Nonoperative Management of Femoroacetabular Impingement in Adolescents: Clinical Outcomes at a Mean of 5 Years

A Prospective Study

Andrew M. Zogby,*† MD, James D. Bomar,*† MPH, Kristina P. Johnson,*† ATC, OPA, Vidyadhar V. Upasani,*† MD, and Andrew T. Pennock,*†‡ MD
Investigation performed at Rady Children's Hospital, San Diego, California, USA

Background: There is a lack of midterm or long-term outcome data on nonoperative management of femoroacetabular impingement (FAI) syndrome in adolescents despite expanding research mostly focused on arthroscopic management.

Purpose: To present 5-year outcome data utilizing a nonoperative protocol on a consecutive series of patients presenting to our clinic with FAI syndrome.

Study Design: Cohort study, Level of evidence, 2.

Methods: A total of 100 patients (62% female; mean age 15 years) who presented to the clinic for evaluation of hip pain and had at least 1 hip with a positive impingement sign were prospectively recruited. The management protocol consisted of an initial trial of rest, physical therapy, and activity modification. Patients who remained symptomatic were offered an intra-articular steroid injection. Patients with recurrent symptoms were then offered arthroscopic treatment. Patient-reported outcomes (PROs), including the modified Harris Hip Score (mHHS) and the Nonarthritic Hip Score (NAHS) were then collected at a mean 1, 2, and 5 years after the initial evaluation.

Results: At enrollment, the mean mHHS and NAHS were 69.6 ± 12.9 and 75.5 ± 15.2, respectively. A total of 51 patients (n = 69 hips) were available at a mean 5-year follow-up, with the mean mHHS and NAHS of 89.5 ± 10.8 and 88.1 ± 12, respectively. There was no significant difference in the mHHS or the NAHS between activity modification and physical therapy, injection, or arthroscopic surgery groups at 5-year follow-up ($P > .6$) and no difference in the proportion of hips meeting the minimal clinically important difference (MCID) for the mHHS based on treatment course ($P = .99$). There was no significant difference in the mHHS or the NAHS between FAI types at any time point, or in the proportion of hips that met the MCID among FAI types ($P = .64$). Also, 11 out of 12 hips that required surgery had surgery in less than 2 years. One hip underwent surgery at 5 years after the initial visit. There was no significant drop-off in the mHHS or the NAHS between the 2-year and 5-year time periods ($P > .3$).

Conclusion: Nonoperative management of FAI syndrome is effective in a majority of adolescent patients, with significant improvements in PROs persisting at a mean 5-year follow-up.

Keywords: femoroacetabular impingement syndrome; adolescent hip pain; labral tear; nonoperative treatment

Femoroacetabular impingement (FAI) syndrome is a common cause of hip pain and physical dysfunction among adolescents.

The number of hip arthroscopies performed yearly to treat FAI syndrome in the United States has increased dramatically, with a disproportionate amount of the current literature focusing on surgical techniques and outcomes rather than nonoperative management.[7,11] However, a recent prospective study[15] demonstrated that a majority of adolescent patients with FAI syndrome can be managed nonoperatively in the short term, with significant improvements in hip outcome scores at a mean follow-up of 2 years.

There remains a paucity of longer-term outcome data for young patients treated nonoperatively for FAI syndrome. Thus, the purpose of this study was to evaluate prospectively collected clinical outcomes at a mean 5-year follow-up for patients managed by a standardized nonoperative protocol for FAI syndrome. We also sought to compare 5-year

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outcomes between patients managed by activity modification and physical therapy alone versus those who underwent steroid injection or hip arthroscopy. We hypothesized that most patients treated nonoperatively would experience sustained improvements in hip outcome scores and would be able to return to full sport/activity level at a 5-year follow-up. We also hypothesized no significant differences in outcomes between treatment groups or FAI types at this timepoint.

METHODS

From April 2013 to August 2016, a total of 100 patients (133 hips) presenting to a single academic, pediatric sports medicine practice were enrolled in an institutional review board–approved prospective study. Patients were approached for inclusion in the study if they presented to the clinic for evaluation of groin-based hip pain and had a positive anterior impingement test on the clinical examination.[15] Patients with a history of hip surgery or radiographic abnormalities consistent with non-FAI hip conditions, such as femoral neck stress fractures, slipped capital femoral epiphysis, tumor, or rheumatologic condition, were not approached to participate in the study. Participants were excluded from this study if they had <40 months' follow-up. Date of birth, sex, primary sport, the duration of symptoms, previous treatment, the modified Harris Hip Score (mHHS), and the Nonarthritic Hip Score (NAHS) were collected upon enrollment. Two patients (n = 3 hips) did not complete the NAHS at enrollment but did complete the mHHS at enrollment and were included in this study. Hips were excluded for inadequate follow-up (n = 54), not having the mHHS collected at enrollment (n = 5), and a rheumatologic diagnosis subsequent to enrollment (n = 2).

A subset of patients who did not clinically respond to an initial course of activity modification and physical therapy (34 hips available at 5-y follow-up) were evaluated with a magnetic resonance arthrogram (1.5-T MRA; GE Discovery MR450; GE Healthcare). These magnetic resonance images (MRIs) were read by 1 of the 2 fellowship-trained pediatric musculoskeletal radiologists. One patient had an MRI performed at an outside facility that came with a reading. Routine radiographs were obtained, including an anteroposterior pelvis view and either a frog-leg lateral view or a Dunn lateral view of the affected hip. Radiographic evaluation included the lateral center-edge angle (LCEA), the alpha angle, and the status of the proximal femoral physis. In patients with an MRI scan, the alpha angle was measured on the radial oblique image with the largest prominence of the femoral head/neck junction. Cam impingement was defined as an alpha angle $\geq 50°$ on the frog-leg lateral view, the Dunn lateral view, or the MRI radial oblique imaging. Pincer impingement was defined as the presence of an LCEA $\geq 40°$ or the presence of a crossover sign in a patient with an LCEA $\geq 35°$. Patients meeting our radiographic definitions of cam and pincer type impingement were grouped and called the "combined type impingement" group. An additional group of symptomatic hips with clinical FAI syndrome that did not strictly meet radiographic criteria was also tracked.

All patients were initiated on a pathway that began with activity modification and physical therapy (referred to as "activity modification" group) (Appendix 1, available in the online version of this article). The discontinuation of all sports and activities that involved running, jumping, or high hip flexion for a period of 6 weeks was recommended. After the 6-week period of decreased activity and formal physical therapy, patients were advised to modify their training to remove as much hip flexion as possible. Patients who did not respond to activity modification and physical therapy were offered an image-guided injection of 40 mg triamcinolone and a local anesthetic by the senior authors (V.V.U., A.T.P.) or an interventional radiologist. Patients who declined the injection or failed to improve after injection were indicated for arthroscopic surgery.

Two hips received surgery at an outside facility, but operative notes were not available for evaluation. Surgery at our institution was performed under general anesthesia with muscle relaxation with the patient in the supine position with a hip distractor. An anterolateral peritrochanteric portal and a midanterior portal were used for all arthroscopic surgeries. The hip was distracted approximately 10 mm, and both portals were established with a spinal needle. After completing the diagnostic arthroscopy in the central compartment, the surgeon secured the labrum, if torn or unstable, with suture anchors. The sutures were either passed around the labrum or through the labrum based on the thickness and size of the labral tissue. A rim resection was performed in patients with pincer deformity. An osteochondroplasty was performed in patients with cam deformity until there was no residual impingement during dynamic examination with flexion and internal rotation of the hip. In female patients and male patients with LCEA $<25°$, the capsule was routinely closed.

Postoperatively, patients were kept toe-touch weight-bearing and utilized a continuous passive motion machine for 3 weeks. They were prescribed heterotopic ossification prophylaxis, and formal physical therapy was initiated for them 1 week after surgery. Postoperatively, patients were advanced to a running progression program around

‡Address correspondence to Andrew T. Pennock, MD, Rady Children's Hospital, 3020 Children's Way, Mail Code 5062, San Diego, CA 92123, USA (email: apennock@rchsd.org).

*University of California, San Diego, California, USA.

†Rady Children's Hospital, San Diego, California, USA.

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TABLE 1
Baseline Characteristics[a]

	Activity Mode (n = 50)	Injection (n = 7)	Scope (n = 12)
Sex, n (%)			
Male	15 (30)	2 (29)	3 (25)
Female	35 (70)	5 (71)	9 (75)
Age, y (P = .22)	15 ± 1.6	15.9 ± 1.5	15.4 ± 0.9
	12.2-17.4	13.6-17.5	13.4-17.2
Duration of symptoms before enrollment, mo (*P* = .58)	11.7 ± 17.8	8 ± 7.2	5.7 ± 4.9
	0.25-84	1-18	0.5-12
Follow-up, mo (*P* = .98)	61.5 ± 8.2	61.2 ± 8.1	62.3 ± 7
	43.4-74.9	44.7-71.2	45.5-76.4
LCEA, deg (*P* = .62)	31.7 ± 5.2	32.9 ± 3	30.3 ± 5.7
	22-43	28-38	20-38
Alpha angle—radiograph, deg (*P* = .30)	48.6 ± 9.2	44.3 ± 11.1	45.5 ± 9.9
	36-70	31-60	35-69
Alpha angle—MRI, deg (*P* = .44)	56.1 ± 6.4	59.3 ± 10.5	60.7 ± 8.4
	47-69	50-76	46-74
Physis status, n (%)			
Physis open	9 (18)	1 (14)	0 (0)
Physis closed	41 (82)	6 (86)	12 (100)

[a]Mean ± SD and range are presented for continuous data. LCEA, lateral center-edge angle; MRI, magnetic resonance imaging.

8 to 12 weeks, and full clearance for return to sport was allowed between 4 and 6 months. Patients were contacted by telephone at approximately 1, 2, and 5 years from enrollment for repeat assessment with the mHHS and the NAHS. At that time, patients were also asked about their return to activities, specifically regarding their return to the same sport/activity, return to a different sport/activity, or the decision to discontinue the activity. Failure of treatment was defined as a failure to meet the minimal clinically important difference (MCID) for the mHHS (8-point improvement).[4,9,10]

The hip was used as the unit of analysis, except when evaluating return to activities, in which case the patient was used. Basic descriptive statistics are reported. The Shapiro-Wilk test of normality was performed on all continuous data. Data found to be normal with the Shapiro-Wilk test were also tested with the Levene test of homogeneity of variance. Data found to be normally distributed with both tests were evaluated using the analysis of variance, and non-normally distributed data were evaluated with the Kruskal-Wallis and Mann-Whitney tests. The Wilcoxon signed-rank test was used to evaluate changes in the mHHS and the NAHS between the first clinic visit and subsequent visits. The chi-square and Fisher exact tests were used to evaluate differences in proportions among categorical data. All analyses were performed using SPSS (Version 26; IBM). No a priori power analysis was performed. Statistical significance was defined as $P < .05$.

RESULTS

A total of 69 hips in 51 patients were included with a mean follow-up of 61.6 ± 7.9 months. This represents 51% of the original cohort. The demographic and radiographic information can be found in Table 1. Also, 25% of our cohort (13/51) were multisport athletes. Three patients did not participate in sports at all, and the remaining patients were single-sport athletes at time of enrollment. A total of 32 hips (46%) had cam impingement alone, 9 (13%) had pincer type impingement alone, and 10 (14%) had combined type impingement. The remaining 18 hips (26%) did not strictly meet radiographic criteria of FAI. Of the hips that underwent MRI, 24 had a labral tear; 14 of these had cam impingement, 7 had combined type impingement, 1 had pincer impingement, and 2 did not strictly meet radiographic criteria of FAI. Hips that did not strictly meet radiographic criteria typically had either borderline radiographic parameters or other radiographic signs of impingement (Figure 1). At patient enrollment, the mean mHHS and NAHS were 69.6 ± 12.9 (range, 40.7- 95.7) and 75.5 ± 15.2 (range, 47.5-100), respectively.

At the time of the most recent follow-up, with a mean 61.6 ± 7.9 months (range, 43.4-76.4 months), 72% (50/69) of our cohort were treated with activity modification and physical therapy alone, 10% (7/69) progressed to an injection but did not require surgery, and the remaining 17% (12/69) progressed to arthroscopic surgery. Our cohort saw a significant improvement in the mHHS from the initial visit (69.6 ± 12.9) to 1-year follow-up (86.8 ± 14.8) ($P < .001$). Hips continued to improve from the 1-year to 2-year mark, with a 2-year mHHS being 90.4 ± 9.8 ($P = .03$). There was no significant difference in the mHHS between the 2-year follow-up and the most recent follow-up, with the most recent mHHS being 89.5 ± 10.8 ($P = .32$). Similarly, our cohort saw a significant improvement in the NAHS from the initial visit (75.5 ± 15.2) to 1-year follow-up (85.2 ± 17.4) ($P = .01$). There was no significant change

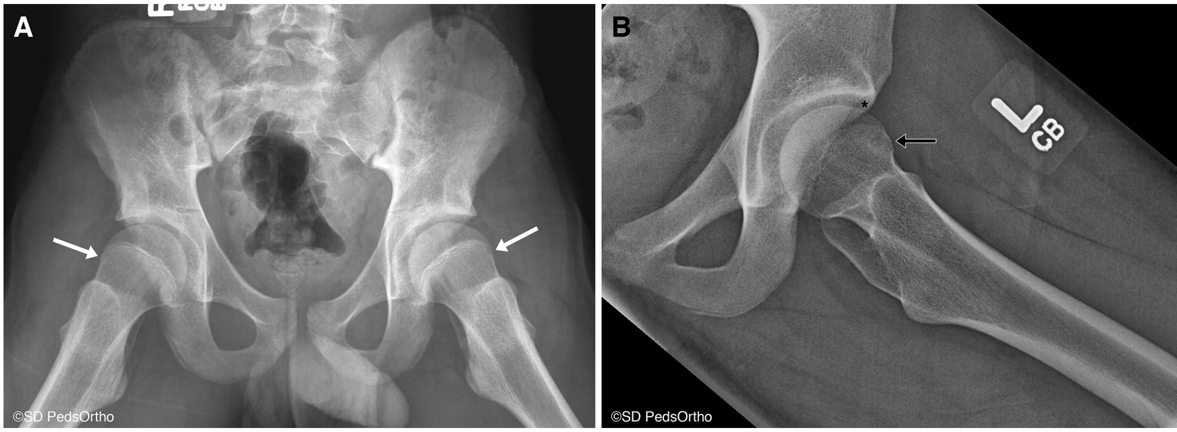

Figure 1. (A) Frog-leg lateral view of a 13.8-year-old boy with a symptomatic left hip with decreased offset of the head-neck junction (white arrows), but not meeting our definition of FAI. We measured the alpha angle on this hip as 49° and the LCEA as 30°. This hip was treated with activity modification and physical therapy and saw an increase in the mHHS from 82.5 at the initial visit to 100 at 69.2 months follow-up. (B) Dunn lateral view of a 16.6-year-old girl with left groin–based hip pain and impingement on examination. This patient did not meet the radiographic criteria for FAI based on the alpha angle and the LCEA, but did have other radiographic signs, including a crossover sign (black asterisk), indicating acetabular retroversion as well as fibrocystic change of the head-neck junction (black arrow). FAI, femoroacetabular impingement; LCEA, the lateral center-edge angle; mHHS, modified Harris Hip Score; NAHS, Nonarthritic Hip Score.

TABLE 2
All PROs Collected During the Course of the Study[a]

		Initial Visit		1-Year Follow-up: Mean 13.9 ± 2.3 mo		1-Year vs Initial Visit	2-Year Follow-up: Mean 27.5 ± 4.7 mo		2-Year vs Initial Visit	5-Year Follow-up: Mean 61.6 ± 7.9 mo		5-Year vs Initial Visit
		n	Mean ± SD	n	Mean ± SD	*P* Value[c]	n	Mean ± SD	*P* Value[c]	n	Mean ± SD	*P* Value[c]
mHHS	Activity modification	50	69.6 ± 14.1	31	88.9 ± 13.3	<.001	42	90.5 ± 11	<.001	50	90.3 ± 10.3	<.001
	Injection	7	69.9 ± 8.3	3	93.9 ± 10.8	.11	6	93.3 ± 4.4	.04	7	86.6 ± 15.3	.09
	Scope	12	69.3 ± 10.5	9	77.2 ± 17.6	.40	11	88.5 ± 6.8	.01	12	88.2 ± 10.4	.01
	P value[b]		≥.999		.15			.65			.65	
NAHS	Activity modification	47	76 ± 16.1	31	86.2 ± 17.2	.02	42	88.3 ± 13.3	<.001	50	87.9 ± 12.7	<.001
	Injection	7	72.5 ± 13.4	3	91.7 ± 6.9	.11	6	90.2 ± 5.2	<.05	7	86.6 ± 13	.13
	Scope	12	75 ± 13.5	9	79.7 ± 19.7	.51	11	88.5 ± 6.9	.01	12	89.7 ± 8.8	.01
	P value[b]		.74		.68			.51			.87	

[a]mHHS, modified Harris Hip Score; NAHS, Nonarthritic Hip Score; PRO, patient-reported outcome.
[b]Comparison between treatment groups at each time point (Kruskal-Wallis).
[c]Comparison between the initial visit and subsequent time period (Wilcoxon signed ranks test).

in the NAHS between the 1-year and 2-year time periods (P = .14) or the 2-year and the most recent follow-up time periods (P = .39). The NAHS at the 2-year time period was 88.5 ± 11.6 and was 88.1 ± 12 at the most recent follow-up (mean 5 years) (Table 2).

Hips treated with activity modification and physical therapy alone met the MCID for the mHHS at a rate of 74% compared with a 71% rate for hips treated with an injection, and a 75% rate for hips treated with arthroscopic surgery. We did not observe a difference in the proportion of hips that met the MCID for the mHHS based on treatment course (P = .99). There was no significant difference in the mHHS or the NAHS among our activity modification group, injection group, or scope group at the initial visit ($P > .7$), 1-year follow-up ($P > .1$), 2-year follow-up ($P > .5$), or 5-year follow-up ($P > .6$). Although hips treated with an injection met the MCID at a similar rate compared with the other treatment methods, the injection group did not see a statistically significant difference in the mHHS or the NAHS from the initial visit compared with the most recent follow-up ($P > .09$). The other 2 treatment groups did see a significant increase in the mHHS and the NAHS from the initial visit to the most recent follow-up. The mean patient-reported outcomes (PROs) for each treatment group at each time

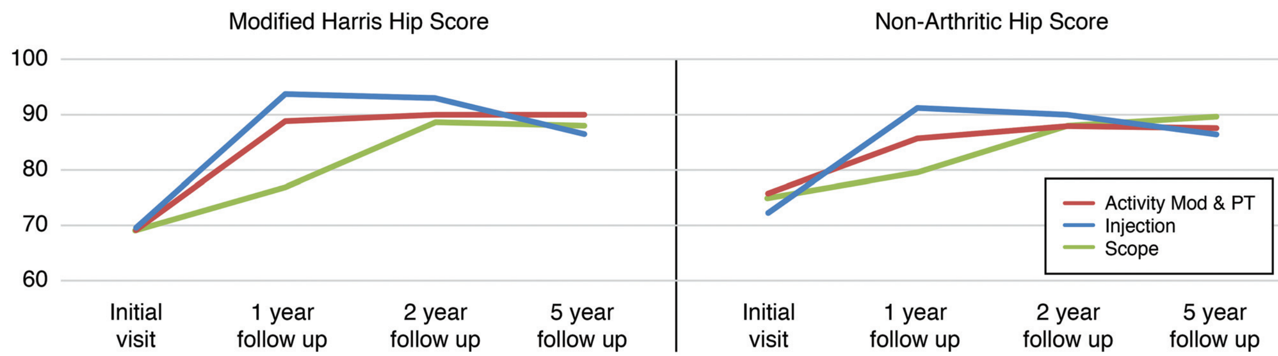

Figure 2. The mean modified Harris Hip Score (left) and the Nonarthritic Hip Score (right) at the initial visit and 1, 2, and 5 years follow-up in each treatment group. Mod, modification; PT, physical therapy.

TABLE 3
All PROs Collected During the Course of the Study by Impingement Type[a]

		Initial Visit		1-Year Follow-up			2-Year Follow-up			5-Year Follow-up		
				Mean 13.9 ± 2.3 mo		1-Year vs Intial Visit	Mean 27.5 ± 4.7 mo		2-Year vs Intial Visit	Mean 61.6 ± 7.9 mo		5-Year vs Intial Visit
		N	Mean ± SD	N	Mean ± SD	*P* Value[c]	N	Mean ± SD	*P* Value[c]	N	Mean ± SD	*P* Value[c]
mHHs	Cam	32	66.9 ± 14.1	18	89.4 ± 14.1	<.01	27	90.1 ± 8.7	<.001	32	86.4 ± 11.3	<.001
	Pincer	9	74.6 ± 5.5	7	83 ± 11.6	.23	9	84.7 ± 13.4	.09	9	94 ± 10.8	.01
	Cam & Pincer	10	68.1 ± 13.9	8	83.5 ± 17.1	.12	7	90.4 ± 8.9	.03	10	91.3 ± 8.9	.01
	Not meeting radiographic criteria	18	72.6 ± 12.3	10	87.3 ± 16.9	.05	16	94.2 ± 9	<.01	18	92 ± 9.9	<.01
	P value[b]		.23		.45			.17			.08	
NAHS	Cam	31	73.2 ± 15.5	18	87.3 ± 17.6	.02	27	88.4 ± 10.5	<.001	32	84.7 ± 13.2	<.01
	Pincer	9	77 ± 8.7	7	86.3 ± 14.2	.24	9	85.1 ± 14.4	.14	9	91.1 ± 11.9	.01
	Cam & Pincer	9	74.6 ± 18.6	8	81.4 ± 15.8	.40	7	85.2 ± 12.7	.79	10	91.1 ± 8.7	.05
	Not meeting radiographic criteria	17	79.2 ± 15.9	10	81.6 ± 21.1	.72	16	92.2 ± 11.4	.01	18	91 ± 10.6	.01
	P value[b]		.61		.69			.23			.11	

[a]mHHS, modified Harris Hip Score; NAHS, Nonarthritic Hip Score; PRO, patient-reported outcome.
[b]Comparison between treatment groups at each time point (Kruskal-Wallis).
[c]Comparison between the initial visit and subsequent time period (Wilcoxon signed-rank test).

period and line graphs showing change in the mHHS and the NAHS over the course of the study are demonstrated in Table 2 and Figure 2, respectively.

A total of 74% of hips were treated with activity modification and physical therapy alone, and 15 hips (22%) progressed to an injection. The mean time from the initial visit to injection was 4.6 ± 4.3 months (range, 0.4-15.3 months). Of the hips that progressed to an injection, 8 (53%) progressed to surgery. In hips that were injected and subsequently progressed to surgery, surgery occurred at a mean of 9.2 ± 5.9 months after injection (range, 1.3-18.1 months). Four hips underwent surgery without first undergoing an injection. One of these hips had surgery at an outside institution approximately 5 years after the initial visit. Ultimately, 12 hips in our cohort underwent arthroscopic surgery. The mean time from the initial visit to surgery for the hips that were treated at our institution (n = 11) was 9.2 ± 5.9 months (range, 1.3-18.1 months).

Of note, 2 patients who were enrolled in the study but ultimately excluded because the mHHS was not collected at the initial visit went on to require surgery and subsequent revision surgery at outside institutions. One of these patients underwent revision arthroscopic surgery at approximately 43 months after their index procedure. The other patient was scheduled for revision arthroscopic surgery at an outside institution approximately 67 months after the patient's index procedure. None of the patients who underwent surgery at our facility had documented operative complications. Operative and postoperative notes were not available for the procedures performed at outside facilities; therefore, complications could not be assessed.

A subgroup analysis of PROs based on impingement type can be found in Table 3. We observed no significant difference in the mHHS or the NAHS among impingement type at any time period. All impingement types saw a significant increase in PROs from the initial visit to 5-year follow-up,

TABLE 4
Distribution of Return to Activity Response[a]

	Activity Mode (n = 32)		Injection (n = 7)		Scope (n = 9)		Total (n = 48)	
	n	%	n	%	n	%	n	%
Return to same sport/activity	17	53	1	14	2	22	20	42
Return to different sport/activity	9	28	2	29	3	33	14	29
Quit—because of hip pain	1	3	1	14	1	11	3	6
Quit—not because of hip pain	4	13	2	29	2	22	8	17
Quit—no reason given	1	3	1	14	1	11	3	6

[a]Three patients were omitted for not being physically active at enrollment. One patient had a scope on 1 hip and physical therapy on the other hip; this patient was counted as a scope for this analysis.

with the exception of NAHS for combined impingement at 5 years versus the initial visit (*P* = .05). Hips with cam impingement met the MCID for the mHHS at a rate of 69%, hips with pincer impingement at 89%, hips with combined type FAI at 80%, and hips not strictly meeting radiographic criteria of FAI at 72% of the time. We observed no statistically significant difference in the proportion of hips that met the MCID among FAI types (*P* = .64).

The information regarding return to activities can be found in Table 4. A total of 71% of patients in this study went back to the same activity or a different sport/activity. Of the patients who quit their sports/activities, 57% (8/14) quit for reasons other than hip pain. We observed no difference in the proportion of patients who returned to sports/activities among treatment types (*P* = .07) or FAI types (*P* = .22).

DISCUSSION

Most adolescent patients treated nonoperatively for FAI syndrome in this study saw improvements in the mHHS and the NAHS at a mean 5-year follow-up; these improvements were achieved at the 1- and 2-year marks and did not deteriorate at the 5-year mark. Additionally, there were no significant differences in PROs between treatment groups at 5 years. These data support a key role for nonoperative management in adolescent patients with FAI syndrome, with sustained improvements still present at 5 years after treatment. These findings are potentially in contrast to the recent literature suggesting superiority of operative management of FAI syndrome.[6,8,13]

There are 3 recent randomized controlled trials (RCTs) comparing nonoperative and arthroscopic management of FAI syndrome.[8,10,14] In a multicenter RCT, Griffin et al[8] demonstrated significant improvements in both treatment arms with greater improvements in the surgical arm. In contrast to our study, these patients were significantly older (mean age, 35 years) and did not undergo an injection as part of their nonoperative protocol. In a population of active duty military personnel with symptomatic FAI, Mansell et al[10] demonstrated no significant difference between treatment groups, and 33% of patients were unable to return to active duty regardless of treatment. Again, these patients were significantly older and were all active duty military personnel, thus limiting the comparability of these data with ours. A significant limitation of this RCT was the high rate of patient treatment crossover, potentially limiting their findings. In a multicenter RCT, Palmer et al[14] demonstrated a mean 10-point improvement in the Hip Outcome Score Activities of Daily Living in the arthroscopic surgery group compared with individualized physical therapy alone at a mean follow-up of 8 months after treatment. These patients were significantly older (mean age, 36 years) and the final follow-up duration was significantly shorter compared with the present study. Furthermore, in a meta-analysis of these 3 recent RCTs, Dwyer et al[6] concluded that patients treated arthroscopically have significantly improved short-term outcomes compared with physical therapy alone. We do not think that this conclusion is directly applicable to the adolescent population based on our current study, given significant differences in patient populations and nonoperative protocols utilized. Additionally, although our study is not an RCT, we do present substantially longer-term follow-up compared with these RCTs.

In adolescent patients, reports of promising nonoperative outcomes for FAI syndrome are lacking in the literature. In contrast, there are multiple reports of improved outcomes with arthroscopic surgery in this age group.[2,3,4,5,13,16] For example, Nwachukwu et al[13] reported that 85% of adolescent patients treated arthroscopically met the MCID for an improved mHHS 1 year postoperatively, but they did not report any outcomes for nonoperative management. More recently in a case series of 37 patients younger than 18 years, Cvetanovich et al[4] demonstrated that the mean mHHS improved from 58.1 to 82.1 with arthroscopic treatment, with 100% of patients returning to previous sport or activity level at 2-year follow-up. Again, this study did not report nonoperative outcomes. Furthermore, Menge et al[12] reported significant improvements in multiple PROs, including the mHHS (from 56 to 88) at 10 years after hip arthroscopy in a cohort of adolescent patients. This study did not include a nonoperative comparison group but did offer activity modification and physical therapy before surgery. From these data, an argument could be made for the efficacy of arthroscopic treatment of FAI syndrome in adolescents; however, it is impossible to determine the superiority of treatment given the lack of control or nonoperative groups in all of these examples. Our data support that similar improvements can be achieved in many adolescent patients with activity modification and a standardized physical therapy protocol as a first-line treatment. We do acknowledge that a subset of patients will likely progress to requiring surgery, as seen in our cohort and others.

It is important to consider the different pathoanatomic variants that can cause FAI syndrome. In a previous report, patients with cam and combined cam-pincer impingement were 4 times more likely to progress to surgery compared with those with pincer type alone.[15] Our current data demonstrated no statistically significant differences between FAI types in the final mHHS and the NAHS at a mean of 5 years. It is thus plausible that cam impingement is intrinsically less responsive to nonoperative management; however, more data are needed to answer this question. Importantly in our study, although patients with cam impingement scored lower overall, they still experienced statistically and clinically significant improvements in the mHHS and the NAHS.

We acknowledge a number of important limitations in our data. First, we did not address the progression of radiographic arthritis that is hypothetically associated with untreated FAI syndrome,[1] although this concept is not clearly proven in the literature. Future studies looking at long-term MRI and radiographic changes in both operative and nonoperative groups may help address this question. Additionally, we did include a subgroup of patients with clinical FAI syndrome that did not strictly meet radiographic criteria based on study design (n = 18 hips; Table 3). These patients had groin-based hip pain, a positive impingement test on examination, and no extra-articular hip pathology by examination or imaging. These patients tended to have borderline FAI pathology by imaging (Figure 1). We recognize that including this group introduces potential bias, however, these patients had statistically similar PROs to other subgroups throughout the course of the study. We recognize that use of the mHHS and the NAHS as primary endpoints has inherent limitations, however, we elected to use these measures for consistency of comparison with previously published data.[15] The mHHS and the NAHS have potential ceiling effects and were not initially designed to be applied to the adolescent FAI population; however, we do believe that the use of these scores offers clinically significant insight given the significant improvements seen at subsequent timepoints compared with the initial visit. Importantly, we did not see a deterioration in the mHHS or the NAHS at 5 years compared with 2 years, thus further supporting sustained clinical improvements even if scores were nearing a ceiling effect. The study was also underpowered to perform risk stratification to determine which patients are more likely to improve with nonoperative management and which specific factors of our nonoperative protocol are effective. These questions could be clarified with a larger cohort of patients. Our results are not generalizable to the adult population, and we acknowledge that there are good quality RCT and meta-analysis data suggesting a more prominent role for arthroscopic surgery in older patients.[6,8,14] Finally, there was a significant loss to follow-up in our study at 5 years after treatment, with 48% of the symptomatic hips that were enrolled (64/133) being unavailable at the 5-year time period. This could have affected our results. There are also follow-up discrepancies in our intermediate time points. For example, 38% of hips (26/69) were not available at the 1-year time point and 14% of hips (10/69) were not available at the 2-year time point. Long-term follow-up is challenging with this age group in the U.S. health care system, as many patients have moved, have different medical insurance, and have experienced significant life changes, such as attending full-time university or beginning their careers.

In conclusion, our findings support the role of nonoperative management in adolescent patients with FAI syndrome with sustained improvements in PROs at 5 years after the initiation of treatment.

ORCID iD

Andrew T. Pennock https://orcid.org/0000-0002-8628-5603

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