The MCID in the BHD group was defined as 9.6, 14.1, and 9.5 for the Hip Outcome Score–Activities of Daily Living, Hip Outcome Score–Sports Subscale, and modified Harris Hip Score, respectively. Threshold scores for achieving the PASS in both groups were 90.9, 76.6, and 81.9, respectively. A total of 88 patients were identified with having BHD and were matched to 176 controls. No statistical differences were identified for age, BMI, or sex. Both the BHD and the non-BHD groups had statistically significant increases in patient-reported outcome scores over the 5-year period, but the difference in both groups was not statistically significant ($P > .05$ for all). There was no statistical difference in the frequency of patients in the BHD and non-BHD groups achieving the MCID (86.6% vs 85.2%, respectively; $P = .804$) or PASS (76.0% vs 73.7%, respectively; $P = .675$) on at least 1 outcome measure. The logistic regression model demonstrated that being physically active (odds ratio [OR], 27.59; $P = .005$) and being female (OR, 14.64; $P = .025$) were independent predictors of achieving the MCID, while running (OR, 11.1; $P = .002$), being female (OR, 7.6; $P = .011$), and a larger preoperative LCEA (OR, 2.3; $P = .001$) were independent preoperative predictors of achieving the PASS.

Conclusion: The rates of achieving clinical success 5 years after undergoing arthroscopic treatment with capsular closure for FAIS were not significantly different between patients with BHD and those with normal acetabular coverage. Being physically active, running for exercise, female sex, and a larger LCEA were preoperative predictors of achieving clinical success at 5 years in patients with BHD.

Keywords: femoroacetabular impingement syndrome; borderline hip dysplasia; minimal clinically important difference; patient acceptable symptom state; 5-year outcomes

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Hip arthroscopic surgery has become a common procedure for the correction of femoroacetabular impingement syndrome (FAIS), with high success rates and functional improvements consistently reported in the literature.[6,17,23] At both short-term and midterm follow-up, the procedure has led to a reduction in pain, improved functional status, and high rate of return to sport.[1,9,31,61] The success of hip arthroscopic surgery over the alternative open hip approach has been attributed to a decrease in soft tissue damage, stress on hip biomechanics associated with hip dislocations, decreased complications, and above all, a more rapid recovery.

There is a growing trend among hip arthroscopic surgeons to surgically treat patients with FAIS who also have borderline hip dysplasia (BHD). BHD is commonly defined as a lateral center-edge angle (LCEA) with a lower threshold of 18° to 22° and an upper threshold of 25°.[18,19,29,37,39] While some studies have reported high failure rates and a rapid progression of osteoarthritis after arthroscopic surgery for FAIS in this patient population, others have demonstrated superior functional outcomes with low rates of revision surgery similar to patients with a normal LCEA (25°-40°).[13,16,63] However, there is a lack of evidence assessing whether patients with BHD have similar outcomes or rates of achieving the minimal clinically important difference (MCID) or patient acceptable symptom state (PASS) to patients with normal acetabular coverage. Furthermore, there is only 1 study that has addressed establishing threshold scores for achieving the MCID and PASS specific to the BHD population as well as identifying preoperative predictors of achieving both.[2]

The purpose of this study was to compare the rates of achieving meaningful clinical outcomes between patients with and without BHD who have undergone hip arthroscopic surgery for the treatment of FAIS and identify the predictors for achieving clinical success among patients with BHD at 5-year follow-up. We hypothesized that patients with BHD would continue to achieve similar rates of clinical success as defined by reaching either the MCID or the PASS at their 5-year follow-up, as we documented in a previous study that reported the 2-year results of these 2 groups of patients,[2] and that the same modifiable (eg, body mass index [BMI], level of physical activity) and nonmodifiable factors (eg, age, sex) identified in the 2-year study would be predictive of achieving clinical success.

METHODS

After the study was approved by the institutional review board (12022108-IRB01-CR06), prospectively collected data from the senior author's (S.J.N.) database of all patients undergoing hip arthroscopic surgery between January 2012 and August 2014 were reviewed. From this review, 590 patients who had undergone primary hip arthroscopic surgery for the treatment of FAIS were identified. This group of patients was further scrutinized to determine which ones met the inclusion criteria: (1) clinical and radiographic diagnosis of symptomatic FAIS as previously defined,[22] (2) failure of nonoperative management (lifestyle modification, physical therapy, oral anti-inflammatory medications, and for some patients, fluoroscopically guided intra-articular cortisone injections), (3) hip arthroscopic surgery performed for the treatment of FAIS, and (4) a minimum 5-year follow-up. Exclusion criteria included the following: (1) a history of ipsilateral or contralateral hip surgery, (2) a reduced joint space (Tönnis grade >1), (3) evidence or a history of congenital hip disorders (slipped capital femoral epiphysis and Perthes disease), (4) hip arthroscopic surgery for an indication other than FAIS as well as concomitant procedures at the time of surgery, and (5) a lack of 5-year outcome scores.

The previous literature has defined BHD as an LCEA ranging from 18° to 22° as its lower threshold to 25° as the upper threshold.[18,19,29,37,39] The present study defined BHD as an LCEA of 20° to 25° measured from the lateral edge of the sourcil.[10,24] These patients were then matched in a 1:2 fashion to patients with normal coverage (LCEA 25°-40°) by age (±1 year), and BMI (±5 kg/m^2), which have been commonly demonstrated in the literature to influence patient-reported clinical outcomes after hip arthroscopic surgery for FAIS.[21,53]

Radiographic Parameters

All patients in the study had a series of preoperative radiographs and a series of postoperative radiographs at 1-month follow-up.[60] Each series consisted of a standing anteroposterior pelvis radiograph, a false-profile hip radiograph, and a 45° Dunn lateral hip radiograph.[12,41] The alpha angle was measured on all 3 views as previously described.[33,43] The anteroposterior view was used to measure acetabular inclination (Tönnis angle) and the LCEA of Wiberg.[12] The Tönnis grade was determined.[58] The anterior center-edge angle (ACEA) was measured on the false-profile view from the lateral edge of the bone as previously described.[52]

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TABLE 1
Postoperative Rehabilitation Protocol

Phase	Goal	Restrictions	Techniques
1	Protect the joint	20-lb (9 kg) foot-flat weightbearing for 3 wk Limitations in flexion, abduction, and extension at 3 wk No active sitting for more than 30 min at 3 wk	Soft tissue mobilization Isometrics
2	Noncompensatory gait progression and active range of motion	Avoidance of compensatory gait	Joint mobilization Gait training Core strengthening Scar mobilization Lumbar stabilization Elliptical machine at 6 wk
3	Return to preinjury function	Avoidance of agility drills until 10 wk Avoidance of hip rotational activities until 10 wk	Single-leg squat Soft tissue Core strengthening Joint mobilization Gait training
4	Return to sport	Muscle strength and full range of motion goals at 12 wk	Soft tissue and joint mobilization Cardiovascular and strength exercises Agility training Plyometrics Slow progression to return to presurgical level

Surgical Technique

All hip arthroscopic procedures were performed in the same manner by a single fellowship-trained hip surgeon (S.J.N.) at a high-volume academic hospital. The details of the arthroscopic technique have been previously described in the literature, and a summary of the technique follows.[2,20,25,55] Briefly, after anterolateral, anterior, and modified midanterior portals were established, capsulotomy connecting the anterior to anterolateral portal was performed to adequately address the central compartment, including labral repair and acetabular rim shaving for adequate labral adhesion. After procedures were completed in the central compartment, T-capsulotomy was performed to address peripheral compartment abnormalities, including osteochondroplasty of cam deformities. A dynamic examination and fluoroscopic imaging were used to confirm that there was no further impingement and that head-neck offset was restored. After the arthroscopic procedure was concluded, complete capsular closure using plication was performed to ensure normal biomechanical properties of the iliofemoral ligament. The degree of leaflet overlap in capsular plication depended on the degree of capsular laxity and dynamic intraoperative range of motion. Depending on the size of the incision and integrity of the capsule, the vertical T-limb was typically closed with 2 to 4 sutures.

Postoperative Rehabilitation

Rehabilitation started on postoperative day 1 for all patients as previously described for primary FAIS cases.[34] Patients went through a 4-phase rehabilitation protocol that lasted an average of 16 to 18 weeks (Table 1). Briefly, phase 1 prioritized joint protection and soft tissue mobilization techniques, with restriction to 20-lb (9 kg) foot-flat weightbearing during this phase. A hip orthosis and night abduction pillow were used for the first 3 weeks, aiming to prevent active abduction, hip flexion beyond 90°, extension, and external rotation. Patients were weaned off crutches if they demonstrated ambulatory capabilities without significant pain or compensatory movements 3 weeks after surgery. Phase 2 concentrated on normal gait maintenance, full restoration of range of motion, improvement of neuromuscular control, and maintenance of pelvic and core stability. Phase 3 included single-leg squats and strengthening, soft tissue and joint mobilization, and cardiovascular fitness. Phase 4 emphasized returning to preinjury levels of sport participation. Of note, every patient was prescribed 75 mg of indomethacin daily for 10 days as a prophylaxis of heterotopic ossification.[59]

Evaluation of Functional Outcomes

All patients in the analysis completed preoperative and minimum 5-year postoperative hip-specific patient-reported outcome instruments, including the Hip Outcome Score–Activities of Daily Living (HOS-ADL), HOS–Sports Subscale (HOS-SS), and modified Harris Hip Score (mHHS).[7,26,36] In addition, all patients graded their postoperative pain and satisfaction levels using a 0- to 10-cm visual analog scale (VAS). The collection of baseline and 5-year postoperative hip-specific outcomes was conducted using online-based surveys through an encrypted data collection system (OBERD; Universal Research Solutions).

Recently, there has been a shift in the orthopaedic literature from describing postsurgical outcomes as averages of patient-reported scores to describing them as rates of achieving clinical outcomes that are meaningful to patients.[3-5,44,46,49] Previous authors have described thresholds of achieving clinical success, with the MCID as the lowest threshold of achieving clinical success, which is defined by a specific outcome score or change in scores.[51] Furthermore, the PASS has been defined as the postoperative outcome with which patients are satisfied, which is also defined by a specific outcome score.[11] To evaluate the difference in achieving clinical success between patients with and without BHD who underwent hip arthroscopic surgery for FAIS, the threshold value of each outcome instrument for achieving the MCID and PASS was calculated. Similar to previous reports in the literature, a distribution-based MCID was determined by calculating the half standard deviation of the change in HOS-ADL, HOS-SS, and mHHS scores over the 5-year time period.[45,50,51] Any patient with a change in outcome scores over the 5-year time period that was higher than the threshold score of the corresponding questionnaire was considered to have achieved the MCID.

To identify the PASS, patients were asked the following question at 5-year follow-up: "Taking into account all the activities you have during your daily life, your level of pain, and also your functional impairment, do you consider that your current state is satisfactory?" The PASS for the HOS-ADL, HOS-SS, and mHHS was calculated with a receiver operating characteristic (ROC) curve analysis as conducted in previous studies[7,11] (Appendix 1, available in the online version of this article). Consistent with previous psychometric studies in the orthopaedic literature, an area under the curve (AUC) >0.8 was considered acceptably predictive of a model for identifying a threshold score defining patients who did and did not achieve the PASS. The Youden index was used to optimize the sensitivity and specificity for determining the PASS on the HOS-ADL, HOS-SS, and mHHS.[47] Patients were considered to have achieved the MCID or PASS if they achieved this outcome endpoint on any of the administered questionnaires. Furthermore, patients were considered to have achieved clinical success at 5 years after surgery if they achieved either the MCID or the PASS.[5]

Statistical Analysis

All data were screened to determine if they met all parametric statistical assumptions before analysis. A total of 2 binary logistic regression models were created: 1 for reaching at least 1 score threshold for achieving the MCID and another for reaching at least 1 score threshold for achieving the PASS. The process of creating the models is summarized in Figure 1 and was performed as previously described.[42,56] Pearson and Spearman coefficient analyses were carried out to identify correlations between the MCID and PASS versus preoperative variables and to identify variables to place in the exploratory analysis for

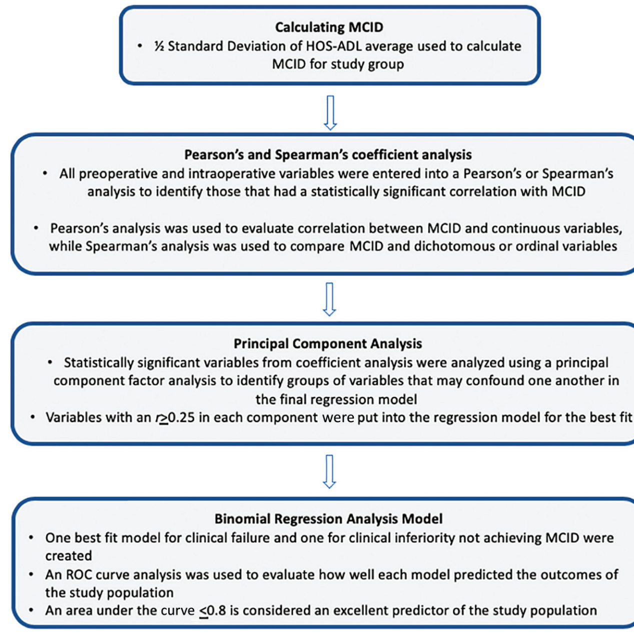

Figure 1. Statistical analysis flowchart. HOS-ADL, Hip Outcome Score–Activities of Daily Living; MCID, minimal clinically important difference; ROC, receiver operating characteristic.

the final logistic models. An exploratory factor analysis was performed on the variables with statistically significant correlations with the primary outcomes (achieving the MCID and PASS) using principal component (PC) extraction (ie, eigenvector decomposition) with a varimax rotation to reduce redundancy in the predictor variables. The Kaiser-Meyer-Olkin test was performed to determine if the predictor variables demonstrated adequate correlation for an exploratory factor analysis. A Kaiser-Meyer-Olkin value of 0.62 was found, which demonstrated that the data were appropriate for factor analysis, as this value exceeded a recommended value of 0.6 for an exploratory factor analysis.[57] A scree plot was created to determine the number of PCs to retain for analysis of the 2 separate models. Each extracted PC was used to calculate the percentage of variance explained by dividing the eigenvalue of each PC by the sum of all eigenvalues. The contribution of each variable to the PC was determined using the factor loading of each variable. Variables that demonstrated a factor loading of greater than ±0.25 for a PC were retained as predictor variables for the follow-up binary logistic regression analysis used to create both models. If the loading components in the analysis had more than 1 variable less than ±0.25, each variable in the component was placed into the model independently. An ROC curve analysis was then used to identify the model with the best fit and therefore the variable with the best fit for the model. The final models for inferior clinical outcomes and clinical failure were chosen based on the highest AUC in the ROC curve analysis.

Descriptive statistics for all continuous variables were reported as mean and standard deviation, and frequency statistics were reported for all noncontinuous variables, unless otherwise stated. A paired-samples t test and chi-

TABLE 2
Patient Characteristics[a]

	BHD Group	Non-BHD Group	*P* Value
Age, mean ± SD, y	33.2 ± 11.9	33.1 ± 12.0	.934
Female sex	64 (72.7)	112 (63.6)	.178
BMI, mean ± SD, kg/m^2	23.9 ± 3.5	24.3 ± 3.7	.451
Procedures performed			
Labral repair	88 (100.0)	176 (100.0)	
Femoroplasty	88 (100.0)	176 (100.0)	
Acetabular rim decortication	79 (89.8)	172 (97.7)	
Capsular closure	88 (100.0)	176 (100.0)	
Clinical failure			
Revision	2 (2.3)		
Conversion to total hip arthroplasty	1 (1.1)		

[a]Data are presented as n (%) unless otherwise specified. BHD, borderline hip dysplasia; BMI, body mass index.

square analysis were used to compare functional outcome scores and rates of achieving clinical success, respectively, between the 2 groups. Statistical significance for all analyses was set at $\alpha \leq .05$. Correlation coefficients were classified by the strength of the correlation, which were defined as follows: excellent (>0.80), very good (0.71-0.80), good (0.61-0.70), moderate (0.41-0.60), and weak (0.21-0.40).

RESULTS

A total of 133 consecutive patients were identified as having BHD (LCEA 20°-25°), of whom 88 (66.2%) had 5-year outcome scores. These patients were matched to 176 controls who had normal acetabular coverage (LCEA 25°-40°). The 264 patients included in the study had a mean age and BMI of 33.2 ± 11.9 years and 24.1 ± 3.6 kg/m^2, respectively, and the majority (66.7%) were female. A subanalysis of the patient characteristics for the 88 patients in the BHD group and 176 patients in the non-BHD group revealed that there was no statistical difference in age, sex, or BMI between the 2 groups (Table 2). All patients in both groups underwent labral repair, femoroplasty, and capsular closure, while 89.8% of the BHD group and 97.7% of the non-BHD group underwent acetabular rim decortication. A total of 3 additional patients in the BHD group, who were not included in the final analysis, underwent surgery on the ipsilateral hip within the 5-year time period, with 2 (2.3%) patients undergoing revision surgery and 1 (1.1%) undergoing conversion to total hip arthroplasty.

Analysis of Radiographic Parameters

A comparison of preoperative and postoperative radiographic parameters between the 2 groups is summarized in Table 3. Briefly, there was no statistically significant difference in the preoperative and postoperative alpha angle on any of the 3 radiographic views between the BHD and non-BHD groups (*P* > .05 for all). An analysis of the preoperative LCEA demonstrated that the BHD group had a significantly smaller angle as compared with the group with normal acetabular coverage (23.2° ± 1.5° vs 32.9° ± 3.7°, respectively; *P* < .001) as well as a significantly smaller postoperative LCEA (22.2° ± 2.9° vs 30.3° ± 3.9°, respectively; *P* < .001). There was also a significant difference in the preoperative ACEA (28.2° ± 5.7° vs 34.7° ± 5.7°, respectively; *P* < .001) and postoperative ACEA (26.6° ± 4.9° vs 31.9° ± 5.3°, respectively; *P* < .001). Furthermore, the BHD group had a significantly larger Tönnis angle (11.3° ± 3.7° vs 4.7° ± 3.9°, respectively; *P* < .001).

TABLE 3
Radiographic Parameters[a]

	BHD Group	Non-BHD Group	*P* Value
Preoperative, deg			
Alpha angle (anteroposterior)	75.1 ± 15.8	77.2 ± 11.9	.25
Alpha angle (false profile)	66.1 ± 13.1	62.9 ± 10.3	.14
Alpha angle (Dunn)	66.9 ± 12.2	65.9 ± 11.4	.627
LCEA	23.2 ± 1.5	32.9 ± 3.7	<.001
ACEA	28.2 ± 5.7	34.7 ± 5.7	<.001
Tönnis angle	11.3 ± 3.7	4.7 ± 3.9	<.001
Tönnis grade, n (%)			
0	80 (90.9)	161 (91.5)	.87736
1	8 (9.1)	15 (8.5)	
Postoperative, deg			
Alpha angle (anteroposterior)	42.7 ± 4.9	43.9 ± 4.7	.1
Alpha angle (false profile)	40.8 ± 4.8	40.7 ± 5.1	.804
Alpha angle (Dunn)	38.1 ± 3.7	38.5 ± 4.7	.455
LCEA	22.2 ± 2.9	30.3 ± 3.9	<.001
ACEA	26.6 ± 4.9	31.9 ± 5.3	<.001

[a]Data are presented as mean ± SD unless otherwise specified. ACEA, anterior center-edge angle; BHD, borderline hip dysplasia; LCEA, lateral center-edge angle.

Comparison of Functional Scores and Rates of Achieving Clinical Success

The analysis of preoperative and postoperative functional scores for the combined study cohort demonstrated statistically significant improvements across all outcome tools (*P* ≤ .001 for all) (Table 4). A subanalysis of scores demonstrated that while the BHD group demonstrated slightly lower scores, there were no significant differences on any patient-reported outcome measure, VAS for pain, or VAS for satisfaction between the 2 groups (*P* > .05 for all) (Table 5).

The change in 5-year functional outcome scores for achieving the MCID for the BHD group was defined as 9.6, 14.1, and 9.5 for the HOS-ADL, HOS-SS, and mHHS, respectively, while the MCID threshold scores for the non-BHD group were 10.1, 15.0, and 10.6, respectively. The change in 5-year functional outcome scores for achieving the PASS for the BHD group was defined as 90.9, 76.6,

TABLE 4
Preoperative and Postoperative Patient-Reported Outcomes[a]

	Preoperative	Postoperative	P Value
HOS-ADL	63.8 ± 20.6	83.2 ± 21.8	<.001
HOS-SS	43.4 ± 24.1	68.9 ± 33.3	<.001
mHHS	54.7 ± 26.8	79.1 ± 20.8	.001
VAS for pain	69.9 ± 17.8	30.1 ± 31.5	<.001

[a]Data are presented as mean ± SD. HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports Subscale; mHHS, modified Harris Hip Score; VAS, visual analog scale.

TABLE 5
Functional Scores[a]

	BHD Group	Non-BHD Group	P Value
Preoperative			
HOS-ADL	64.8 ± 19.2	69.2 ± 18.1	.093
HOS-SS	45.3 ± 22.6	46.8 ± 23.9	.664
mHHS	55.7 ± 15.4	58.7 ± 13.2	.125
VAS for pain	67.7 ± 19.2	70.4 ± 16.5	.341
Postoperative			
HOS-ADL	85.7 ± 19.9	88.7 ± 19.9	.164
HOS-SS	74.6 ± 30.7	79.6 ± 23.9	.21
mHHS	80.9 ± 19.6	83.5 ± 18.0	.37
VAS for pain	28.6 ± 30.7	29.5 ± 27.8	.84
VAS for satisfaction	75.5 ± 30.6	77.8 ± 29.8	.593

[a]Data are presented as mean ± SD. BHD, borderline hip dysplasia; HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports Subscale; mHHS, modified Harris Hip Score; VAS, visual analog scale.

TABLE 6
MCID Rates[a]

	BHD Group	Non-BHD Group	P Value
MCID			
HOS-ADL	46 (69.7)	71 (60.2)	.198
HOS-SS	44 (75.6)	73 (68.2)	.39
mHHS	47 (79.6)	78 (78.0)	.805
Any MCID	58 (86.6)	104 (85.2)	.804
PASS			
HOS-ADL	46 (61.3)	81 (60.4)	.9
HOS-SS	46 (64.8)	85 (68.0)	.646
mHHS	42 (60.9)	72 (61.0)	.984
Any PASS	54 (76.0)	101 (73.7)	.675

[a]Data are presented as n (%). BHD, borderline hip dysplasia; HOS-ADL, Hip Outcome Score–Activities of Daily Living; HOS-SS, Hip Outcome Score–Sports Subscale; MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; PASS, patient acceptable symptom state.

TABLE 7
Logistic Regression Models of Preoperative Predictors of Achieving the MCID and PASS[a]

	Odds Ratio	95% CI	P Value
Achieving the MCID			
Physically active	27.59	2.67-285.49	.005
Female sex	14.64	1.40-153.13	.025
Achieving the PASS			
Running	11.124	2.382-51.948	.002
Female sex	7.622	1.584-36.678	.011
Preoperative LCEA	2.300	1.406-3.764	.001

[a]LCEA, lateral center-edge angle; MCID, minimal clinically important difference; PASS, patient acceptable symptom state.

and 81.9 for the HOS-ADL, HOS-SS, and mHHS, respectively, while the PASS threshold scores for the non-BHD group were 91.9, 75.2, and 79.8, respectively. The chi-square analysis demonstrated no statistical difference in the rates of reaching the threshold scores for achieving the MCID and PASS on any of the outcome measures between the 2 groups (Table 6).

Factors Associated With Achieving Clinical Success

The factor analysis for inferior clinical outcomes consisted of 4 PCs that explained 61% of the variance of the predictor variables. The rotated factor analysis can be found in Appendix 2 (available online). The variables retained for analysis were based on the PC loading. The logistic regression model of the variables is reported in Table 7. Briefly, patients who self-reported being physically active (ie, engaging in regular exercise) (odds ratio [OR], 27.59; P = .005) and female (OR, 14.64; P = .025) had higher chances of achieving the MCID on at least 1 outcome measure. The ROC curve analysis demonstrated that the MCID logistic regression model had an excellent fit (AUC = 0.888) (Appendix 3, available online). The PASS logistic regression model demonstrated that running for cardiovascular exercise (OR, 11.1; P = .002), being female (OR, 7.6; P = .011), and having a larger preoperative LCEA on the affected side (OR, 2.3; P = .001) were statistically significant preoperative predictors of achieving the PASS on at least 1 outcome measure. The ROC curve analysis demonstrated that the PASS logistic regression model had an excellent fit as well (AUC = 0.875) (Appendix 4, available online).

DISCUSSION

The main findings of the current study were that although patients with BHD who underwent hip arthroscopic surgery for the treatment of FAIS had different score thresholds for achieving the MCID and PASS at 5 years after surgery when compared with their counterparts with normal acetabular coverage, the rates of achieving both were not statistically different between the 2 groups. Furthermore, in the BHD group, those who engaged in exercise and were female were more likely to achieve the MCID on at least 1 outcome measure, while those who ran for sport, were female, and had a larger preoperative LCEA were likely to achieve the PASS at higher rates. Last, only 3.4% of patients with BHD underwent additional surgery within the 5-year time period, with 2 undergoing revision surgery and 1 undergoing conversion to total hip arthroplasty.

Previous studies in the literature have reported on outcomes of patients with BHD undergoing hip arthroscopic surgery for FAIS. Recently, a study from the Multicenter Arthroscopic Study of the Hip Group evaluated 2-year outcomes of patients with dysplasia, as defined by an LCEA ≤25.0°, who underwent hip arthroscopic surgery and compared their outcomes with patients with normal acetabular coverage and overcoverage. An analysis of the 437 patients demonstrated no significant differences in International Hip Outcome Tool–12 scores or reoperation rates among the 3 study groups.[38] Other smaller case series have demonstrated similar results, with scores among patients with BHD similar to those of patients with normal acetabular coverage.[8,18,40,64] In a systematic review, Shah et al[54] evaluated 13 studies to identify clinical and radiographic predictors of failed hip arthroscopic surgery in the management of patients with hip dysplasia. The authors concluded that the predictors of clinical failure included moderate to severe hip dysplasia (LCEA <15°), severe cartilage lesions, a larger Tönnis angle, a broken Shenton line, and a decreased joint space, while borderline to mild (LCEA 15°-25°) acetabular dysplasia in the absence of severe cartilaginous lesions demonstrated an acceptable long-term survival rate (7-year survival: 89.6%).[54]

The current study adds to the literature, providing a longer follow-up with a robust statistical analysis. In addition, this study is the first to define the 5-year MCID and PASS in a BHD group as well as the rates of achieving both. Previous studies have evaluated the rates of achieving clinical success in patients with BHD 2 years after surgery and compared outcomes in patients with FAIS and BHD and patients having FAIS and normal acetabular coverage. Beck and colleagues[2] indicated that the majority of patients in the BHD group achieved the MCID and PASS at high rates (86.6% and 78.6%, respectively) and that these were not significantly different from their non-BHD counterparts. In the current study, the rates of achieving clinical success as defined by the MCID and PASS were relatively unchanged, indicating that most patients with BHD continued to experience clinical success at midterm follow-up. Furthermore, both studies indicated low rates of requiring revision surgery or conversion to arthroplasty. These studies possibly indicated that proper minimal acetabular rim decortication, capsular management techniques, and regimented postoperative physical therapy may lead to satisfactory outcomes in patients with BHD.

The orthopaedic literature has demonstrated a trend in reporting rates of achieving clinical success defined by postsurgical outcomes that patients consider meaningful.[14,45-48,50,51] In this study, the MCID was identified for both the BHD and the non-BHD groups using the half standard deviation of the change in functional scores over a 5-year period, while the PASS score threshold was identified through an anchor-based method. Previous studies have demonstrated that threshold values for achieving clinical success vary based on disease.[30,32] In the current study, although the difference in threshold values for achieving the MCID and PASS between the BHD and non-BHD groups was very modest, it highlighted the point that threshold scores vary by population and should be calculated for each specific group studied. Furthermore, the difference in rates of achieving the MCID and PASS in one particular study group demonstrated the importance of using both as metrics for measuring clinical success, as some patients may be limited from achieving the MCID or PASS.

Studies have demonstrated that female patients with normal acetabular coverage report inferior functional outcomes after hip arthroscopic surgery compared with their male counterparts.[20,28,35,62] Unlike the previous analysis, however, the present study demonstrated that female patients with BHD were much more likely to achieve both the MCID and the PASS. Additionally, these results are consistent with the findings of Cvetanovich et al[13] and Beck et al[2] that demonstrated that female patients with borderline dysplasia had superior outcome scores and achieved higher rates of clinical success. While no current biomechanical study has evaluated the differences in acetabular morphology by sex, BHD may be a normal anatomic variant in female patients, whereas in male patients, it may represent a structural abnormality.

Limitations

The current study has a number of limitations that should be noted. First, the study used robust statistical analyses for creating the predictive models for achieving the MCID and PASS, both of which demonstrated excellent fit based on the ROC curve analysis; however, it is possible that better models exist. Second, we were not able to account for all patients lost to follow-up, and it is possible that some patients may have undergone revision surgery or conversion to total hip arthroplasty at other institutions. Third, one-third of eligible patients with BHD did not have 5-year follow-up, which may have introduced a bias into the study population. Fourth, despite the consecutive nature and complete follow-up, the results are those of a single high-volume, fellowship-trained hip arthroscopic surgeon. Hip arthroscopic surgery has a well-documented and steep learning curve[15,27]; thus, the results of the current study should be extrapolated cautiously.

CONCLUSION

The rates of achieving clinical success 5 years after undergoing arthroscopic treatment with capsular closure for FAIS were not significantly different in patients with BHD compared with patients with normal acetabular coverage. Being physically active, running for exercise, female sex, and a larger LCEA were preoperative predictors of achieving clinical success at 5 years in patients with BHD.

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