Effect of Femoral Anteversion on Clinical Outcomes After Hip Arthroscopy

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Purpose: To compare the clinical outcomes after hip arthroscopy of patients with femoral retroversion, normal femoral version, and excessive femoral anteversion. **Methods:** Patients who underwent primary hip arthroscopy from August 2008 to April 2011 and underwent femoral anteversion measurement by magnetic resonance imaging/magnetic resonance arthrogram were included. The patients were divided into 3 groups: retroversion, normal version, and excessive anteversion. The normal-version group was considered to have a value within 1 SD of the mean femoral version value. Four patient-reported outcome scores and the visual analog pain score were prospectively collected with analysis performed retrospectively. **Results:** Two hundred seventy-eight patients met the inclusion criteria. Among these patients, mean anteversion was 8.2° ± 9.3°, creating a retroversion group defined as −2° or less and an anteversion group defined as 18° or greater. There were 25 patients in the retroversion group, 219 in the normal-version group, and 34 in the excessive-anteversion group. Most labral tears were noted in the 12- to 2-o'clock range, with the main difference at the anterior 3-o'clock position, where the excessive-anteversion group showed a lower incidence of tearing (30%) than the retroversion group (73%) and normal-anteversion group (78%). Postoperatively, there was a statistically significant improvement from preoperative scores in all 3 groups and for all scores ($P < .001$). When the postoperative scores were compared for the 3 groups, although all scores were higher in the retroversion group than in the other 2 groups, this was not statistically significant and there were no significant differences in scores among the 3 groups (modified Harris Hip Score, $P = .104$; Non-Arthritic Hip Score, $P = .177$; Hip Outcome Score—Activities of Daily Living, $P = .152$; Hip Outcome Score—Sport-Specific Subscale, $P = .276$; visual analog scale score, $P = .508$). **Conclusions:** On the basis of patient-reported outcome scores without accounting for diagnoses and treatments, the amount of femoral anteversion does not appear to affect the clinical outcomes after hip arthroscopy. **Level of Evidence:** Level III, retrospective comparative study.

The evolution of hip arthroscopy as it pertains to various hip pathologic conditions has been rapid with ever-expanding indications. Appropriate patient evaluation is vital to successful outcomes in hip arthroscopy. Although much is known about acetabular retroversion and its relation to pincer-type impingement, less is known about the effect of femoral version in patients with femoroacetabular impingement (FAI) and instability.

Several studies have examined the association between excess femoral anteversion and retroversion and its role in the development of arthritis.[1,2] Tönnis and Heinecke[2] showed the relation between femoral and acetabular anteversion and retroversion and their effect on range of motion, the incidence of hip pain, and osteoarthritis.

Hip arthroscopy has been used to treat many patients with nonarthritic hip pain. The role of cam deformity and pincer deformity in FAI has been widely studied[3,4]; the role of femoral anteversion as it relates to nonarthritic hip pain and hip arthroscopy has been considered, yet it has not been studied widely.[5-7] Moreover, clinical outcome studies comparing patients with various amounts of femoral anteversion are lacking, except for a study relating to iliopsoas release.[8]

The purpose of this study was to compare the clinical outcomes after hip arthroscopy of patients with femoral retroversion, normal femoral version, and excessive

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The authors report the following potential conflict of interest or source of funding: B.G.D. receives support from Arthrex, MAKO Surgical, American Hip Institute, Breg, ATI, Pacira, Stryker, Orthomerica, DJO Global.

Received September 5, 2013; accepted July 9, 2014.

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0749-8063/13652/$36.00

http://dx.doi.org/10.1016/j.arthro.2014.07.009

femoral anteversion. Our hypothesis was that all patients would have similar clinical outcomes regardless of the degree of femoral anteversion.

Methods

Between the study period of August 2008 and April 2011, patients who underwent primary hip arthroscopy and underwent femoral anteversion measurement by magnetic resonance imaging (MRI)/magnetic resonance arthrogram (MRA) were included. Patients were excluded if they had previous surgery, a Tönnis arthritis grade greater than 1, inflammatory arthropathy, Legg-Calvé-Perthes disease, or MRI/MRA without femoral anteversion measurement. In the practice setting of the senior author (B.G.D.), most patients have undergone MRI before referral. Because not all MRI centers perform sequences from which femoral anteversion can be measured, these values were not available in a large cohort of patients; thus these patients had to be excluded from the study. Institutional review board approval was obtained.

The patients were divided into 3 groups: retroversion, normal version, and excessive anteversion. This division was established by first calculating the mean and standard deviation of the MRI version measurements. Patients were then placed in the retroversion group if their femoral anteversion measurement was beyond 1 SD below the mean. Alternatively, patients were placed in the excessive-anteversion group if their femoral anteversion measurement was beyond 1 SD above the mean. Femoral version was measured with MRI by a board-certified radiologist by referencing off the posterior femoral condyles and a line through the center of the neck in the axial oblique plane.[9,10] MRI was chosen for anteversion measurements because this is the modality most often used, as opposed to computed tomography (CT) scans, as part of routine preoperative workup.

All data were prospectively collected and retrospectively reviewed, with visual analog scale and patient-reported outcome (PRO) scores obtained preoperatively and postoperatively (3 months, 1 year, 2 years, and 3 years), including the modified Harris Hip Score (mHHS),[11] the Non-Arthritic Hip Score,[12] the Hip Outcome Score—Activities of Daily Living,[13] and the Hip Outcome Score—Sport-Specific Subscale. The visual analog scale score was measured on a scale from 0 to 10, with 0 being no pain and 10 being severe pain. Patient satisfaction was recorded based on a scale from 0 to 10, with 0 being completely unsatisfied and 10 being completely satisfied. Any conversion to total hip arthroplasty (THA) was noted. The senior author evaluated all patients and performed surgery on all patients. A subgroup analysis was performed for each group, comparing the PRO scores of those patients who underwent iliopsoas release and those who did not.

Radiographic imaging included standing and supine anteroposterior pelvis, bilateral Dunn, cross-table lateral, and false-profile views. MRA was obtained in all patients to diagnose pathology of the labrum, capsule, ligamentum teres, and peritrochanteric space.

Diagnoses were made based on radiographic and intraoperative findings. Pincer FAI was defined as a crossover sign or coxa profunda (lateral center-edge angle $>40^\circ$), and cam FAI was defined as an alpha angle greater than 50° on the Dunn view. Labral tears were confirmed by intraoperative findings. Internal snapping was defined as painful snapping of the hip or by iliopsoas impingement signs intraoperatively.[14] Intraoperative data obtained included the location of labral tears (clock face) and procedures performed on the labrum, capsule, and iliopsoas. The clock-face method of measuring labral tearing uses the 12-o'clock position as the most superolateral portion of the acetabulum and the 6-o'clock position as the transverse ligament. The 3-o'clock position is the anterior-most portion of the acetabulum on a right hip, and left hip measurements are adjusted to the right such that the 3-o'clock position is anterior for a left hip.[6] As a general treatment algorithm, pincer impingement was treated with acetabuloplasty and cam impingement was treated with femoroplasty.[15] Labral repair was performed when there was labral tearing and sufficient labral tissue for repair. Iliopsoas release was performed in patients with symptomatic internal snapping or a positive iliopsoas impingement sign on the labrum at the 3- to 4-o'clock position.[14] The capsule was repaired routinely except in patients in whom a release was considered to be therapeutic, such as patients with stiff hips or thickened capsules.

Statistical Analysis

Descriptive statistics were used for patient demographic data and procedures. A paired Student t test was used to compare preoperative with postoperative PROs. The χ^2 test was used to compare preoperative diagnoses, gender, side, and procedures. Patient demographic data and postoperative PROs were compared with a 1-way analysis of variance with Tukey post hoc analysis to measure significance among the 3 groups. An unpaired Student t test was used for the subgroup analysis of patients who had received iliopsoas release versus those who had not. A power analysis was performed using a previous study with a mean difference in mHHS of 9 points, with an SD of 16 points.[8] Using these values and assuming power of 0.8 with $P < .05$ considered significant, we determined that the minimum sample size would need to be 172 patients to achieve significance.

Results

During the study period, 740 hip arthroscopies were performed. Two hundred seventy-eight patients met the inclusion criteria for the study. Of these, 4 were lost to follow-up, achieving a 95.6% rate of 2-year

Table 1. Patient Demographic Data for Survivors (Patients Without Conversion to THA) in the 3 Anteversion Groups That Underwent Hip Arthroscopy

Demographic Characteristic	Retroversion	Normal Anteversion	Excessive Anteversion	*P* Value
No. of patients	22	196	27	
Age, yr (range)	37.9 (14 to 55)	37.8 (14 to 66)	38.4 (15 to 69)	$P = .98$
Gender	5 male and 17 female	75 male and 121 female	7 male and 20 female	$P = .19$
Side	12 right and 10 left	101 right and 95 left	17 right and 10 left	$P = .53$
Workers' Compensation, n	0	23	2	$P = .19$
Femoral version, ° (range)	−7.9 ± 5.4 (−2 to 18)	7.5 ± 4.8 (0 to 17)	24.9 ± 8.2 (18 to 49)	$P < .001$
Follow-up, mo (range)	28.4 ± 5.6 (24 to 42)	28.3 ± 5.8 (24 to 50)	32.3 ± 6.8 (24 to 45)	
Labral tear, n (%)	21 (95)	196 (100)	27 (100)	
Pincer FAI, n (%)	3 (14)	42 (21)	8 (30)	$P = .40$
Cam FAI , n (%)	5 (23)	34 (17)	1 (4)	$P = .14$
Combined FAI, n (%)	11 (50)	97 (49)	16 (59)	$P = .63$
Iliopsoas snapping, n (%)	6 (27)	46 (23)	6 (22)	$P = .91$
GTPS, n (%)	5 (23)	17 (9)	3 (11)	$P = .12$

NOTE. Values in Femoral version and Follow-up rows are presented as Mean ± standard deviation (range).
GTPS, greater trochanter pain syndrome.

follow-up. Mean anteversion was 8.2° ± 9.3°, making retroversion defined as −2° or less and excessive anteversion defined as 18° or greater. We chose this method because it defined abnormal values for anteversion based on the mean for this large cohort. This is similar to how laboratory references values vary among laboratories and are defined by their means/standard deviations. By use of these grouping parameters, there were 25 patients in the retroversion group, 219 in the normal-anteversion group, and 32 in the excessive-anteversion group.

Of the aforementioned patients, 3 (12%) in the retroversion group, 21 (9.6%) in the normal-anteversion group, and 5 (15%) in the excessive-anteversion group underwent conversion to THA at a mean of 11.8 ± 8 months after arthroscopy (10.4% overall).

For patients who are survivors, defined as those who did not require THA, the PRO scores are reported and patient demographic data are listed in Table 1. Of note, the mean age was similar among groups ($P = .98$). There was a significant difference in the length of follow-up for the excessive-anteversion group compared with the other 2 groups ($P = .064$ compared with retroversion group and $P = .004$ compared with normal-version group), whereas the retroversion and excessive-anteversion groups had similar lengths of follow-up ($P = .998$). The diagnoses of FAI, labral tear, internal snapping, and peritrochanteric pain were similar among the 3 groups.

The soft-tissue procedures that were performed for the labrum, iliopsoas, and capsule are listed in Table 2. Notably, labral repair was performed more often than debridement, and the rate of iliopsoas release was similar among all groups. Most labral tears were noted in the 12- to 2-o'clock range, with the main difference at the 3-o'clock position, where the excessive-anteversion group showed a lower incidence of tearing, 30% versus 73% and 78% for the retroversion and normal-anteversion groups, respectively (Fig 1).

The preoperative PRO scores are shown in Table 3. On the basis of the 1-way analysis of variance, there were no statistically significant differences among the groups in preoperative scores. Postoperatively, there was a statistically significant improvement from preoperative scores in all 3 groups and for all scores. When the postoperative scores were compared among the groups, although the retroversion group had higher scores than the other 2 groups, this was not statistically significant and there were no significant differences in scores among the 3 groups (Table 4, Fig 2). Two patients in the retroversion group, 21 patients in the normal-anteversion group, and 1 patient in the excessive-anteversion group required revision hip arthroscopy.

The results of the subgroup analysis, comparing the patients who underwent iliopsoas release with those who did not, are shown in Table 5. Within each anteversion group, there was no difference in PRO scores

Table 2. Surgical Procedures for the 3 Anteversion Groups That Underwent Hip Arthroscopy

Soft-Tissue Procedure	Retroversion (n = 22)	Normal Anteversion (n = 196)	Excessive Anteversion (n = 27)	*P* Value
Labral repair, n (%)	13 (59)	111 (57)	17 (63)	$P = .91$
Labral debridement, n (%)	9 (41)	85 (43)	10 (37)	$P = .81$
Labral reconstruction, n (%)	0 (0)	0 (0)	1 (4)	
Iliopsoas release, n (%)	7 (32)	56 (29)	6 (22)	$P = .73$
Capsule repair, n (%)	12 (52)	73 (37)	11 (41)	$P = .28$

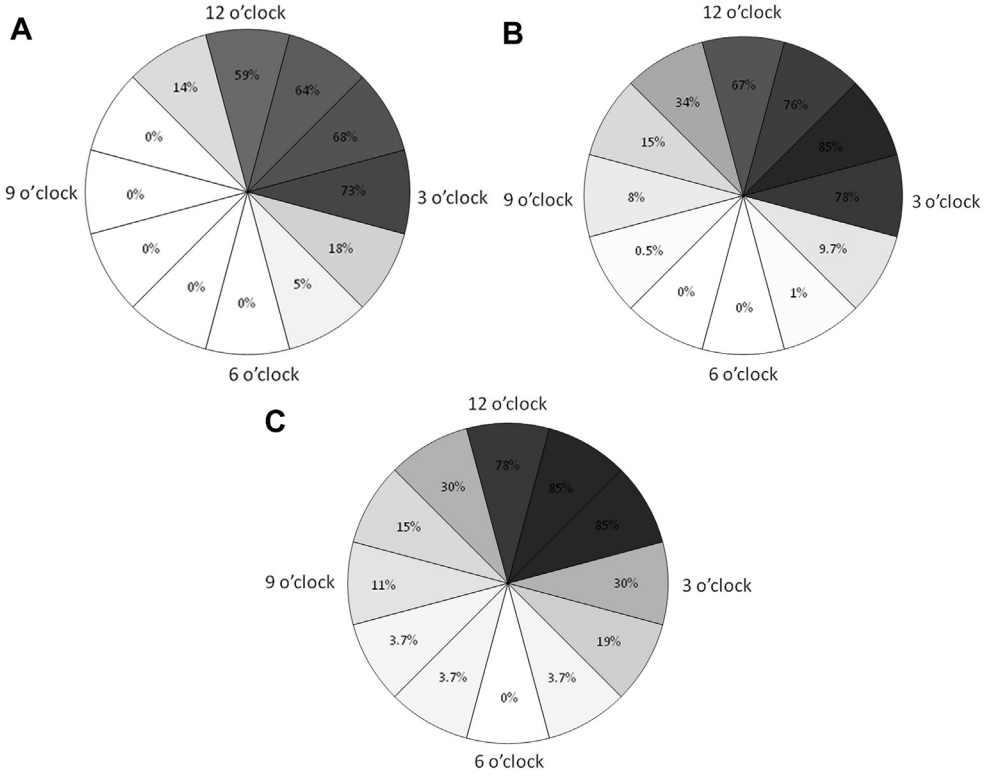

Fig 1. The clock-face diagrams show the location of labral tears for each anteversion group: (A) retroversion, (B) normal anteversion, and (C) excessive anteversion. There was a similar incidence of tears at the 12- to 2-o'clock positions, but there was a lower incidence of labral tears at the 3-o'clock position in patients with excessive femoral anteversion.

except for the patient satisfaction scores in the normal-anteversion group, where the patients who underwent release had significantly higher satisfaction scores.

Discussion

The clinical outcomes, without accounting for preoperative diagnoses and subgroup analysis, were shown to be similar for patients with retroversion, normal anteversion, and excessive anteversion after hip arthroscopy. 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. This is the largest study to compare clinical outcomes taking into account femoral anteversion, showing good patient-reported clinical outcomes that are comparable with those in other previously published studies.[8,16,17]

According to the location of the labral tears, there was a lower incidence of 3-o'clock tears in the anteversion group. This finding was not shown in another study comparing femoral anteversion with findings at hip arthroscopy in patients with FAI.[6] The authors of the previous study noted a 2.2 times higher likelihood of having a 3-o'clock tear in patients with anteversion greater than 15°. Another study looked at anterior acetabular labral tears on MRI, correlating them with various bony morphologies including femoral anteversion, and did not show any correlation between anterior labral tears and bony morphology.[18] One possible reason for our lower incidence of anterior, 3-o'clock labral tears is depicted in Figure 3. Figure 3 shows femoral anteversion and its effect on the relation of the head-neck junction to the anterior acetabulum and provides a possible explanation for the location of labral tearing. However, more specific

Table 3. Preoperative PRO Scores for the 3 Anteversion Groups

Preoperative PRO Score	Retroversion (n = 22)	Normal Anteversion (n = 196)	Excessive Anteversion (n = 27)	*P* Value
VAS score	5.8 ± 2.3	5.8 ± 2.2	6.4 ± 1.7	$P = .37$
mHHS	64.5 ± 15.1	61.6 ± 17.3	62.2 ± 12.3	$P = .735$
NAHS	59.4 ± 19.2	58.7 ± 18.7	59.3 ± 14.7	$P = .978$
HOS-ADL	68.3 ± 21.0	63.4 ± 20.7	64.2 ± 19.0	$P = .574$
HOS-SSS	46.9 ± 27.4	42.0 ± 24.6	45.8 ± 23.3	$P = .569$

NOTE. Data are presented as mean ± standard deviation unless otherwise indicated.

HOS-ADL, Hip Outcome Score—Activities of Daily Living; HOS-SSS, Hip Outcome Score—Sports Subscale Score; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

Table 4. Postoperative PRO Scores Comparing Difference Among the 3 Anteversion Groups

Postoperative PRO Score	Retroversion (n = 22)	Normal Anteversion (n = 196)	Excessive Anteversion (n = 27)	*P* Value
VAS score	2.6 ± 1.93	3.0 ± 2.4	2.6 ± 2.4	$P = .508$
mHHS	89.2 ± 10.0	81.5 ± 16.7	80.8 ± 16.7	$P = .104$
NAHS	87.0 ± 10.5	79.8 ± 18.2	81.6 ± 15.3	$P = .177$
HOS-ADL	90.8 ± 9.8	82.7 ± 18.9	83.9 ± 19.1	$P = .152$
HOS-SSS	79.2 ± 17.9	69.6 ± 28.1	72.9 ± 28.7	$P = .276$
Satisfaction	7.6 ± 2.9	7.8 ± 2.2	8.5 ± 2.2	$P = .761$

NOTE. Data are presented as mean ± standard deviation unless otherwise indicated.

HOS-ADL, Hip Outcome Score—Activities of Daily Living; HOS-SSS, Hip Outcome Score—Sports Subscale Score; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

studies are warranted to determine whether femoral anteversion has an effect on the location of rim impingement.

The function of the labrum and the importance of labral repair or labral preservation regarding clinical outcomes have been well delineated[19,20]; however, the management of the iliopsoas and capsule is less understood. In conflicting studies regarding iliopsoas release in patients with excess femoral anteversion, some authors have noted worse outcomes in this subgroup whereas other authors have shown that this is a commonly needed procedure in patients with higher version angles.[6,8] We showed similar rates of iliopsoas release in all 3 groups, with the indication for release being symptomatic internal snapping or iliopsoas impingement lesions noted at the time of arthroscopy. A subgroup analysis comparing patients who received iliopsoas release with those who did not was performed for each anteversion group. There was no difference in the outcomes within the groups. In the excessive-anteversion group, the 6 patients who underwent iliopsoas release did not show significantly worse results than those who did not undergo iliopsoas release. This finding is in contradiction to a study by Fabricant et al.,[8] although their methods were slightly different. They compared excessive anteversion (>25°) with normal/low version in a cohort of patients who all underwent iliopsoas release. On the basis of lower postoperative mHHS values in patients who had increased anteversion, Fabricant et al. concluded that this group may be at greater risk of inferior clinical outcomes with iliopsoas release. However, it is worth noting that in their study, there was a greater increase in Hip Outcome Score—Sport-Specific Subscale values with iliopsoas release, yielding conflicting results. These mixed results and the equivocal results found in our study suggest that further research is needed on the role of pathology of the iliopsoas and the appropriate treatment with respect to femoral anteversion.

We did not find a significant difference in the rate of conversion to THA among the 3 groups. The overall rate of conversion to THA shown in this study was 10.4%, which is within a normal range compared with other studies but is still high.[21,22] In part, this can be attributed to the early study period. More recent research has shown a joint space of less than 2 mm to be an indicator of conversion to

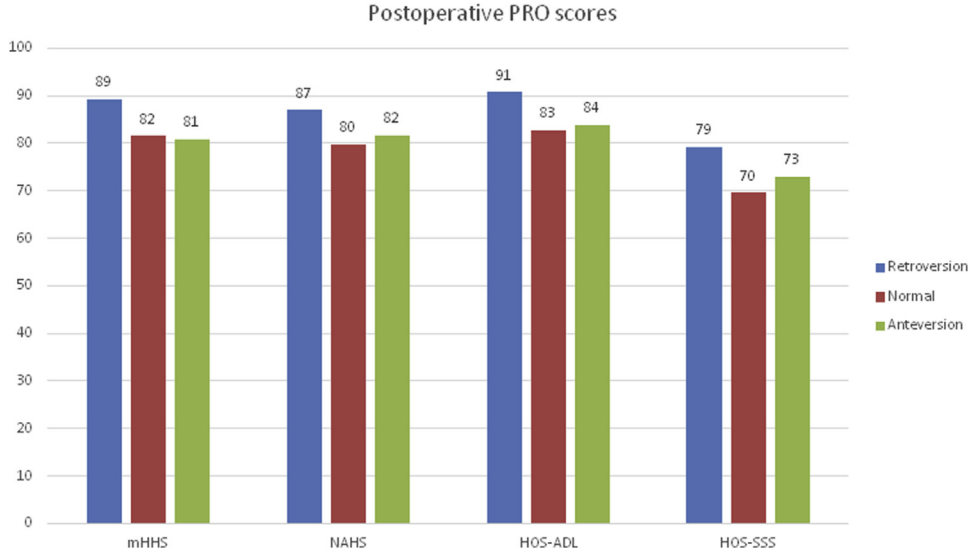

Fig 2. PRO scores for the 3 groups that underwent hip arthroscopy. Grouping was based on femoral version measurements obtained during preoperative MRI. (HOS-ADL, Hip Outcome Score—Activities of Daily Living; HOS-SSS, Hip Outcome Score—Sports Subscale Score; NAHS, Non-Arthritic Hip Score.)

Table 5. Iliopsoas Release Subgroup Analysis: Postoperative PRO Scores for Each Version Group Comparing Patients Within Each Group Who Underwent Iliopsoas Release With Those Who Did Not

	Retroversion			Normal Anteversion			Excessive Anteversion		
PRO Score	IP Release	No IP Release	*P* Value	IP Release	No IP Release	*P* Value	IP Release	No IP Release	*P* Value
VAS score	3.0	2.3	$P = .479$	2.6	3.2	$P = .187$	2.5	3.1	$P = .568$
mHHS	86.0	90.7	$P = .326$	83.7	80.7	$P = .267$	84.4	85.5	$P = .892$
NAHS	83.0	88.8	$P = .240$	82.5	78.6	$P = .174$	79.8	82.3	$P = .776$
HOS-ADL	89.8	91.2	$P = .762$	84.8	81.8	$P = .333$	85.5	84.9	$P = .948$
HOS-SSS	78.6	79.5	$P = .909$	71.8	69.0	$P = .530$	78.7	72.5	$P = .652$
Satisfaction	7.6	7.5	$P = .978$	8.4	7.7	$P = .030$	8.2	8.6	$P = .540$

HOS-ADL, Hip Outcome Score—Activities of Daily Living; HOS-SSS, Hip Outcome Score—Sports Subscale Score; IP, iliopsoas; NAHS, Non-Arthritic Hip Score; VAS, visual analog scale.

THA.[21] In addition, the amount of dysplasia that can safely undergo arthroscopy had yet to be determined during the early part of the study period. These 2 known risk factors for failure after arthroscopy are more widely known and accepted, with the hope that future outcome studies will show low rates of conversion to THA.

The strengths of this study include the large size of the cohort. With 278 patients in the cohort, it is unlikely that a type II statistical error occurred, especially given the power analysis that was performed. We consider the grouping of patients as a strength of this study. Previous studies have used somewhat arbitrary cutoff values to classify excessive anteversion and retroversion. Although there is high interobserver agreement in the measurement of femoral anteversion on MRI, there does remain a certain level of inconsistency.[10] In addition, MRI has been shown to possibly underestimate the measurement of anteversion by 8.9° when compared with CT.[9] By grouping based on 1 SD from the mean of the entire cohort and using MRI studies from only 2 centers, we sought to minimize any variations in measurement. This grouping led to similar groups with similar ages and preoperative PRO scores and with significant differences in femoral version.

Limitations

A weakness of the study is the use of MRI to measure anteversion. CT has been found to have a higher interobserver reliability in some studies, though at the expense of radiation.[9] Many authors advocate MRI measurements, citing accuracy, ease of use, and lack of radiation as reasons for its use.[10,23] The senior author uses MRI routinely in preoperative evaluation, and thus MRI measurements were more readily available. We attempted to minimize bias in measurements by grouping patients by values greater than 1 SD or less than 1 SD from the mean of the entire cohort. Another consideration regarding this study is that acetabular version was not studied. Although this is not routinely measured on axial MRI and CT, other measurements such as the crossover sign and ischial spine prominence are signs of acetabular retroversion that could have been used for the purposes of this study. We chose not to study the effects of acetabular retroversion to focus on the effects of femoral anteversion, which was shown by Tönnis and Heinecke[2] to contribute more to restriction of motion and pain than acetabular version. Another weakness is the use of the clock-face method of location of labral tears. This method has been shown to be accurate in comparing MRI with intraoperative

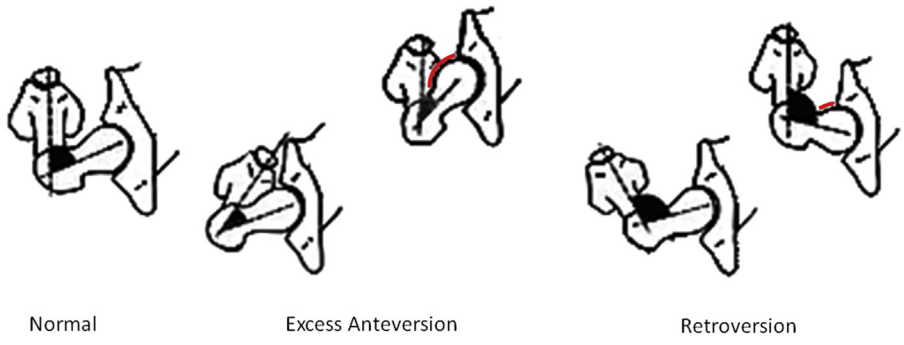

Fig 3. Femoral anteversion and its effect on the relation of the head-neck junction to the anterior acetabulum. With excessive anteversion and the foot forward, there is an increased distance from the anterior rim to the head-neck junction. With retroversion and the foot forward, there is a decreased distance from the anterior rim to the head-neck junction. This decreased distance can theoretically predispose retroverted femurs to anterior impingement in a position of less internal rotation, especially in the context of cam deformities.

findings with 85% accuracy within 1 hour. The exact reproducibility of this method has yet to be determined, but its long use by a single surgeon in this study does provide for consistency in determining the location of labral tears.[24]

Conclusions

On the basis of PRO scores without accounting for diagnoses and treatments, the amount of femoral anteversion does not appear to affect the clinical outcomes after hip arthroscopy.

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