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HIP

Is a periacetabular osteotomy as efficacious in retroversion as it is in dysplasia?

THE ROLE OF FEMORAL ANTEVERSION ON OUTCOME

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Aims
Periacetabular osteotomy (PAO) is an established treatment for acetabular dysplasia. It has also been proposed as a treatment for patients with acetabular retroversion. By reviewing a large cohort, we aimed to test whether outcome is equivalent for both types of morphology and identify factors that influenced outcome.

Methods
A single-centre, retrospective cohort study was performed on patients with acetabular retroversion treated with PAO (n = 62 hips). Acetabular retroversion was diagnosed clinically and radiologically (presence of a crossover sign, posterior wall sign, lateral centre-edge angle (LCEA) between 20° and 35°). Outcomes were compared with a control group of patients undergoing PAO for dysplasia (LCEA < 20°; n = 86 hips). Femoral version was recorded. Patient-reported outcome measures (PROMs), complications, and reoperation rates were measured.

Results
The mean Non-Arthritic Hip Score (NAHS) preoperatively was 58.6 (SD 16.1) for the dysplastic hips and 52.5 (SD 12.7) for the retroverted hips (p = 0.145). Postoperatively, mean NAHS was 83.0 (SD 16.9) and 76.7 (SD 17.9) for dysplastic and retroverted hips respectively (p = 0.041). Difference between pre- and postoperative NAHS was slightly lower in the retroverted hips (18.3 (SD 22.1)) compared to the dysplastic hips (25.2 (SD 15.2); p = 0.230). At mean 3.5 years' follow-up (SD 1.9), one hip needed a revision PAO and no hips were converted to total hip arthroplasty (THA) in the retroversion group. In the control group, six hips (7.0%) were revised to THA. No differences in complications (p = 0.106) or in reoperation rate (p = 0.087) were seen. Negative predictors of outcome for patients undergoing surgery for retroversion were female sex, obesity, hypermobility, and severely decreased femoral anteversion.

Conclusion
A PAO is an effective surgical intervention for acetabular retroversion and produces similar improvements when used to treat dysplasia. Femoral version should be routinely assessed in these patients and when extremely low (< 0°), as an additional procedure to address this abnormality may be necessary. Females with signs of hypermobility should also be consulted of the likely guarded improvement.

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Introduction
Version abnormalities of the acetabulum and/or femur may lead to femoroacetabular impingement (FAI), which is associated with hip pain and implicated in the development of osteoarthritis.[1-4] Acetabular retroversion is a deformity leading to pincer-type impingement.[5,6] It is defined as an abnormal orientation of the acetabulum in the axial plane, which results in anterior over-coverage of the femoral head and may be associated with posterior under-coverage.[6,7] The majority of

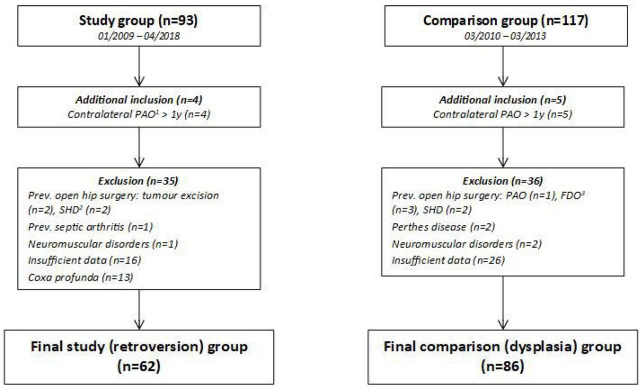

Fig. 1

Flowchart of the cohort included in the study. FDO, femoral derotation osteotomy; PAO, periacetabular osteotomy; SHD, surgical hip dislocation.

hips with acetabular retroversion have normal overall femoral head coverage.[7]

The Bernese Periacetabular Osteotomy (PAO) is a versatile procedure that allows reorientation of the acetabulum along all three axes. Although originally described as a treatment for acetabular dysplasia, with good clinical outcome,[8,9] the technique has also been used to address the malorientation of the acetabulum in acetabular retroversion. Although good clinical results have been reported, studies have been few and with small cohorts.[5,6,10,11] As our understanding of hip mechanics evolves, it is evident that femoral version is an important parameter to consider in the decision algorithm. A high prevalence of femoral version abnormalities has been noted in patients presenting with hip pain[4,12] and this may influence outcome after hip surgery.[12,13] By reviewing a large cohort of patients who underwent a PAO, we aimed to assess whether patients with retroversion benefit from the procedure as much as patients with dysplasia, and identify any factors influencing outcome in acetabular retroversion, including femoral version.

Methods

Study design. This is a retrospective, single-surgeon, single-centre, consecutive case series patients who underwent a minimally invasive PAO between January 2009 and April 2018. The study was a service evaluation and thus did not require NHS Research Ethics Committee, NHS/Health and Social Care (HSC) R&D Office or Health Research Authority (HRA) approval.

A prospectively recorded database was queried. All patients who underwent a PAO for the treatment of acetabular retroversion formed the study group (retroversion group). These patients were compared with a group of patients that underwent a PAO for the treatment of acetabular dysplasia (dysplasia group) between March 2010 and March 2013. The dysplastic cohort has previously been used to investigate the effectiveness of the surgical technique.[14]

Cohort description. Over the study period, 735 PAOs were performed by a single surgeon (JDW) in a tertiary referral unit; of those, 93 were for the treatment of symptomatic acetabular retroversion (13%). The dysplasia comparison group consisted of 117 hips. If patients underwent a PAO on the contralateral side during the follow-up period, this hip was also included in the analysis (n = 4 retroversion; n = 5 dysplasia). Study exclusion criteria included previous, open surgery, neuromuscular disorders, previous septic arthritis, and coxa profunda (lateral centre-edge angle (LCEA) > 35° and acetabular index (AI) < 0°) or incomplete clinical information (Figure 1). All patients had undergone previous conservative treatment including physiotherapy and one or more intra-articular infiltrations with temporary improvement.

Of the 148 PAOs included in this study, 62 were performed in hips (51 patients) with clinical features of FAI,[15] and radiological features of acetabular retroversion as determined by both supine and anteroposterior (AP) pelvic radiographs and 3D imaging using previously described techniques.[6,11] The patients with retroversion had LCEA between 20° and 35° and AI between 0° and 10°.

In the retroversion group, there were five males (five hips; 8.1%) and 46 females (57 hips; 91.9%). The mean age at PAO was 33.2 years (standard deviation (SD) 7.8; Table I)

The comparison group consisted of 60 patients (86 hips): three males (three hips; 3.5%) and 57 females (83 hips, 96.5%) with a mean age of 25.5 years (SD 7.0). These patients underwent PAO because of symptomatic dysplasia, as defined by a LCEA < 20° and an AI > 10° (Table I).

Mean follow-up was 3.5 years (SD 1.9) in the retroversion group and 6.7 years (SD 1.8) in the dysplasia group ($p < 0.001$, independent-samples *t*-test). Comorbidities such as obesity (defined as a BMI > 30 kg/m^2) and hypermobility (Beighton score > 4) were noted.

Surgical technique. The senior author (JDW) performed all surgeries. The minimally invasive, modified technique of the original description of the PAO by Ganz et al[16] was used, the results of which have been previously described.[14] No arthrotomy was performed in any of the hips undergoing PAO. There was one patient (one hip) that had a scheduled second procedure (arthroscopic femoral osteochondroplasty) planned to be performed eight weeks after the PAO. Prior to the PAO, 33 hips (33 patients) had undergone a hip arthroscopy; 22 hips (35.5%) in the retroversion group and 11 hips (12.8%) in the dysplasia group (odds ratio 3.7 (95% confidence interval (CI) 1.7 to 8.5); p = 0.001, chi-squared test).

Radiological assessments. Radiological evaluation was performed on supine, AP pelvic radiographs. Parameters

Table I. Demographic and surgical data of the cohort.

Variable	Retroversion	Dysplasia	p-value
Hips, n	62	86	
Mean age, yrs (SD; range)	33.2 (7.8; 15 to 47)	25.5 (7.0; 17 to 47)	< 0.001*
Sex, n (%)			0.198†
Male	5 (8.1)	3 (3.5)	
Female	57 (91.9)	83 (96.5)	
Mean follow-up, yrs (SD; range)	3.5 (1.9; 1.00 to 8.75)	6.7 (1.8; 1.00 to 9.67)	< 0.001*
Comorbidities, n (%)			
Hypermobility‡	9 (14.5)	7 (8.1)	0.218†
Obesity§	7 (11.3)	9 (10.5)	0.873†
Previous surgery, n (%)			
Hip arthroscopy	22 (35.5)	11 (12.8)	0.001†

*Independent-samples *t*-test.
†Chi-squared test.
‡Beighton > 4.
§BMI > 30 kg/m^2.
SD, standard deviation.

Table II. Patient-reported outcome measures pre- and post-periacetabular osteomy for each group.

PROM	Retroversion	Dysplasia	p-value*
Mean NAHS (SD; n)			
Preoperative	52.5 (12.7; 22)	58.6 (16.1; 42)	0.145
Postoperative	76.7 (17.9; 62)	83.0 (16.9; 86)	0.041
Δ	18.3 (22.1; 22)	25.2 (15.2; 42)	0.230
Mean UCLA (SD)			
Preoperative	4.6 (1.8; 22)	4.8 (2.3; 41)	0.981
Postoperative	5.4 (1.5; 62)	5.5 (1.5; 86)	0.747
Δ	0.6 (2.0; 22)	0.7 (2.1; 41)	0.608
Mean iHOT (SD)			
Preoperative	24.6 (12.7; 22)	25.9 (12.4; 6)	0.614
Postoperative	63.7 (28.3; 62)	73.4 (26.5; 85)	0.025
Δ	42.6 (25.0; 22)	45.6 (25.3; 6)	0.758
Mean EQ-5D (SD)			
Preoperative	0.440 (0.273; 22)	0.538 (0.251; 6)	0.326
Postoperative	0.699 (0.229; 62)	0.769 (0.169; 85)	0.086
Δ	0.288 (0.259; 22)	0.177 (0.222; 6)	0.287

*Mann-Whitney U test.
EQ-5D, EuroQol-five dimension questionnaire; iHOT, international Hip Outcome Tool; NAHS, Non-Arthritic Hip Score; PROM, patient-reported outcome measure; SD, standard deviation; UCLA, University of California, Los Angeles Activity Score.

assessed from pre- and postoperative radiographs included: LCEA, AI, presence of crossover sign (COS), posterior wall sign (PWS) and ischial spine sign (ISS),[6] and the Tönnis grade.[4] In hips with a positive COS, the crossover ratio was calculated. Radiological parameters were measured by three authors (JV, SS, or ST). The mean measurement was used for analysis.

In addition, all patients had preoperative CT scans of the pelvis; however, not all scans were performed in our centre with a previously described protocol[17] which includes the femoral condyles. Therefore, femoral version could not be calculated for all hips, but was available for 77% of the cohort, 48 (77%) of the retroversion cases and 66 of the dysplastic cases (77%).

Femoral version was measured according to Murphy et al.[12,18] Normal femoral version was considered to be between 10° and 25°.[4,12] Severely decreased femoral version was defined as femoral version < 0°, moderately decreased femoral version as femoral version between 0° and 10°. Moderately increased femoral version was defined as a femoral version between 25° and 35°, and severely increased > 35°.[12]

Outcome assessments. Outcome measures included patient-reported outcome measures (PROMs), and complication, reoperation, and joint preservation rates. PROMs were obtained at the time of the patient's latest follow-up. Those included the Non-Arthritic Hip Score (NAHS),[19] the University of California Los Angeles (UCLA) activity scale,[20] the short version of the international Hip Outcome Tool (iHOT-12),[21] and the EuroQol five-dimension questionnaire (EQ-5D).[22] Preoperative values were retrieved from patient records or from the British Non-Arthroplasty Hip Register (NAHR). The difference between the latest follow-up and the preoperative values was defined as Δ. Length of follow-up was determined from the date of surgery to the last clinical review.

The Clavien-Dindo classification[23] was used to grade complications. Elective removal of screws took place in 30 of 62 hips (48.2%) in the retroversion group (47.4%), and in 49 of 86 hips in the dysplasia group (57.0%) and was not considered a complication/reoperation.

Statistical analysis. Statistical analysis was performed using SPSS v. 25 (IBM). Paired *t*-tests were used to compare preoperative and postoperative LCEA, AI, and crossover ratio. A Wilcoxon signed-rank test was used to compare preoperative and postoperative presence of COS and PWS. Mann-Whitney U tests were used to compare non-parametric variables between study and control group. Cross-tabulation, chi-squared, and Fisher's exact test were used to compare categorical variables. The Kruskal-Wallis test was used to measure influence of femoral anteversion on the ΔPROM scores. A value < 0.05 was considered significant.

Results

PROMs. Preoperative scores were available for 44 hips in the retroversion group (71.0%) and 48 hips in the dysplastic group (55.8%). All patients had postoperative PROM scores (NAHS, UCLA, iHOT, and EQ-5D). For both groups the mean PROMs significantly improved as detailed in Table II. Overall, 15.6% of hips (n = 7) in the retroversion group did not improve (ΔNAHS ≤ 0 or ΔiHOT ≤ 0) compared to 6.3% in the dysplasia group (n = 3). The retroversion group had inferior, but not statistically significant, PROMs preoperatively and a lesser, but not statistically significant, improvement in PROMs; as a result, the retroversion group had inferior PROMs (NAHS, i-HOT-12) at latest follow-up (Figures 2 and 3).

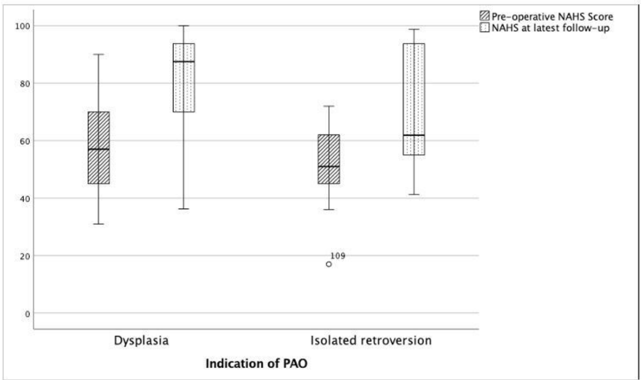

Fig. 2

Box plot showing the preoperative Non-Arthritic Hip Score (NAHS) and the NAHS at latest follow-up for the dysplastic and retroverted hips. The transverse line represents the median and the upper and lower edges of the box represent the interquartile range. PAO, periacetabular osteotomy.

Table III. Non-Arthritic Hip Score at latest follow-up for different risk factors.

Variable	Retroversion	p-value*	Dysplasia	p-value*
Sex, mean (SD; n)		0.008		0.739
Male	93.8 (10.0; 5)		82.5 (11.1; 3)	
Female	75.2 (17.7; 57)		80.5 (18.9; 83)	
Obesity, mean (SD; n)		0.167		0.041
Yes	66.8 (11.8; 7)		64.2 (27.6; 9)	
No	78.0 (18.2; 55)		82.4 (16.5; 77)	
	0.2			
Hypermobility, mean (SD; n)		0.023		0.187
Yes	64.6 (17.7; 9)		70.9 (21.8; 7)	
No	78.8 (17.2; 53)		81.5 (18.3; 79)	

*Mann-Whitney U test.
SD, standard deviation.

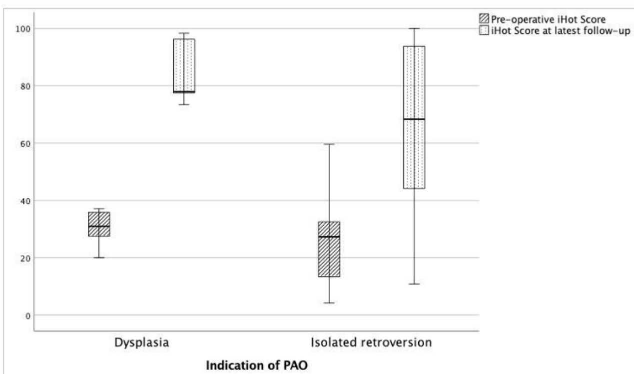

Fig. 3

Box plot showing the preoperative international Hip Outcome Tool (iHOT) and the iHOT at latest follow-up for the dysplastic and retroverted hips. The transverse line represents the median and the upper and lower edges of the box represent the interquartile range. PAO, periacetabular osteotomy.

Among the whole cohort, female sex (78.4 (SD 18.6) vs 89.5 (SD 1.2); p = 0.092, Mann-Whitney U test), obesity (65.3 (SD 21.5) vs 80.6 (SD 17.3); p = 0.003, Mann-Whitney U test), and hypermobility (67.3 (SD 19.2) vs 80.3 (SD 17.9); p = 0.052, Mann-Whitney U test) were associated with inferior NAHS scores at latest follow-up. Female sex (p = 0.008, Mann-Whitney U test) and hypermobility (p = 0.023, Mann-Whitney U test) were associated with significantly inferior NAHS in the retroversion group (Table III). However, in the dysplastic group, female sex (p = 0.739, Mann-Whitney U test) and hypermobility (p = 0.187, Mann-Whitney U test) were not associated with inferior NAHS, although obesity was (p = 0.041, Mann-Whitney U test).

Radiological results. Following the PAO all radiological parameters improved in accordance to the type of correction aimed for, as detailed in Table IV. The mean femoral anteversion was significantly lower in the retroversion group (13.8° (SD 10.4°)) than in the dysplasia group (20.6° (SD 10.2°); p = 0.001, paired *t*-test). Decreased and severely decreased anteversion was present in 24.2% (15/62) of the retroversion group and 10.5% (9/86) of the dysplastic group. The distribution of femoral anteversion in the study and comparison group is shown in Table V.

In the retroversion group, patients with a severely decreased femoral anteversion (< 0°) had significantly less favourable final PROM scores (i.e. NAHS and iHOT) in comparison to other patients (Table VI).

Complications and additional procedures. A total of 54 complications were identified in 29 hips (19.6%) the details of which are described in Table VII. There was no difference in the complication rate between the groups (p = 0.106, chi-squared test).

No stress fractures or nonunions were seen in the retroversion group. On the contrary, five dysplastic hips (5.8%) sustained an inferior pubic ramus stress fracture and 12 hips (14.0%) had an asymptomatic, superior pubic ramus nonunion. There was a high rate of iliopsoas discomfort during the recovery period in both groups (14 in retroversion group versus 17 in dysplasia group; p = 0.678, chi-squared test). The majority treated with steroid injections to the psoas sheath and two patients required an open psoas tendon release, while the others improved following the injection.

A total of 15 reoperations took place in 11 hips (7.4%). In the retroversion group, three reoperations took place in two hips (3.2%). One hip (1.6%) underwent a revision PAO due to malcorrection of the acetabulum but remained symptomatic after revision and subsequently underwent arthroscopic labral debridement and osteochondroplasty. All hips were preserved at follow-up. In the dysplastic group, 12 reoperations occurred in nine hips (10.5%; p = 0.087, chi-squared test). Six hips (7.0%) were converted to a total hip arthroplasty (THA), with a mean of 6.1 years (SD 2.5) between PAO and THA.

Table IV. Radiological parameters of each group.

Parameter	Retroversion Preoperative	Retroversion Postoperative	Retroversion p-value	Dysplasia Preoperative	Dysplasia Postoperative	Dysplasia p-value
Mean LCEA, ° (SD)	29.3 (4.1)	33.7 (4.4)	< 0.001*	13.8 (5.8)	28.7 (5.0)	< 0.001*
Mean AI, ° (SD)	4.7 (4.3)	1.4 (3.7)	< 0.001*	18.1 (5.5)	6.1 (3.7)	< 0.001*
Crossover sign, n (%)	62 (100)	9 (14.5)	< 0.001†	14 (16.3)	5 (5.8)	0.007†
Mean crossover ratio (SD)	0.40 (0.12)	0.05 (0.15)	< 0.001†	0.06 (0.13)	0.03 (0.12)	0.005†
Posterior wall sign, n (%)	59 (95.2)	3 (4.8)	< 0.001†	14 (16.3)	7 (8.1)	0.020†
Ischial spine sign, n (%)	58 (93.5)	N/A	N/A	7 (8.1)	N/A	N/A

*Paired *t*-test.
†Wilcoxon signed-rank test.
AI, acetabular index; LCEA, lateral centre-edge angle; N/A, not applicable; SD, standard deviation.

Table V. Distribution of femoral anteversion for each group.

Femoral anteversion	Retroversion	Dysplasia	p-value
Mean, ° (SD)	13.8 (10.4)	20.6 (10.2)	0.001*
Distribution, n (%)			
Severely decreased	3 (4.8)	1 (1.2)	0.306†
Decreased	12 (19.4)	8 (9.3)	0.074‡
Normal	29 (46.8)	31 (36.0)	0.156‡
Increased	3 (4.8)	22 (25.6)	< 0.001†
Severely increased	1 (1.6)	4 (4.7)	0.200†
Missing	14 (22.6)	20 (23.3)	0.543‡

*Independent-samples *t*-test.
†Fisher's exact test.
‡Chi-squared test.
SD, standard deviation.

Table VI. Comparison of Non-Arthritic Hip Score at latest follow-up between severely decreased femoral anteversion and other groups of femoral version.

NAHS	Total	Mean at final follow-up (SD)	p-value*
Severely decreased	3	50.4 (5.8)	N/A
Decreased	12	86.1 (12.3)	0.004
Normal	29	73.7 (17.6)	0.018
Increased	3	75.4 (15.1)	0.046
Severely increased	1	83.0	0.157

* Mann-Whitney U test comparing with severely decreased.
N/A, not applicable; SD, standard deviation

Table VII. Complications, reoperations, and survival analysis.

Variable	Retroversion	Dysplasia	p-value
Complications Grade I, n (%)			
Asymptomatic HO	0 (0.0)	1 (1.2)	0.581*
Asymptomatic nonunions	0 (0.0)	12 (14.0)†	0.001*
Complications Grade II, n (%)			
Psoas tendinopathy (conservative)	14 (22.6)	15 (17.4)	0.437‡
Neuropathic pain LFCN	1 (1.6)	2 (2.3)	0.621*
Stress fracture	0 (0.0)	5 (5.8)	0.063*
DVT	0	1 (1.2)	0.581*
Complications Grade III, n (%)			
Psoas tendinopathy (surgical release)	0	2 (2.3)	0.336*
Revision PAO	1 (1.6)	0	0419*
Complications Grade IV, n (%)	0	0	N/A
Complications Grade V, n (%)	0	0	N/A
Reoperations, n (%)			
Psoas tendon release	0	2 (2.3)	0.336*
Arthroscopy	2 (3.2)	4 (4.7)	0.888*
THA	0	6 (7.0)	0.036*
Revision PAO	1 (1.6)		0.419*
Hip preservation rate, %	100	93.0	0.036*

*Fisher's exact test.
†All nonunion of superior pubic ramus.
‡Chi-squared test.
DVT, deep venous thrombosis; HO, heterotopic ossification; LFCN, lateral femoral cutaneous nerve; PAO, periacetabular osteomy; THA, total hip arthroplasty.

Discussion

In spite of the recognition of acetabular retroversion as a potential cause of pincer impingement with the first case series described in 1999,[6] there have only been three cohort studies of patients undergoing PAO for this condition since then. Siebenrock et al[11] reported on the outcomes of a cohort of 29 hips in 22 patients in 2003 and this group was followed up again with a further report at a mean of ten years.[10] Parry et al[5] reported on a cohort of 20 hips from two centres and compared outcomes with a cohort of ten hips with features of retroversion associated with dysplasia. Wyatt et al[24] described short-term outcomes in a cohort of 31 hips undergoing minimally invasive PAO through a trans-sartorial approach. A further study by Peters et al[25] described an algorithmic approach to the management of acetabular retroversion and included a cohort of patients undergoing a PAO for FAI associated with acetabular retroversion. In this study, all the hips that underwent a PAO (n = 30) had a LCEA of < 20° with a mean of 15.7° (SD 12.6°). In our view, these cases would primarily be considered dysplastic hips with associated retroversion as described by Li and Ganz[26] and would have been included in the dysplasia group in our series. There is clearly likely to be an overlap, to some degree, of hips with retroversion features producing impingement and those which are mildly dysplastic, but still producing impingement symptoms rather than symptoms related to dysplasia. However, a consistent feature in the description of FAI secondary to acetabular retroversion is a relatively high LCEA.[7,8,15]

We found that patients with retroversion improved significantly compared to their preoperative status after treatment with PAO. The retroversion patients had slightly inferior preoperative and postoperative PROM scores, without significant differences. Wyatt et al[24] also highlighted that the level of pain experienced by these patients seems to be out of proportion to the rather subtle radiological abnormality. Although there was no significant difference in the outcome scores between the groups in our series, there was a trend for the retroversion patients to have lower scores. In addition, 15.9% (7/44) of patients in the retroversion group had no improvement in their scores compared with 4.3% (2/46) in the dysplasia group. Comparison with other studies is difficult as these have used historical outcome measures such as Merle d'Aubigne[10,11] and the Harris Hip Score,[5] which are not validated for these patient groups and interventions. Wyatt et al[24] reported significant improvements in iHOT12 and EQ-5D scores, but baseline scores were only available for approximately 60% of cases and scores at one year were only available for 30% of the cohort. However, the preoperative and postoperative scores for iHot12 and EQ-5D were rather similar, improving from a mean of 19 to 64.5 at 12 months (24.6 (SD 12.7) to 63.7 (SD 28.3) in our study) and 0.42 to 0.69 (0.440 (SD 0.273) to 0.699 (SD 0.229) in our study) respectively.

The acetabular correction in our series appears very satisfactory with a residual crossover sign being present in 14.5% (9/62) of cases, but this being very minor as evidenced by the mean postoperative crossover ratio (0.05%). Of note is that there is a tendency for the LCEA to increase and the AI to decrease with the correction of anteversion; findings similar to Siebenrock et al,[11] and with those starting with a higher LCEA there is clearly the risk of creating over-coverage. It is important to be aware of this risk as it might have an impact on outcome. Looking at our postoperative values for LCEA and AI, these would still be in the range considered acceptable for these acetabular parameters.

None of the patients in our series underwent an open arthrotomy at the time of surgery, rather, the decision was taken to intervene arthroscopically in the retroversion group prior to the decision to proceed with a PAO (35% of cases), particularly where there was an associated cam morphology. The decision to proceed with a subsequent PAO was then determined by the level of symptomatic improvement following the hip arthroscopy, and in those who did not improve a PAO was then performed. The possibility of the need for a PAO was always discussed with the patient at the outset. Patients who did not have a preoperative hip arthroscopy had better final PROM scores (NAHS (80.1 (SD 17.8) vs 75.2 (SD 20.3); p = 0.279, Mann-Whitney U test) and iHOT (69.1 (SD 26.8) vs 63.8 (SD 31.4); p = 0.374, Mann-Whitney U test)), but without significant differences. One case underwent arthroscopic intervention subsequent to PAO. This contrasts with Siebenrock et al,[11] where arthrotomy with offset correction was performed in 24 out of 29 hips, and in the series of Parry et al[5], where 29 out of 30 cases underwent an open arthrotomy, with 50% of the retroversion group undergoing an offset correction. The role of hip arthroscopy in the context of PAO surgery for both dysplasia and retroversion remains controversial and is the subject of ongoing studies.[27-29] We did not have sufficient data from this study to be able to determine what proportion of patients who underwent hip arthroscopy with retroversion features did not then subsequently require a PAO.

There is limited information on femoral neck anteversion in patients undergoing PAO surgery for acetabular retroversion, but with the effect of acetabular orientation on range of motion, particularly internal rotation in flexion, the version of the femoral neck must play a major role. The mean version measurements in the acetabular retroversion group are clearly different (13.8° (SD 10.4)) to the dysplasia group (20.6° (SD 10.2°)). In addition, the proportion of hips with lower than normal femoral neck anteversion (< 10°) was significantly different in the retroversion group (31.3% (15/48) vs 13.6% (9/66); p = 0.023, chi-squared test), but only severely decreased femoral neck anteversion (< 0°) was associated with less good outcomes in the hips treated for acetabular retroversion (Table VI). This is perhaps not surprising, and indicates that the acetabular correction can address the impingement potential up to a certain point, but that there maybe a threshold where the femur needs to be addressed as well. Other authors have highlighted the importance of femoral version in relation to hip pain indicating that this should be part of routine investigation.[4,12,13]

Female sex, obesity, and hypermobility were the other factors associated with inferior outcomes. In our study group most patients were female (91.9%; 57/62) which is a likely cause of bias. In a study on the arthroscopic treatment of retroversion, women also did worse than men.[30] The combination of pincer-type FAI and hypermobility has been considered as a risk factor for less successful outcomes following surgical hip dislocation as a treatment for FAI.[31] Novais et al[32] described obesity as a risk factor for complications after PAO, but they could not demonstrate a relationship between the obesity and outcome after PAO. We feel it is important to formally assess the Beighton criteria so that patients can be informed that their outcome may be affected by their hypermobility[14] and recovery usually takes significantly longer.

The surgical complication rate was very low for both cohorts of patients. Zaltz et al[33] found a 6% risk of major complications (Clavien-Dindo grade III/IV) associated with PAO. We reported one grade III complication in the retroversion group (1.6%) and two in the dysplasia group (2.3%). The overall figures for minor complications are somewhat skewed by our approach to persistent iliopsoas symptoms (20.9%; 31/148). During the recovery period, where it appears these are interfering with rehabilitation, patients are scheduled for an iliopsoas tendon sheath injection, which is usually effective in dealing with symptoms and allowing recovery to progress. An interesting finding was that there were no patients with stress fractures or nonunions in the retroversion group, compared to the dysplasia group. The incidence of stress fractures after PAO has been reported to be between 2% and 18%.[34,35] The most likely explanation would be the smaller displacement of the acetabular fragment leading to faster bone union and normalization of the stresses across the pelvic ring. Wyatt et al[24] noted a similar finding in their cohort of patients undergoing PAO for retroversion.[24]

This study has some limitations. It is a retrospective review and there was a lack of complete, preoperative clinical PROMs data. For a group of patients, only preoperative NAHS was available, while for another group only iHOT scores were available. This occurred when we changed our follow-up protocol to align with the NAHR. Although we were able to obtain a maximum of postoperative PROM scores, we had limited ΔPROM scores. Secondly, we were unable to retrieve all femoral neck anteversion measurements, which weakened our analysis of the influence of femoral anteversion on the outcome, but for 77% (114/148) of the cohort this information was available. Thirdly, the mean follow-up was only 3.5 years (SD 1.9) in the retroversion group; longer follow-up would be necessary to evaluate the long-term hip preservation rate for patients with retroversion treated with PAO.

A PAO can be an effective procedure to address symptoms associated with acetabular retroversion. Similar improvement can be expected when compared to PAO for dysplasia. Further research with longer follow-up is necessary to confirm these results. Our study confirms a high prevalence of femoral rotational abnormalities in patients undergoing PAO, and we recommend assessing femoral anteversion preoperatively. Patients with severely decreased femoral anteversion associated with acetabular retroversion had worse final clinical PROM scores. Other negative predictors of outcome of PAO in retroversion were obesity and hypermobility.

Take home message

- Acetabular retroversion should be treated with a periacetabular osteomy (PAO).
- Similar good results can be expected as in patients with dysplasia treated with PAO.
- Femoral version can influence outcome.

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