Does Femoral Retroversion Adversely Affect Outcomes After Hip Arthroscopy for Femoroacetabular Impingement Syndrome? A Midterm Analysis

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Purpose: To report 5-year outcomes of arthroscopic treatment of femoroacetabular impingement syndrome in patients with femoral retroversion compared with a control group of patients with normal femoral anteversion. **Methods:** Data were prospectively collected and retrospectively reviewed for all patients who underwent hip arthroscopy between August 2008 and April 2013. Patients were included in analysis if they underwent hip arthroscopy during this period and had femoral version $\leq 0°$ calculated using magnetic resonance imaging. Exclusion criteria included prior ipsilateral hip conditions/surgeries or Tönnis grade >1. These patients were pair matched with patients having femoral anteversion between 10° and 20° based on gender, body mass index $\pm$ 10, and age $\pm$ 10 years. Patient-reported outcomes (PROs) were collected at 3 months and 1 year postoperatively and annually thereafter. An a priori power analysis was performed. **Results:** A total of 59 patients were identified as the experimental group out of 69 eligible for inclusion (86%). All 59 patients were matched, with a mean age of 37.4 years and mean body mass index of 26.9. Twenty patients were female, and 39 were male. These patients demonstrated significant improvement from their preoperative state in all patient-reported outcomes and visual analog score scores ($P < .001$). Thirty-eight patients met the threshold for minimal clinically important difference, and 35 achieved patient acceptable symptomatic state for the modified Harris Hip Score questionnaire. Seven patients converted to total hip replacement. No differences were noted between retroverted and control patients in any of the outcome measures collected, in pain or satisfaction ratings, in the frequency of or duration to secondary surgeries or in complication rate ($P > .05$). **Conclusions:** Patients with femoral retroversion demonstrated significantly higher outcomes at minimum 5-year follow-up after undergoing arthroscopic hip surgery. These outcomes were not different from those of patients with normal femoral version. While femoral retroversion should not be considered a contraindication to hip arthroscopy, it should be carefully considered as a factor in patient selection and surgical planning. **Level of Evidence:** Level III, retrospective comparative study.

Arthroscopic hip surgery for the treatment of acute and chronic chondrolabral pathology and femoroacetabular impingement (FAI) is a successful procedure in patients who have well-maintained joint space and known abnormalities, as demonstrated by physical examination, patient history, x-rays, magnetic resonance imaging (MRI), or 3-dimensional computed tomography scan.[1-5]

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It has been well established that predictors of poor outcomes after arthroscopic hip surgery include female gender, advanced age, dysplasia, high body mass index (BMI), and articular cartilage damage.[6-11] However, it is unclear whether femoral retroversion is also a negative prognostic factor. On the one hand, due to the impingement between the femoral neck and acetabulum, femoral retroversion has suggested to be a possible causative factor of pincer-type FAI, predisposing patients to labral tears, chondral wear, and osteoarthritis.[12,13] Previous studies have indicated that femoral retroversion is a negative prognostic factor associated with inferior patient-reported outcomes (PROs).[14] On the other hand, a prior study from our institution showed that patients with isolated femoral retroversion, defined as femoral version ≤0°, had favorable outcomes that were similar to a control group at a minimum 2-year follow-up.[15] Ferro et al.[16] also reported similar outcomes between patients with low (5°), normal (5°-15°), or high (>15°) version at a mean follow-up of 2 years. Despite these promising short-term outcomes, there is a paucity of literature on this subject at midterm follow-up. As arthroscopic treatment of FAI does not alter femoral version,[14] rotational osteotomy has been considered as a potential surgical alternative. However, there is little literature on the outcomes of this treatment.

The purpose of this study was to report 5-year outcomes of arthroscopic treatment of FAI syndrome in patients with femoral retroversion compared with a control group of patients with normal femoral anteversion. Our hypothesis was that these favorable outcomes were not durable and that femoral retroversion would portend an inferior prognosis when compared with a pair-matched control group of patients with femoral version between 10° and 20°.

Methods

Patient Selection

Data were prospectively collected as part of our institutional Hip Preservation Registry and were retrospectively reviewed for patients who underwent hip arthroscopy at our institution between August 2008 and April 2013. Institutional review board approval was obtained for this study. Patients were considered for inclusion if they received arthroscopic treatment during this period; presented with femoral version ≤0°, calculated on preoperative MRI imaging; and had preoperative PRO scores for the following questionnaires: modified Harris Hip Score (mHHS), Non-Arthritic Hip Score (NAHS), Hip Outcome Score-Sports Specific Scale (HOS-SSS), and visual analog scale (VAS). Patients were excluded from analysis if they were previously diagnosed with an ipsilateral hip condition, such as avascular necrosis, Legg-Calvé-Perthes disease, or slipped capital femoral epiphysis; if they underwent prior hip surgery; or if their Tönnis grade of osteoarthritis was >1.

These individuals were matched in a 1:1 ratio to control patients by gender, age at surgery ±10 years, and body mass index ± 10. The control group consisted of patients who satisfied the same inclusion and exclusion criteria but who presented with a femoral anterversion angle between 10° and 20° according to preoperative MRI images. A previous study from our institution used 10° to 20° to elucidate a difference between the 2 groups if a difference truly existed between retroverted and anteverted femora.[6] Furthermore, Ito et al.[17] defined normal version as 5° to 20°, so a range 10° to 20° for the control group allowed for a clearer determination of the effects of retroversion, if one existed.

Participation in the American Hip Institution Hip Preservation Registry

While the present study represents a unique analysis, data on some patients in this study may have been reported in other studies. All data collection received Institutional Review Board approval.

Physical Examination

All patients underwent a physical examination by the senior author (B.G.D.), both preoperatively and at subsequent follow-up office visits. This exam assessed range of motion, gait, alignment, and strength. Impingement tests—anterior, lateral, and posterior—were used to assess for FAI. The anterior impingement test put the hip through forced flexion, adduction, and internal rotation; the lateral impingement test through forced abduction and external rotation; and the posterior impingement test through extension, followed by external rotation.[18,19] The senior author also performed the Trendelenburg test for abductor function,[20] the Beighton test for ligamentous laxity,[21] and other assessments for various intra- and extra-articular pathologies.

Radiographic Imaging

A series of radiographic images were obtained on all patients prior to surgery, which included the following views: anteroposterior pelvic, modified 45° Dunn, cross-table lateral, and false-profile.[22-25] Evaluations of these images were performed using GE Healthcare's Picture Archiving and Communication System (GE-PACS; Fairfield, CT), with different measurements obtained from each of the views.

The supine anteroposterior pelvic view was used to measure the extent of osteoarthritis, according to Tönnis grade; acetabular version, based on ischial spine protrusion, crossover sign, and posterior wall sign; acetabular inclination, using lateral center-edge angle

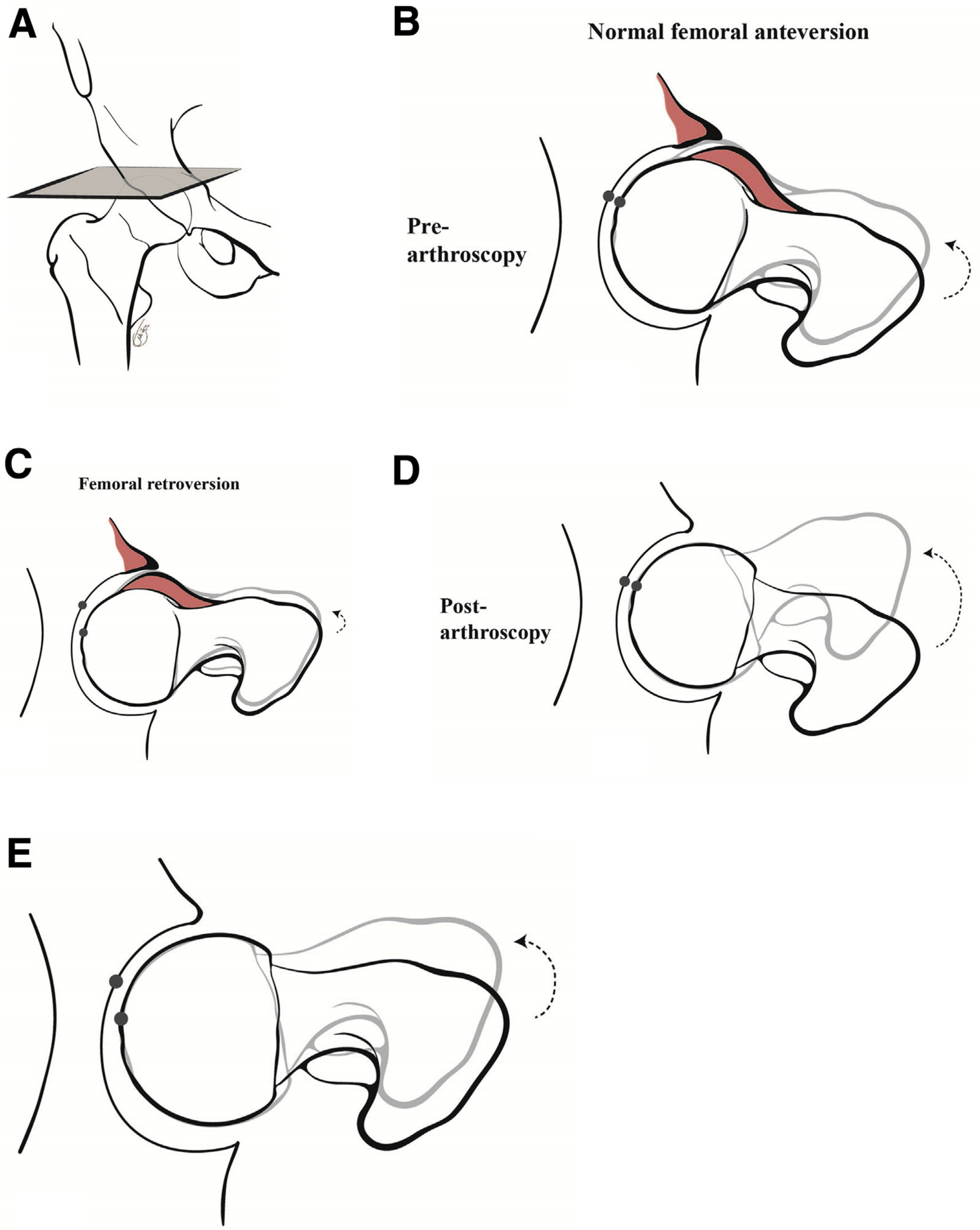

Fig 1. (A) Anterior view of hip. (B) Superior view of hip with normal femoral anteversion and femoroacetabular impingement depicting range of internal rotation. (C) Superior view of hip with femoral retroversion and femoroacetabular impingement depicting range of internal rotation. (D) Superior view of hip with normal femoral anteversion after arthroscopy to correct femoroacetabular impingement. The degree of internal rotation is increased post-arthroscopy. (E) Superior view of hip with femoral retroversion after arthroscopy to correct femoroacetabular impingement. The degree of internal rotation is increased postarthroscopy.

(LCEA) and Tönnis angle; and joint-space narrowing, with measurements taken from the edge of the femoral head to the lateral, central, and medial sourcil.[26,27] An LCEA measurement <18° indicated dysplasia, whereas an angle >40° indicated pincer-type impingement and acetabular overcoverage.[28,29] This view was also used to assess the orientation of the hip and the depth of the hip socket, based on the neck-shaft angle measurement and the presence of coxa profunda, respectively. The anterior center-edge angle, a measure of acetabular anterior coverage, was determined from the false-profile view.[30] The modified Dunn view was used to measure alpha angle and head-neck offset to identify cam impingement, roughly indicated by an alpha angle >60° or a <0.8-cm offset.[31]

MRI or magnetic resonance arthrography was performed on all patients prior to operative intervention. Femoral version measurements were completed using the oblique method.[32] First, a line parallel to the posterior femoral condyles was drawn. Next, a line was drawn through the center of the femoral neck on the oblique axial images. These images and lines were then superimposed over one another. The angle between the drawn lines was reported as the femoral version measurement and was recorded in degrees. This imaging was interpreted by a board-certified musculoskeletal

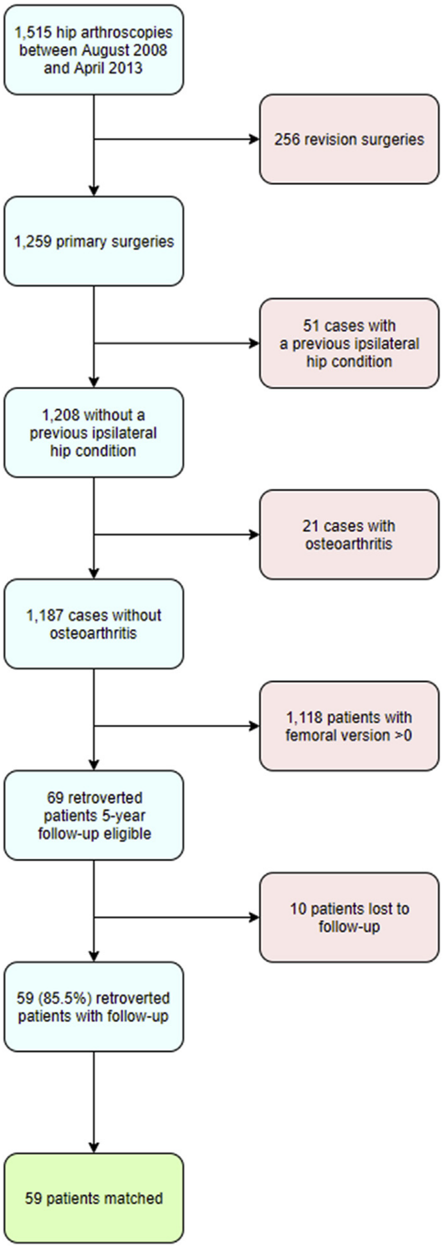

Fig 2. Patient selection flowchart.

radiologist as well as the senior author to evaluate for labral pathology, generalized chondral damage, and calculation of femoral neck version. Although both MRI and computed tomography can be used to determine version, previous studies have reported that both are comparable in terms of calculation and accuracy.[33,34]

Surgical Indication and Technique

Patients were indicated for arthroscopic surgery if their radiographic imaging, history, and physical examination demonstrated evidence of FAI or labral tears; if they experienced moderate to severe pain that was unresponsive to at least 3 months of nonsurgical treatment, including physical therapy, nonsteroidal anti-inflammatory drugs, and activity modification; and if they demonstrated no evidence of advanced arthritis based on preoperative diagnostic imaging.

Careful surgical indications and planning were completed in patients with femoral retroversion, with specific attention paid to understanding the extent of preoperative range of motion, bony architecture, and location of chondrolabral damage. Retroverted femora intuitively require less internal rotation prior to causing FAI during attempted flexion and internal rotation (Fig. 1). Care was taken to plan for thorough inspection of anterolateral labral injury that would occur in early impingement. Likewise, the surgical plan was adjusted to account for anatomically decreased head-neck offset.

All hip arthroscopies were performed by the senior author. Under general endotracheal anesthesia, patients were situated in the modified supine position with well-padded perineal post, and traction was applied to the hip under fluoroscopy. After establishment of anterolateral and midanterior portals, as well as interportal capsulotomy, a diagnostic arthroscopy of the central compartment was performed to assess the labrum, intra-articular cartilage, and ligamentum teres (LT). Labral tears were classified according to Seldes et al.[35] Acetabular or femoral head chondral damage was recorded based on acetabular labrum articular disruption and Outerbridge classifications.[36,37] Ligamentum teres injuries were defined by Domb and Villar classification systems.[38,39]

Various procedures were carried out based on a patient's intra-articular and peritrochanteric damage. Acetabuloplasty and femoral osteoplasty were performed under fluoroscopic guidance to treat pincer-type and cam-type impingement, respectively. Resection of cam-type impingement was completed with the goal of recreating appropriate head-neck offset, spherical contour of the femoral head, and impingement-free range of motion.[40]

Labral tears were debrided, repaired, or reconstructed depending on the extent of injury, size of labrum, and amount of available labral tissue. Peripheral tears were candidates for debridement with labral preservation. This procedure was performed with the curved 4.5-mm shaver, and all stable labrum was preserved. Acute tears or those involving only moderate intrasubstance damage were treated with repair using the looped stitch or labral base refixation techniques.[2]

Ligamentum teres injuries were debrided using the Tac-S radiofrequency wand (Smith & Nephew; London). Iliopsoas fractional lengthening was performed on patients with painful internal snapping hip syndrome or positive iliopsoas impingement sign on the labrum. When completed, the iliopsoas tendon was released at the level of the joint line, leaving the muscular portion intact and thereby preserving hip flexion strength. At the end of the procedure, the

Table 1. Demographic Data for Retroverted and Control Group

	Retroverted	Control	*P* Value
Hips included in study (%):			.71
Left	25 (42.4)	28 (47.5)	
Right	34 (57.6)	31 (52.5)	
Gender (%):			
Male	20 (33.9)	20 (33.9)	>.999
Female	39 (66.1)	39 (66.1)	
Age at surgery, years, mean ± SD (range)	37.4 ± 14.8 (14.2-74.7)	37.2 ± 14.3 (14.9-68.7)	.94
Body mass index, mean ± SD (range)	26.9 ± 5.7 (15.7-43.4)	26 ± 5 (18.5-42.8)	.27
Follow-up time, mo, mean ± SD (range)	70.6 ± 11.8 (60-113.4)	71.6 ± 9.7 (60-97.8)	.22

capsule was repaired, except for on patients presenting with stiff hips or thickened capsules, for whom a capsular release was considered therapeutic.

Rehabilitation Protocol

Postoperative protocol was tailored to the specific procedures performed, but all patients wore an X-Act ROM brace for stability (DJO Global; Vista, CA), were limited to a maximum of 20 pounds of foot flat weight-bearing activity with crutches for varying lengths of time, and used a stationary bike daily for a total of 8 weeks postoperatively. Physical therapy began as early as 1 day after surgery, with the specific duration to start dependent on the procedures performed. Patients who underwent labral repair or debridement used crutches and stability brace for 2 weeks, and they began physical therapy the day after surgery. Patients who underwent labral reconstruction used crutches and stability brace for 6 weeks, and they began physical therapy 6 weeks after surgery.

Surgical Outcome Tools

Patients completed the mHHS, NAHS, HOS-SSS, and VAS outcome questionnaires preoperatively and postoperatively at 3 months, 1 year, and annually thereafter. Postoperative follow-up also included patient satisfaction ratings on a scale from 0 to 10 and reporting of any surgical complications. Only postoperative scores were obtained for the international Hip Outcome Tool (iHOT-12), Veterans RAND-12 (VR-12), and 12-item Short Form Survey (SF-12), as these questionnaires were implemented beginning in the middle of the study period. Rate of and duration to secondary surgical procedures—both arthroscopy and total hip arthroplasty—were recorded at these same time intervals. For mHHS, the proportion of patients who met the patient acceptable symptomatic state (PASS; ≥74 points) and who achieved the minimal clinically important difference (MCID; $\Delta \geq 8$ points) was calculated.[41,42]

Statistical Analysis

An a priori power analysis was completed to calculate the number of patients necessary in each group to realize a minimum of 80% power using a 1:1 matching ratio. Based on an expected mean difference in the mHHS of 8 points, the power analysis determined that 55 patients would be required for each group.[43]

Descriptive statistics were reported for demographic data, procedures performed, and PRO scores. For these and all analyses, a threshold of .05 was set to quantify statistically significant differences. For continuous

Table 2. Intraoperative Findings for Retroverted and Control Group

	Retroverted, n (%)	Control, n (%)	*P* Value
Seldes:			.79
0	1 (1.7)	0 (0)	
I	23 (39)	26 (44.1)	
II	22 (37.3)	23 (39)	
I & II	13 (22)	10 (16.9)	
ALAD:			.26
0	4 (6.8)	3 (5.1)	
1	19 (32.2)	18 (30.5)	
2	13 (22)	23 (39)	
3	18 (30.5)	10 (16.9)	
4	5 (8.5)	5 (8.5)	
Outerbridge (acetabulum):			.58
0	3 (5.1)	2 (3.4)	
1	22 (37.3)	20 (33.9)	
2	14 (23.7)	22 (37.3)	
3	13 (22)	9 (15.3)	
4	7 (11.9)	6 (10.2)	
Outerbridge (femoral head):			.74
0	47 (79.7)	43 (72.9)	
1	1 (1.7)	2 (3.4)	
2	6 (10.2)	6 (10.2)	
3	5 (8.5)	6 (10.2)	
4	0 (0)	2 (3.4)	
LT percentile class (Domb):			.053
0, 0%	35 (59.3)	24 (40.7)	
1-0, <50%	15 (25.4)	16 (27.1)	
2-50, <100%	9 (15.3)	15 (25.4)	
3, 100%	0 (0)	4 (6.8)	
LT Villar class:			.10
0, no year	35 (59.3)	24 (40.7)	
1, complete tear	0 (0)	3 (5.1)	
2, partial tear	20 (33.9)	26 (44.1)	
3, degenerative tear	4 (6.8)	6 (10.2)	

ALAD, acetabular labrum articular disruption; LT, ligamentum teres.

Table 3. Surgical Procedures Conducted in Retroverted and Control Groups

	Retroverted, n (%)	Control, n (%)	*P* Value
Labral treatment:			.19
Debridement	20 (33.9)	28 (47.5)	
Repair	37 (62.7)	31 (52.5)	
Reconstruction	1 (1.7)	0 (0)	
None	1 (1.7)	0 (0)	
Capsular treatment:			.26
Repair	28 (47.5)	21 (35.6)	
Release	31 (52.5)	37 (62.7)	
Acetabuloplasty	43 (72.9)	41 (69.5)	.84
Femoroplasty	49 (83.1)	45 (76.3)	.49
Ligamentum teres debridement	19 (32.2)	31 (52.5)	.04
Iliopsoas fractional lengthening	25 (42.4)	17 (28.8)	.18

variables, normal distribution and equal variance was assessed using the Shapiro-Wilk test and *F*-test. Normally distributed data with equal variance were analyzed with a 2-tailed *t*-test, whereas nonparametric data were compared with the Wilcoxon signed-rank or Mann-Whitney tests, depending on the size of the samples. Chi-square or Fisher exact tests were used for all categorical variables. This statistical analysis was performed using Microsoft Excel (Microsoft, Redmond, WA).

Results

Patient Demographics

During the study period, 69 patients satisfied the inclusion and exclusion criteria, of whom 59 had a minimum of 5-year follow-up (85.5%). The patient selection flowchart is depicted in Figure 2. All 59 patients were matched in a 1:1 ratio to control patients with normal femoral version (10°-20°) by gender, age at surgery ±10 years, and BMI ± 10. Demographic data are depicted in Table 1, which shows no difference between groups in these variables, in laterality of surgery, or in duration to follow-up ($P > .05$). The retroversion group was composed of 20 male and 30 female patients, whose average age, BMI, and follow-up time were 38.2 ± 13.1 years, 26.2 ± 5.0, and 66.4 ± 15.0 months, respectively.

Intraoperative Findings and Procedures

Intraoperative diagnostic data, presented in Table 2, demonstrate no difference between the retroversion and control groups in labral tear type, acetabular or femoral head cartilage damage, or LT injuries ($P > .05$). Table 3 illustrates frequency data of various arthroscopic procedures. The only significant finding was that the LT was less commonly debrided in retroverted patients than in the control group. This procedure was performed on 19 patients in the retroversion group (32.2%) compared with 31 (52.5%) control patients ($P = .04$).

Radiographic Findings

There were no significant differences between the retroverted and control group in any preoperative and postoperative radiographic measurements (Table 4). However, there was a significant decrease between preoperative and postoperative values for LCEA ($P < .001$) and alpha angle ($P < .001$) in both groups.

Surgical Outcomes

Table 5 contains the PRO scores measured preoperatively and at least 5 years postoperatively. As depicted in this table and by Figure 3, retroverted patients significantly improved in all PROs recorded pre- and postoperatively, as well as the VAS for pain assessment. Average mHHS, NAHS, and HOS-SSS scores increased

Table 4. Radiographic Findings in Retroverted and Control Groups

	Retroverted	Normal	*P* Value
Tönnis, 0:1	50:5	49:6	>.999
LCEA, mean ± SD (range):			
Pre	29.4 ± 5.5 (15, 40)	29.7 ± 5.3 (16, 50)	.926
Postoperative	27.9 ± 6 (13, 42)	28.6 ± 4.9 (18, 40)	.507
Pre-post *P* value	.008	.007	
ACEA, mean ± SD (range):			
Pre	30.9 ± 8 (17, 55)	31.5 ± 6.2 (17, 44)	.409
Postoperative	30.5 ± 7.8 (11, 46)	29.4 ± 7 (13, 45)	.462
Pre-post *P* value	.980	.266	
Acetabular inclination, mean ± SD (range):			
Pre	5.2 ± 5.4 (−4, 24)	4.4 ± 4.3 (−9, 15)	.863
Postoperative	4.9 ± 4.8 (−8, 17)	4.9 ± 3.4 (−7, 12)	.946
Pre-post *P* value	.813	.070	
Alpha angle, mean ± SD (range):			
Pre	61.6 ± 11.8 (41, 88)	62.4 ± 11.9 (35, 90)	.732
Postoperative	44.5 ± 7.8 (32, 80)	46 ± 8.2 (29, 69)	.244
Pre-post *P* value	<.001	<.001	

LCEA, lateral center-edge angle; ACEA, anterior center-edge angle.

Table 5. Patient-Reported Outcomes for Retroverted and Control Group

	Retroverted	Control	*P* Value
mHHS:			
Pre	59.8 ± 14.0 (25-85)	59.9 ± 17.5 (21-95.7)	.978
Latest	84.7 ± 14.8 (40-100)	85.3 ± 14.8 (46-100)	.948
Preop to postop comparison	<.001	<.001	
Delta	23.9 ± 19.4 (−17-71)	24.3 ± 24.9 (−40-73)	.934
NAHS:			
Pre	58.2 ± 17.5 (16-96)	60.7 ± 16.9 (30-93)	.426
Latest	83.1 ± 15.3 (32.5-100)	84.5 ± 14.8 (45-100)	.549
Preop to postop Comparison	<.001	<.001	
Delta	24.7 ± 20.3 (−13.8-84)	21.9 ± 21.7 (−33.5-67.5)	.502
HOS-SSS:			
Pre	43.0 ± 25.6 (0-100)	42.2 ± 25.8 (3-83.3)	.869
Latest	69.6 ± 28.7 (0-100)	72.2 ± 25.6 (13.9-100)	.766
Preop to postop comparison	<.001	<.001	
Delta	25.1 ± 30.1 (−36-94)	25.0 ± 34.6 (−41.7-94)	.994
VAS:			
Pre	5.9 ± 2.3 (1-10)	5.6 ± 2.4 (0-10)	.521
Latest	2.5 ± 2.4 (0-8)	2.4 ± 2.3 (0-8.2)	.984
Preop to postop comparison	<.001	<.001	
Delta	−3.4 ± 3.1 (−10-2)	−3.0 ± 3.4 (−10-3.8)	.507
IHOT-12	70.9 ± 21.7 (2.2-100)	73.8 ± 22.6 (13.4-98.6)	.406
SF-12 Mental	57.2 ± 6 (39.4-68.7)	54.7 ± 8.6 (30.9-64.8)	.214
SF-12 Physical	47.8 ± 8.7 (20.5-57.2)	48.8 ± 8.8 (30.2-62.3)	.460
VR-12 Mental	61.6 ± 5.4 (49.1-67.3)	60 ± 8.1 (33.8-66.9)	.644
VR-12 Physical	49.7 ± 7.7 (21.8-58.6)	50.1 ± 8.3 (30.3-61.8)	.590
Patient satisfaction	7.5 ± 2.9 (0-10)	8.1 ± 2.2 (0-10)	.465

NOTE. Data are reported as mean ± SD (range).

HOS-SSS, Hip Outcome Score-Sport Specific Subscale; iHOT-12, International Hip Outcome Tool-12; Latest, latest follow-up time after minimum 5 years; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; SF-12, 12-Item Short Form Survey; VAS, visual analog scale; VR-12, Veterans RAND-12.

by 23.9, 24.7, and 25.1 points, respectively (*P* < .001). Average VAS scores decreased by 3.4, measured on a 10-point scale (*P* < .001). Outcome scores only measured postoperatively—iHOT-12, SF-12, VR-12, and satisfaction—did not significantly differ with the control group: patients' average scores at minimum 5-year follow-up were 70.9 on iHOT (*P* = .41), 57.2 and 47.8 on the SF-12 mental (*P* = .21) and physical (*P* = .46)

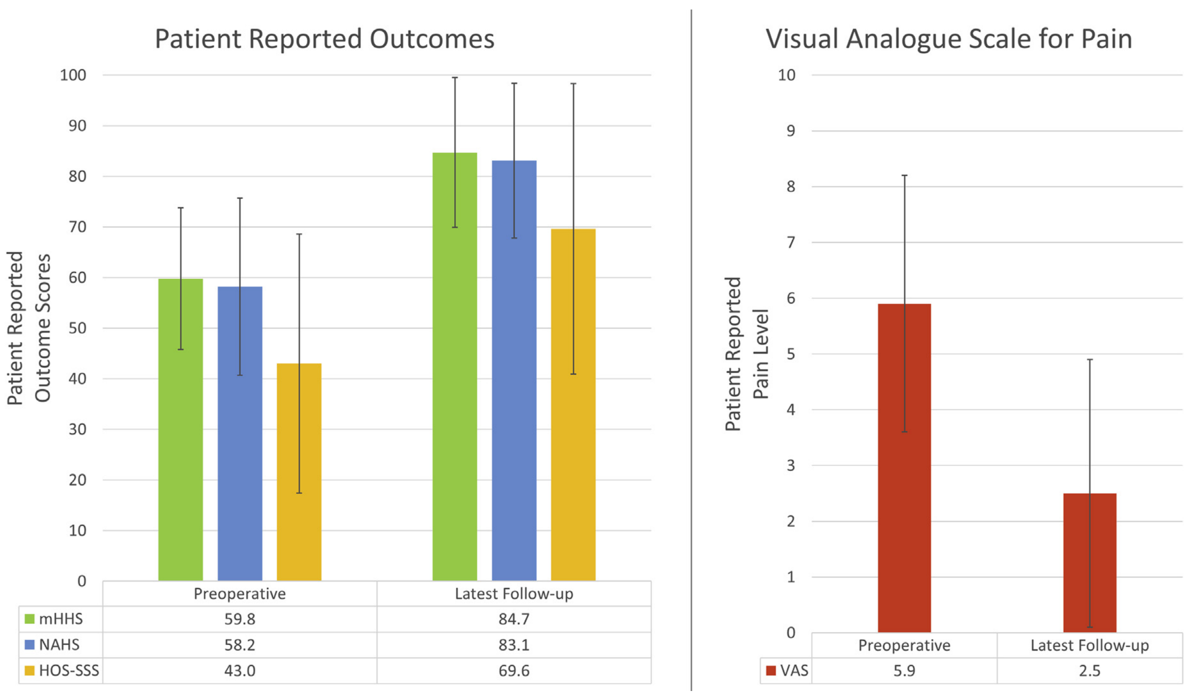

Fig 3. Preoperative and latest follow-up patient-reported outcomes and visual analog scale scores for the retroverted patients.

Table 6. Patient-Reported Outcomes for Labral Repair Subgroup

	Retroverted	Control	*P* Value
mHHS:			
Pre	61 ± 14.2 (25-81)	59.6 ± 17.5 (21-86)	.712
Latest	85.2 ± 15.7 (40-100)	85.4 ± 15.2 (46-100)	.846
Pre-post *P* value	<.001	<.001	
Delta	23.9 ± 19.9 (−17-71)	25.7 ± 25.7 (−40-73)	.761
NAHS:			
Pre	59.5 ± 15.7 (27.5-89)	62.6 ± 16.5 (31-90)	.424
Latest	82.3 ± 17 (32.5-100)	84.3 ± 15.3 (50-100)	.590
Pre-post *P* value	<.001	<.001	
Delta	22.8 ± 17 (−13.8-63.3)	20.9 ± 21.7 (−33.5-62.5)	.698
HOS-SSS:			
Pre	42.7 ± 24.4 (0-92)	40.4 ± 24.1 (3-83)	.703
Latest	68.1 ± 31.4 (0-100)	70.6 ± 26.8 (13.9-100)	.935
Pre-post *P* value	<.001	<.001	
Delta	24.7 ± 29.4 (−36-86)	28.6 ± 33.7 (−22.2556-94)	.638
VAS:			
Pre	5.6 ± 2.1 (2-9)	5.9 ± 2.6 (0-10)	.501
Latest	2.4 ± 2.4 (0-8)	2.5 ± 2.5 (0-8.2)	.989
Pre-post *P* value	<.001	<.001	
Delta	-3.2 ± 3 (−8-2)	-3.2 ± 3.5 (−10-3.8)	.971
IHOT	72.1 ± 23.5 (2.2-100)	71 ± 23.4 (13.4-98.4)	.825
SF-12 Mental	56.5 ± 5.9 (39.4-63.3)	53.9 ± 9 (34.7-62.1)	.255
SF-12 Physical	49.7 ± 7.6 (20.5-57.2)	50.5 ± 8.6 (30.2-62.3)	.435
VR-12 Mental	61.7 ± 5.3 (49.1-67.3)	59.9 ± 8.1 (43.6-66.8)	.674
VR-12 Physical	51.2 ± 7.1 (21.8-58.6)	51.5 ± 8.3 (30.3-61.8)	.494
Patient satisfaction	7.4 ± 2.8 (0-10)	8.2 ± 2 (4-10)	.317

NOTE. Data are reported as mean ± SD (range) unless otherwise specified.

HOS-SSS, Hip Outcome Score-Sport Specific Subscale; iHOT-12, International Hip Outcome Tool-12; Latest, latest follow-up time after minimum 5 years; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; SF-12, 12-Item Short Form Survey; VAS, visual analog scale; VR-12, Veterans RAND-12.

Table 7. Patient-Reported Outcomes for Capsular Repair/Plication Subgroup

	Retroverted	Control	*P* Value
mHHS:			
Pre	60.4 ± 16.3 (25-85)	56.1 ± 17.9 (21-81.4)	.382
Latest	83.3 ± 16.1 (40-100)	88.1 ± 14 (61-100)	.417
Pre-post *P* value	<.001	<0.001	
Delta	22.9 ± 21.2 (−17-71)	31.9 ± 25.2 (−20.4-73)	.186
NAHS:			
Pre	57.2 ± 19.7 (16-96)	59.7 ± 17.9 (30-90)	.654
Latest	80.9 ± 16.9 (32.5-100)	87.9 ± 14 (50-100)	.092
Pre-post *P* value	<.001	<.001	
Delta	23.7 ± 21.8 (−11.3-84)	27.6 ± 23.2 (−25-67.5)	.560
HOS-SSS:			
Pre	43.4 ± 23.7 (0-83)	40.3 ± 27.9 (3-83)	.615
Latest	68.7 ± 28.3 (8.3-100)	75.2 ± 27.1 (13.9-100)	.440
Pre-post *P* value	<.001	<.001	
Delta	25.3 ± 31 (−24.4-86)	33.3 ± 38.4 (−22.3-94)	.439
VAS:			
Pre	5.7 ± 2.3 (1-10)	6.2 ± 2.5 (0-10)	.447
Latest	2.6 ± 2.3 (0-8)	1.4 ± 1.8 (0-5.8)	.058
Pre-post *P* value	<.001	<.001	
Delta	-3.1 ± 3.1 (−10-2)	-4.8 ± 3.3 (−10-3.8)	.080
IHOT	70.2 ± 21.9 (2.2-100)	78.6 ± 22.4 (13.4-98.4)	.076
SF-12 Mental	57.5 ± 5.5 (44.3-68.7)	53.6 ± 8.9 (34.7-62.2)	.127
SF-12 Physical	47.5 ± 9.6 (20.5-56.8)	51.6 ± 8 (30.2-61.9)	.028
VR-12 Mental	61.7 ± 5 (49.1-66.9)	59.9 ± 7.8 (45.1-66.9)	.851
VR-12 Physical	49.7 ± 8.8 (21.8-58)	52.7 ± 7.9 (30.3-60.2)	.047
Patient satisfaction	7.8 ± 2.1 (2-10)	8.4 ± 1.7 (5-10)	.396

NOTE. Data are reported as mean ± SD (range) unless otherwise specified.

HOS-SSS, Hip Outcome Score-Sport Specific Subscale; iHOT-12, International Hip Outcome Tool-12; Latest, latest follow-up time after minimum 5 years; mHHS, modified Harris Hip Score; NAHS, Non-Arthritic Hip Score; SF-12, 12-Item Short Form Survey; VAS, visual analog scale; VR-12, Veterans RAND-12.

Table 8. Minimal Clinically Important Difference and Patient Acceptable Symptom State for Retroverted and Control Groups

mHHS	Retroverted	Control	*P* Value
MCID 8	38 (73.1)	37 (75.5)	.82
PASS 74	35 (59.3)	36 (61)	>.999

NOTE. Data are reported as n (%).
MCID, minimal clinically important difference; mHHS, modified Harris Hip Score; PASS, patient acceptable symptom state.

portions, and 61.6 and 49.7 on the VR-12 mental ($P = .64$) and physical ($P = .59$) portions. Patients reported an average satisfaction score of 7.5 on a 10-point scale, which did not differ from control patients ($P = .47$). Subgroup analyses of labral repair only and capsular repair only are presented in Table 6 and Table 7.

As shown in Table 8, 38 patients in the retroversion group reported improvement that met the threshold for MCID, and 35 patients achieved PASS for the mHHS questionnaire. Neither the proportion of patients who achieved MCID ($P = .82$) nor the proportion who achieved PASS ($P > .999$) differed significantly from the control group.

Secondary Procedures

Table 9 displays reoperations in patients following their hip arthroscopies. In the retroversion group, 6 patients (10.2%) underwent secondary arthroscopies at an average duration of 29.3 months from their primary surgeries (range, 8-71 months). Four surgeries were for labral retear, 1 for heterotopic ossification, and 1 for trochanteric bursitis. Neither the frequency of ($P = .42$) nor the duration to ($P = .50$) these procedures differed significantly from the control group. The same finding is true of conversion to total hip arthroplasty. Seven patients (11.9%) converted to total hip replacement at an average duration of 30.9 months (range, 6-59.1 months). The diagnosis for all patients was osteoarthritis. Both the frequency of ($P = .60$) and duration to ($P = .91$) these endpoints were not significantly different from control patients. None of the total hip arthroplasty patients who were reported also underwent secondary arthroscopies.

Complications

Three (6.0%) complications occurred in the retroverted group. Two patients had superficial infections, which resolved with antibiotics. One patient developed sciatica-like symptoms, which resolved with conservative measures. Although no patients in the control group had complications, there were no significant differences in the number of complications between both groups ($P = .242$).

Discussion

This study demonstrated that patients with baseline retroverted femora (<0°) evaluated at midterm 5-year follow-up continue to have significant improvement in all PRO metrics from their preoperative state. No difference between changes in PRO, VAS, or patient satisfaction was found when comparing the retroverted group with a pair-matched control group, indicating that femoral version does not appear to affect clinical outcomes after arthroscopy. To our knowledge, this is one of the earliest studies assessing midterm clinical outcomes with minimum 5-year follow-up after hip arthroscopy taking into account femoral retroversion. Good patient-reported clinical outcomes are comparable with previously published articles having a minimum 2-year follow-up.[14,15,44,45] Additionally, the proportion of patients who achieved PASS and MCID for mHHS and who achieved PASS and MCID for HOS-SSS did not differ significantly from the control group.

As discussed by Jackson et al.[44] and Hartigan et al.,[15] femoral retroversion leads to decreased femoral internal rotation before contact of the femoral neck on the acetabular rim compared with patients with more normal version.[15,44] Arthroscopic femoral osteoplasty does not significantly alter the native femoral version; however, it does help to recreate normal head-neck offset, which in turn improves the amount of internal rotation of the hip when flexed. This improved range of motion and lack of impingement can explain improved patient outcomes that are maintained at midterm follow-up. Kelly et al.[45] demonstrated that patients with femoral retroversion, defined as femoral version <5°, had equal magnitudes of improvement in their internal rotation postoperatively compared with those with normal or increased version.[45] The authors concluded that cam decompression is effective in improving internal rotation independent of femoral version and that decreased femoral version may not be an independent determinant of impingement.[45]

Table 9. Secondary Surgeries for Retroverted and Control Groups

	Retroverted	Control	*P* Value
Secondary arthroscopies, n (%)	6 (10.2)	10 (16.9)	.42
Time to secondary arthroscopy, mo, mean ± SD (range)	29.3 ± 24.6 (8-71)	40 ± 32.3 (0.8-95.1)	.50
Total hip replacement, n, (%)	7 (11.9)	10 (16.9)	.60
Time to total hip replacement, mo, mean ± SD (range)	30.9 ± 19.3 (6-59.1)	29.6 ± 19.1 (4.1-59.7)	.91

In regards to the LT, both groups had a high incidence of injury or degeneration: 18 patients (45%) in the retroverted group and 24 patients (60%) in the control group. There was a lower incidence of arthroscopic debridement in the retroverted group, 15 patients (37.5%), versus the control group, 25 patients (62.5%), which was statistically significant ($P = .0435$). The average ages of the retroverted and control groups were 39.2 and 39.1 years old, and the high incidence of LT injury in our study is consistent with a previous report from Domb et al.[46] describing patients older than 30 years having a relative risk of 1.51 for an LT tear. In that same study, we found that patients with LT tears have less acetabular retroversion. It was postulated that insufficient acetabular coverage might compromise the structural stability of the joint. Similarly, in patients with retroverted femora, who are known to have decreased hip internal rotation prior to FAI, it may be postulated that this lack of motion may limit maximal tensile forces across the LT, therein leading to decreased incidence of injury. This theory is consistent with findings by Botser et al.,[38] who showed that increased hip internal rotation was a risk factor for LT tears. Analysis of a larger patient population is needed to further elucidate the relationship between LT tears, bony morphologic characteristics, and hip range of motion.

Of the few prior studies examining PRO of hip arthroscopic surgery when considering proximal femoral version, the aforementioned article by Kelly et al.[45] and another by Ferro et al.[16] showed no difference in clinical outcomes in patients with femoral neck retroversion compared with those with normal or increased anteversion.[16,45] Conversely, Fabricant et al.[14] demonstrated that patients treated with hip arthroscopic surgery with femoral version <5° did not improve as much as patients with normal version (5°-20°) on the mHHS and International Hip Outcome Tool-33. Our study continues to show an improvement in reported midterm 5-year outcomes among patients with femoral retroversion, and the results were not significantly different when compared with a pair-matched control group of patients with normal femoral version.

The strengths of this study include its midterm 5-year follow-up of arthroscopic hip surgery in patients with femoral retroversion. Additionally, this study is one of the earliest to directly compare the results of those patients with a pair-matched controlled group. This study used 3 PROs of high clinimetric value to attempt to demonstrate any differences between the 2 groups.

Limitations

There are limitations of this study that must be addressed. First, this study was retrospective in nature. Second, there is a paucity of information in the literature to guide surgical indications in femoral retroversion to perform anteverting osteotomy. Furthermore, a power analysis was performed based on detecting an mHHS difference, so differences in the other metrics used could still be beta error. Additionally, multiple procedures were performed on each patient, including labral repair, repair, and debridement and capsular repair and release. Therefore it is difficult to attribute successful outcomes solely to resection of impingement lesions; however, other than the rate of LT debridement, there were no significant differences between the groups in the procedures performed.

Conclusions

Patients with femoral retroversion demonstrated significantly higher outcomes at minimum 5-year follow-up after undergoing arthroscopic hip surgery. These outcomes were not different from those of patients with normal femoral version. While femoral retroversion should not be considered a contraindication to hip arthroscopy, it should be carefully considered as a factor in patient selection and surgical planning.

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