

# Femoral de-rotation osteotomy versus hip arthroscopy for management of femoroacetabular impingement in adult patients with decreased femoral anteversion: a matched retrospective cohort study

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## ABSTRACT

Femoral de-rotation osteotomy (FDO) and hip arthroscopy are both recognized surgical options for the management of femoroacetabular impingement (FAI) in the setting of decreased femoral anteversion ( $<5^\circ$ ). Minimal comparative data exist regarding the difference in outcomes between these two techniques, and we believe this is the first study to provide that comparison. This retrospective cohort study included a total of 20 patients with such pathology, matched for age, gender and body mass index. A total of 10 patients were included in the FDO group [median anteversion  $-0.5^\circ$  (true retroversion); average follow-up 17.9 months]. In total, 10 patients were included in the hip arthroscopy group [median anteversion  $-0.5^\circ$  (true retroversion); average follow-up 28.5 months]. Both groups demonstrated statistically and clinically significant improvement in the post-operative International Hip Outcome Tool (iHOT-33) scores [median improvement: FDO group, 37.7 points ( $r$  14–58.8;  $P < 0.041$ ); hip arthroscopy group, 35.9 points ( $r$  11.1–81;  $P < 0.05$ )], noting that the minimal clinically important difference for the iHOT-33 is 6.1 points. However, the study was not adequately powered to delineate a difference in improvement between the two groups. The findings suggest significant improvement in patient-reported outcomes, and clinical findings can be achieved with either FDO or hip arthroscopy for FAI in the setting of decreased femoral anteversion. However, selection of the most suitable surgical procedure using a patient-specific approach may optimize outcomes in this challenging population.

## INTRODUCTION

Femoroacetabular impingement (FAI) is a commonly recognized syndrome, leading to hip pain in young adult patients. Left unmanaged, FAI can lead to early-onset hip osteoarthritis [1–4]. The classic types of FAI include cam, pincer and mixed impingement [5]. Cam-type impingement is the result of an abnormal thickness of the femoral neck demonstrated by a decreased anterior offset ratio or an asphericity at the femoral head–neck junction demonstrated by an increased alpha angle [6]. Pincer-type impingement results from general or focal anterior acetabular over-coverage, causing linear contact between the acetabular rim and the femoral head–neck junction [1].

Decreased femoral version has also been identified as an important factor for consideration in patients presenting with FAI. This particular anatomical relationship can amplify impingement from cam or pincer lesions or can itself be the

primary cause of impingement [3, 4, 6–9]. Normal anteversion, which is the anatomic relationship between the femoral neck axis and the distal femoral condyles, typically ranges from  $8^\circ$  to  $20^\circ$  in adults [2, 3, 6, 7, 10, 11] and is most often referenced to the transepicondylar or posterior condylar axis [12]. Femoral ‘retroversion’ is typically defined as  $<5^\circ$  of anteversion [6, 13], although we prefer specific terms such as ‘decreased femoral anteversion’ or ‘true retroversion’, which may be more universally understood.

The use of hip arthroscopy has significantly grown and is usually successful in the treatment of symptomatic patients with FAI. However, several studies have concluded that patients with decreased femoral version may experience less benefit from hip arthroscopy, with potential for residual pain and poor functional outcomes [6, 8, 13, 14]. In contrast, after comparing the clinical outcomes following hip arthroscopy in patients

with femoral retroversion, normal femoral version and excessive femoral anteversion, Jackson *et al.* reported no difference in scores between the three groups and concluded that ‘the significant improvements in outcomes for all groups after arthroscopy indicate that abnormalities in proximal femoral version do not appear to affect the clinical outcomes after hip arthroscopy’ [15]. However, in a study of 243 hip arthroscopy patients stratified by femoral version, the improvement in those with femoral version  $<5^\circ$  was of significantly smaller magnitude despite still meeting clinical significance [13]. Hip arthroscopy is also not without risk, and although conceptually a significant volumetric bone resection at the femoral head–neck junction may eradicate even severe cam impingement, it may predispose to an iatrogenic femoral neck fracture [6]. Likewise, significant resection of the acetabular rim can lead to acetabular deficiency and iatrogenic dysplasia.

Alternatively, these patients with FAI and decreased femoral version may be managed with an anteverting femoral de-rotation osteotomy (FDO). In fact, Tönnis and Heinecke concluded that only rotational osteotomies performed to increase anteversion are successful in such patients [16]. In a previous study, we described our technique for FDO and reported significant improvement in patient-reported outcomes and clinical findings following FDO for symptomatic hip impingement in the setting of decreased femoral anteversion ( $<5^\circ$ ) [17]. These results were found despite the presence of other pathologic findings such as cam lesions and labral tears that were not specifically addressed [17].

Although both hip arthroscopy and FDO have been shown to be acceptable surgical options for FAI in the setting of decreased femoral version, minimal data exist regarding the difference in outcomes between these two techniques, and to our knowledge there has been no study with a direct comparison. Therefore, the primary aim of this study was to compare outcomes of patients who had either undergone an FDO or hip arthroscopy for symptomatic FAI in the presence of reduced femoral neck anteversion ( $<5^\circ$ ). The secondary aim of the study was to investigate associated complications.

## PATIENTS AND METHODS

This matched retrospective cohort study utilized prospectively collected database information of patients who underwent elective FDO or hip arthroscopy by the senior author (K.D.J.) for symptomatic FAI at our institution during the 5-year period of 2016–20. The research protocol was approved by the Conjoint Health Research Ethics Board at the University of Calgary. Patients were matched according to age, gender and body mass index. The inclusion criteria were as follows: (i) any patient with symptomatic FAI and limited hip internal rotation (IR) with the hip flexed to  $90^\circ$ ; (ii) any patient with decreased femoral anteversion ( $<5^\circ$ ) on imaging; (iii) any patient in whom symptoms failed to improve with non-operative treatment; (iv) any patient who subsequently underwent elective anteverting FDO or hip arthroscopy; (v) any patient who completed a minimum post-operative follow-up period of 1 year and (vi) any patient with minimum 16 years of age at the time of surgery. Also, no patients in the FDO group had hip arthroscopy intervention prior to undergoing FDO. For patients meeting criteria (i), (ii) and (iii),

both surgical options were outlined in detail. Differentiating factors that may lead to the patient undergoing a hip arthroscopy rather than an FDO include: (i) total hip rotational arc of motion at  $90^\circ$  of flexion [IR + external rotation (ER)]  $<60^\circ$  which therefore does not support FDO; (ii) the patient did not desire a perceived larger operation requiring a femoral osteotomy or (iii) the patient smokes tobacco and refused smoking cessation. Patients with Workers Compensation Board (WCB) claims were excluded.

### Clinical exam

As described in our previous study [17], all patients had a comprehensive physical exam performed pre-operatively by the principal investigator (PI) K.D.J. FAI was diagnosed clinically with an amalgamation of patient history and suggestive physical exam findings. These findings typically include reduced hip IR with the patient supine and the hip flexed to  $90^\circ$  along with a positive hip flexion, adduction and internal rotation (FADIR) test. Passive hip range of motion (ROM) was evaluated, with the degree of IR and ER documented. Clinical exam was repeated at each follow-up visit by the PI with findings documented.

### Imaging

Also as previously described [17], all patients had standardized supine pelvic anteroposterior and Dunn’s lateral plain radiographs of the affected hip. Magnetic resonance imaging (MRI) or a magnetic resonance arthrogram was performed for all patients to assess for intra-articular pathology. Femoral version was calculated as the angle between the femoral neck axis and the posterior condylar axis of the femur, with the details of calculation described in our previous paper [17]. If the initial MRI did not include images at the knee to perform a ‘femoral torsional protocol’, a low-dose computed tomography scan at the hip and knee was subsequently obtained due to improved availability. Post-operative plain radiographs of the affected hip and ipsilateral femur (for FDO) are obtained at the standardized follow-up schedule for each procedure.

### Outcome measures

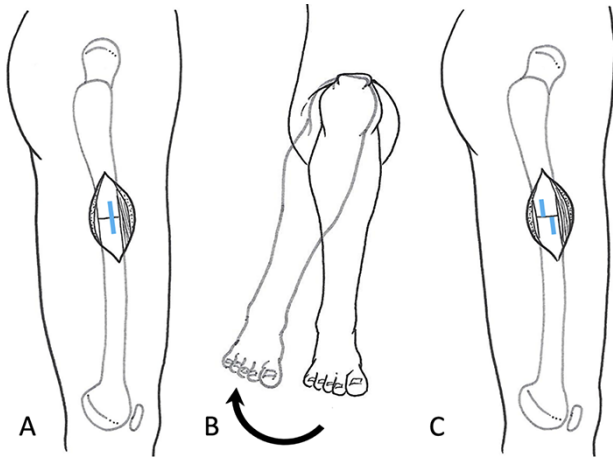
Patient-reported outcomes were assessed utilizing the International Hip Outcome Tool (iHOT-33), a self-administered outcome tool to measure health-related quality of life in young active patients with hip disorders [18]. A score from 0 to 100 is generated, with 0 representing the lowest and 100 representing the highest possible quality of life. The minimal clinically important difference (MCID) for the iHOT-33 is 6.1 points [18]. A power calculation revealed that 16 patients were required in each group to determine a statistical difference in improvement in the iHOT-33 score.

During clinical follow-up visits, the patient’s general perception of post-operative improvement, along with the presence or absence of a positive FADIR sign, was recorded.

Intra- and post-operative complications were assessed, as were rates and timing of osteotomy union in those who received an FDO procedure.

## SURGICAL TECHNIQUES

All procedures were performed by the senior author (K.D.J.).



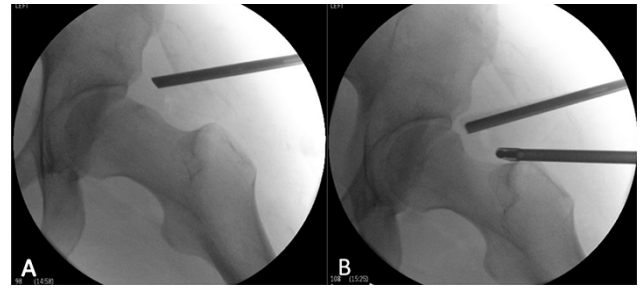
**Fig. 1.** Example of correction performed during a right FDO. (A) Alignment prior to rotational correction; (B) rotational correction manoeuvre and (C) alignment following rotational correction. Used with permission from Mastel *et al.* [17].

### Femoral de-rotation osteotomy

Our preferred technique for FDO was previously described in detail and was the result of procedural evolution in response to outcomes and complications (Fig. 1; [17]). In summary, the femur is prepared for an antegrade piriformis-entry femoral nail, an osteotomy completed through a sub-vastus approach and the definitive femoral nail inserted and locked proximally. After removing the insertion handle, the hip is flexed to 90° and brought into IR until a point of impingement, and then additional IR was performed, allowing the distal fragment to rotate around the proximally fixed nail (Fig. 1B). Correction is determined based on numerous factors including a typical minimum target of 20° IR (when the hip is flexed to 90°), comparison and matching to the contralateral side if the problem is unilateral, correction of the patella to a forward-facing position with the leg extended and assessment of rotational alignment at the osteotomy site (Fig. 1A and C). Once the desired correction is confirmed, the nail is locked statically distally and then compressed proximally. The hip can then be taken through a full ROM to confirm the resulting amount of IR and ER and static position of the patella and foot when the leg is positioned in extension on the OR table.

### Hip arthroscopy

Hip arthroscopy was performed in the lateral decubitus position with a perineal post and hip distractor (Smith & Nephew). Anaesthesia typically consists of a combined general anaesthetic and short-acting spinal anaesthetic to minimize post-operative pain. Following hip distraction, anterior and posterior peritrochanteric access was obtained under fluoroscopic guidance followed by a third, mid-anterior portal. An inter-portal capsulotomy and a T-capsulotomy were performed. Pathology in the intra-articular and peripheral compartments was managed when indicated including possible chondral debridement, microfracture, labral repair and acetabular rim trim/sub-spinous recession. A thorough femoral head and neck osteochondroplasty was performed in all cases, extending from the medial synovial fold



**Fig. 2.** Fluoroscopic images during hip arthroscopy demonstrating (A) femoral neck cam lesion, (B) following thorough femoral osteochondroplasty with elimination of cam lesion and restoration of femoral neck concavity.

back to the retinacular vessels (Fig. 2). The T-capsulotomy was routinely repaired; however, the inter-portal capsulotomy was selectively repaired in patients with borderline acetabular dysplasia, excessive hip mobility and soft-tissue laxity. The current literature would support the fact that there is insufficient evidence for routine inter-portal capsulotomy closure [19]. Post-operatively, patients were routinely instructed to partially weight bear with a 50-pound limit for 6 weeks to reduce the risk of femoral neck fracture. A hip flexion restriction of 60° for 6 weeks was utilized for those who underwent labral repair. Diclofenac/Misoprostol was prescribed for 6 weeks post-operatively for heterotopic ossification (HO) prophylaxis.

### RESULTS

A total of 64 patients were identified as having undergone FDO or hip arthroscopy for FAI in the setting of decreased femoral anteversion (<5°). In total, 40 were excluded for having incomplete ROM data ( $n=7$ ), missing iHOT-33 scores ( $n=18$ ), recent surgery ( $n=1$ ; <1 year), poor ROM at baseline making them ineligible for FDO ( $n=6$ ), WCB injury ( $n=2$ ), alternate diagnosis ( $n=5$ ; slipped capital femoral epiphysis and developmental dysplasia of the hip) or additional procedures on the hip ( $n=1$ ). There were 14 eligible patients in the FDO group and 10 in the hip arthroscopy group. After matching, a total of 20 patients were included, with 10 in each of the FDO and hip arthroscopy groups.

Patient demographics and pre-operative findings for each group are demonstrated in Table I. The median age at time of surgery was 33 ( $r$  20–44) years for the FDO group and 35.5 ( $r$  17–46) years for the hip arthroscopy group ( $P=0.94$ ). Median femoral anteversion was  $-0.5^\circ$  ( $r$   $-8$  to  $2$ ) for the FDO group and  $-0.5^\circ$  ( $r$   $-17$  to  $5$ ) for the hip arthroscopy group ( $P=0.73$ ). The mean duration of follow-up was 17.9 ( $r$  12–35) months for the FDO group and 28.5 ( $r$  12–63) months for the hip arthroscopy group ( $P=0.36$ ). The following operation details were noted in the hip arthroscopy group: 10/10 patients had an osteochondroplasty, 6/10 acetabular rim trim, 3/10 acetabular chondral debridement, 3/10 labral debridement, 5/10 labral repairs and 10/10 repairs of T-capsulotomy.

Both groups demonstrated statistically and clinically significant improvement in post-operative iHOT-33 scores with a median improvement of 37.7 points ( $r$  14–58.8;  $P<0.05$ ) for the FDO group and 35.9 points ( $r$   $-11.1$  to  $81$ ;  $P=0.014$ )

**Table I. Patient demographics, pre-operative clinical and imaging findings and relevant comparisons for the de-rotation femoral osteotomy and hip arthroscopy groups**

Intervention group		FDO	Hip arthroscopy	Comparison
Patient demographics	Age at surgery (median years)	33 (r 20–44)	35.5 (r 17–46)	$P = 0.94$
	Gender	4 male (40%); 6 female (60%)	7 male (70%); 3 female (30%)	$P = 0.37$
	Body mass index (median)	25.3	27.9	$P = 0.36$
	Laterality	9 right; 1 left	7 right; 3 left	
	Femoral anteversion angle (median degrees)	-0.5 (r -8 to 2)	-0.5 (r -17 to 5)	$P = 0.73$
Pre-operative clinical findings	Previous hip surgery	0/10 cases	0/10 cases	
	Positive hip impingement sign	10/10 cases	10/10 cases	
	Hip IR (median degrees)	5 (r -5 to 10)	5 (r 0–15)	$P = 0.29$
Pre-operative X-ray	Hip ER (median degrees)	70 (r 60–90)	60 (r 45–70)	$P < 0.05$
	Tonnis 0	9/10 cases	9/10 cases	
	Tonnis 1	1/10 cases	1/10 cases	
	CEA (mean degrees)	33.5 (r 25–47)	31.3 (r 24–44); 1/10 cases <25	
Pre-operative MRI	Alpha angle (mean degrees)	57.6 (r 44–74); 7/10 cases $\geq 50$	70 (r 59–83); 10/10 cases $\geq 50$	
	Presence of labral pathology	8/10 hips (80%)	9/10 hips (90%)	
	Articular degeneration	Mild: 3 hips (30%) Moderate: 1 hip	Mild: 5 hips (50 %) Moderate: 1 hip	

for the hip arthroscopy group at final follow-up (Table II). The difference in improvement between the two groups was not statistically significant ( $P = 0.791$ ). Post-operatively, all patients in the FDO group reported they were satisfied with the procedure. There were two dissatisfied patients in the hip arthroscopy group. One had continued groin pain and clinical anterior impingement, which significantly improved following a subsequent FDO procedure performed 2.4 years after the hip arthroscopy. The second patient had moderate degenerative changes pre-operatively and also re-injured the hip after arthroscopy. He is now awaiting a total hip replacement. There were nine patients in the hip arthroscopy group with a positive anterior impingement sign at the time of final follow-up (five mild and four moderate to severe) and five such patients in the DFO group (all mild).

There were significant hip ROM changes noted pre-operatively to post-operatively in the FDO group (Table III). The median pre-operative IR was  $5^\circ$ , which subsequently increased to  $25^\circ$  (median of the difference  $22.5$ ,  $r$  15–40,  $P < 0.05$ ). The median pre-operative ER was  $70^\circ$ , which decreased to  $50^\circ$  (median of the difference  $-22.5$ ,  $r$  -40 to -10,  $P < 0.05$ ). Hip ROM did not change significantly pre- to post-operatively in the hip arthroscopy group. The median pre-operative IR in this group was  $5^\circ$ , which increased to  $10^\circ$  (median of the difference  $5$ ,  $r$  -5 to 15,  $P = 0.212$ ). The median pre-operative ER was  $60^\circ$  and remained the same post-operatively (median of the difference  $2.5$ ,  $r$  -15 to 10,  $P = 0.942$ ).

### Complications

There were no intra-operative complications in either study group. Post-operatively, HO was identified in two patients in the FDO group, with one being symptomatic and requiring

**Table II. Median pre- and post-operative iHOT-33 scores, along with median improvement, post-operative patient perception of improvement and ongoing presence of anterior hip impingement sign for FDO and hip arthroscopy groups**

		FDO	Hip arthroscopy
iHOT-33	Pre-operative (median)	33 (r 24–56)	39 (r 1–63)
	Post-operative (median)	77.3 (r 59.7–91.8)	78.9 (r 12.5–100)
	Improvement (median of difference)	37.7 (r 14–58.8; $P < 0.05$ )	35.9 (r -11.1 to 81; $P = 0.014$ )
	Patient-reported significant improvement	10/10 cases	8/10 cases
Persistent anterior impingement sign		5/10 cases	9/10 cases

excision with hardware removal. Three other patients in the FDO group experienced painful hardware and elected to proceed with removal of distal locking screws. Two patients have already undergone hardware removal and are subsequently experiencing significant improvement in symptoms. Notwithstanding, the amount of improvement has not yet been quantified with a follow-up iHOT-33 score.

There were no cases of HO in the hip arthroscopy group although one patient experienced peptic ulcer disease following nonsteroidal anti-inflammatory drug use for prophylaxis. There were no identified cases of prolonged transient nerve palsy. As previously noted, two patients in the hip arthroscopy group had

**Table III. Pre- and post-operative clinical internal and external hip rotation along with the overall change (reported as median of difference)**

		FDO	Hip arthroscopy
IR	Pre-operative (median)	5 ( <i>r</i> -5 to 10)	5 ( <i>r</i> 0-15)
	Post-operative (median)	25 ( <i>r</i> 20-50)	10 ( <i>r</i> 0-20)
	Difference (median of the difference)	22.5 ( <i>r</i> 15-40; <i>P</i> < 0.05)	5 ( <i>r</i> -5-15; <i>P</i> = 0.212)
ER	Pre-operative (median)	70 ( <i>r</i> 60-90)	60 ( <i>r</i> 45-70)
	Post-operative (median)	50 ( <i>r</i> 40-60)	60 ( <i>r</i> 45-70)
	Difference (median of the difference)	-22.5 ( <i>r</i> -40 to -10; <i>P</i> < 0.05)	2.5 ( <i>r</i> -15 to 10; <i>P</i> = 0.942)

severe symptomatic ongoing FAI. One had significant subjective improvement following a subsequent FDO and the other is awaiting total hip arthroplasty for secondary osteoarthritis.

The overall major complication rate in the FDO group was 50% (HO and painful hardware) and 30% in the hip arthroscopy group (post-operative medication related and persistent pain). The re-operation rate was 40% in the FDO group and 20% in the hip arthroscopy group, recognizing that this rate in the FDO group mainly represents a simple procedure to remove a single distal locking screw, not re-operation to treat ongoing impingement.

## DISCUSSION

Although hip arthroscopy is an increasingly common procedure for symptomatic FAI with repeatedly demonstrated efficacy, there is varying literature as to its benefit in patients with symptomatic FAI in the setting of decreased femoral version. While there are numerous reports of less successful results [6, 8, 13, 14] in these particular patients, there are other reports of no decreased efficacy [15]. It has been reported that decreased femoral version can exacerbate the effects of a cam lesion by engaging the lesion into the acetabulum earlier in the process of hip flexion [6]. Therefore, a small cam lesion may be symptomatic in a patient with decreased femoral version, whereas a large cam lesion may be present yet asymptomatic in a patient with normal or increased anteversion. It is interesting to note that there were two dissatisfied patients in the hip arthroscopy group, one that perceived significant improvement with a subsequent FDO procedure performed 2.4 years later, despite a thorough initial osteochondroplasty. This may suggest that greater correction can be obtained with an FDO, which is also reflected in the ROM outcomes of our study where a significantly greater increase in IR was obtained in the FDO group. Similar, in our previous study of 33 FDO cases for the management of FAI in patients with decreased femoral version, we identified three cases where a patient had previously undergone one or more hip arthroscopies for impingement with persistence of symptoms that only

improved after FDO [17]. The results of these cases may support the critical influence of femoral version, with the potential for amplified impingement with a small residual cam lesion in the presence of significantly decreased femoral version. It may therefore not be possible to always fully resolve hip impingement with a safely performed osteochondroplasty alone in certain patients with decreased femoral version [13].

There have been numerous descriptions of FDO procedures for the management of FAI in patients with decreased femoral version [6, 8, 20], and we previously described our technique and reported significant improvement in such patients [17]. Consistent with our previous study [17], no intra-articular surgery was performed in the FDO group in the current study despite the presence of labral pathology in 80% of patients, and an average alpha angle of 57.6° was obtained, with 7/10 patients having a value >50°. Therefore, this again supports the concept that significant benefit can be achieved by addressing the most aberrant underlying mechanical pathology, which in these patients was felt to be the decreased femoral version. However, it is unknown if these patients who underwent FDO would have had further improvement in symptoms with the addition of intra-articular procedures including a cam osteochondroplasty and labral repair when indicated. A future study evaluating this would be warranted.

As decreased femoral version may be present in up to 16.6% of patients presenting with FAI [4], it is critical to consider such underlying deformity in all patients with FAI. Numerous studies have suggested a correlation between decreased femoral anteversion and a subsequent decrease in hip IR [3, 4, 6, 14]. Therefore, this simple clinical finding can help identify those at increased risk of impingement [21]. The present group of patients with decreased femoral anteversion (median: -0.5° in the FDO group and -0.5° in the hip arthroscopy group) reflected this pattern of decreased hip IR (Table 1). The senior author routinely investigates femoral version with imaging in any patient presenting with FAI who has <15° of IR with the hip flexed to 90°.

To our knowledge, this study has been the first direct comparison of FDO and hip arthroscopy in patients with FAI and decreased femoral version. Quantification of patient improvement was performed using a patient-reported outcome measurement tool, the iHOT-33. The median improvement in post-operative iHOT-33 score was 37.7 (*r* 14-58.8; *P* < 0.05) for the FDO group at a mean follow-up of 17.9 months and 35.85 (*r* -11.1 to 81; *P* = 0.014) for the hip arthroscopy group at a mean follow-up of 28.5 months, demonstrating a statistically and clinically significant improvement for both groups, recalling that the MCID for the iHOT-33 is 6.1 points [18].

The difference in median iHOT-33 improvement between the two groups was only 1.8 points; however, this study is not adequately powered to determine if this difference is statistically significant based on power calculation, suggesting a requirement of 16 patients in each cohort. This proves to be a significant limitation of this small retrospective cohort study; however, a planned randomized trial will aim to delineate more specific differences. Additionally, despite no significant difference in the mean duration of follow-up between the groups (17.9 months in the FDO group, 28.5 months in the hip arthroscopy group; *P* = 0.36), the lack of complete 2-year follow-up in the FDO group is a limitation.

Ultimately, the current study demonstrates that both procedures are associated with a significant benefit to patients with FAI in the presence of decreased femoral version. However, each procedure is associated with potential downsides. Although hip arthroscopy was associated with less overall risk of complication and is perceived to have less morbidity than an FDO, it may not be possible to safely excise enough bone during an arthroscopic osteochondroplasty to fully relieve impingement in all patients with the antagonistic influence of decreased femoral version. Further investigation will continue to determine the most appropriate indications and the differences in outcomes related to FDO and hip arthroscopy in patients with FAI and decreased femoral version. However, the authors currently believe the most contributing pathology should be considered, including the size of a cam lesion and associated femoral version, to determine the most appropriate and desirable procedure for each patient on an individual basis.

### CONCLUSION

Significant improvement in both patient-reported outcome measures and clinical findings can be achieved with either FDO or hip arthroscopy for symptomatic hip impingement in the setting of decreased femoral anteversion ( $<5^\circ$ ). Further research will be beneficial in delineating specific differences in outcomes between these two procedures. However, the use of a patient-specific approach to guide selection of the most suitable surgical procedure to manage FAI in this specific subset of patients may optimize outcomes.

### DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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### CONFLICT OF INTEREST STATEMENT

None declared.

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