



No association between femoral or acetabular angles and patient-reported outcomes in patients with femoroacetabular impingement syndrome—results from the HAFAI cohort

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ABSTRACT

Patients with femoroacetabular impingement syndrome (FAIS) are diagnosed using imaging, but detailed description especially the acetabular shape is lacking and may help give more insight to the pathogenesis of FAIS. Furthermore, associations between patient-reported outcomes (PROs) and the radiological angles might highlight which radiological angles affect outcomes experienced by the patients. Hence, the aims of this study were (i) to describe computer tomography (CT) acquired angles in patients with FAIS and (ii) to investigate the association between radiological angles and the Copenhagen Hip and Groin Outcome Score (HAGOS) in patients with FAIS. Patients scheduled for primary hip arthroscopic surgery for FAIS were included. Based on CT, following angles were measured before and 1 year after surgery; femoral anteversion, alpha, lateral centre edge, acetabular index, anterior sector, posterior sector and acetabular anteversion. All patients completed the HAGOS. Sixty patients (63% females) aged 36 ± 9 were included. One year after surgery, significant alterations in the alpha angle and the acetabular index angle were found. Neither baseline PROs nor changes in PROs were associated with the radiological angles or changes in angles. Since neither changes in CT angles nor baseline scores were associated with HAGOS, the improvements felt by patients must origin from somewhere else. These findings further underlines that morphological changes seen at imaging should not be treated arthroscopically without a patient history of symptoms and clinical findings.

INTRODUCTION

Patients with femoroacetabular impingement syndrome (FAIS) are diagnosed on the basis of imaging findings, symptoms and clinical signs [1]. However, evidence suggests that imaging findings in this patient group such as cam morphology, pincer morphology and/or hip labral tears are normal findings in asymptomatic persons, especially in athletes [2]. Nevertheless, imaging findings are still

important when diagnosing FAIS [1] in order to separate these patients from patients with other pathologies in the hip and/or groin area.

Cam and pincer morphology have been quantified using the alpha angle and the lateral centre edge angle in prospective studies in order to investigate development of osteoarthritis (OA) [3, 4]. Quantifying cam and pincer morphology using further description of the femoral and

acetabular angles might provide insight into the pathological pattern in patients with FAIS.

Patient-reported outcomes (PROs) are frequently been used in patients with FAIS [5]. Nevertheless, it has not been investigated whether PROs that have undergone validation in patients with FAIS, such as the Copenhagen Hip and Groin Outcome Score (HAGOS) [6], are associated with multiple radiological measures of the femoral and acetabular shape.

Hence, the aim of the study was to (i) investigate femoral and acetabular angles before and 1 year after surgery in patients with FAIS, and (ii) to investigate associations between femoral and acetabular angles and HAGOS subscales and changes 1 year after surgery. Although Aim (i) was exploratory, for Aim (ii), we hypothesized that patients with more extreme angles would present with worse PROs.

MATERIALS AND METHODS

Design

The design of the study was a prospective cohort study investigating a consecutively included sample of patients scheduled for hip arthroscopic surgery at Horsens Hospital, Horsens, Denmark [7]. All patients gave their informed consent in accordance with the Declaration of Helsinki II. The study was approved by the Central Denmark Region Committee on Biomedical Research Ethics (1-10-72-239-14) and the Danish Data Protection Agency (1-16-02-499-14). The study was registered at clinicaltrials.org and a study protocol has been published [7]. The present data are secondary data from the main study, from which several publications already exist [8–10].

Patients

Inclusion and exclusion criteria have been published before, but briefly patients were included if they were scheduled for primary hip arthroscopic surgery for FAIS [1, 7] including cam, pincer or mixed impingement, a joint space width of >3 mm at the lateral sourcil and age between 18 and 50 years. Exclusion criteria were previous corrective hip surgery of the included hip, Legg-Calvé-Perthes disease, epiphysiolysis, alloplastic surgery at the hip, knee or ankle region (both legs), cancer, neurological diseases, inability to speak or understand Danish or pregnancy at the time of inclusion. All 60 patients with FAIS underwent hip arthroscopic surgery performed by the same, experienced surgeon (Bent Lund, >2000 hip arthroscopies performed) at Horsens Hospital, Horsens, Denmark. Patients were operated in a supine position through standard antero-lateral and mid-anterior portals. Labral tears were refixated with suture anchors. Bony deformities were addressed by

osteoplasty using a motorized burr. The standard protocol after surgery included full weight bearing as tolerated and the use of crutches for 2–6 weeks. The patients followed a home-based rehabilitation programme progressed by specialized physiotherapists 2 weeks, 6 weeks and 2 months after surgery [9, 10].

Measurements

Computed tomography

Low-dose computed tomography (CT) scans were conducted on a Philips Brilliance 64-CT-scanner (Philips Medical Systems, Best, The Netherlands) at the Horsens Hospital, Horsens, Denmark. Images in the trans-axial and coronal planes were reformatted through the centres of the femoral heads. These centre-points were used as a reference for the measurements of coverage of the acetabulum. All measurements of the femoral and acetabular angles were performed by the same, experienced musculoskeletal radiologist (Lone Rømer). The following angles were measured for both hips.

Femoral shape:

- i. The alpha angle of Nötzli was measured on oblique axial views, as the angle between a line from the centre of the femoral head through the middle of the femoral neck and a line through a point where the contour of the femoral head-neck junction exceeds the radius of the femoral head.
- ii. The femoral anteversion angle was measured as the angle between the long axis of the femur neck and condylar axis of the distal femur. The femoral anteversion angle was measured on three superimposed axial slices. One through the centre of the femoral head, a slice through the base of the femoral neck and the third slice at the femoral condyles.

Acetabular shape:

- i. The lateral centre edge angle, a measurement of the lateral coverage of the acetabulum above the femoral head in the coronal plane.
- ii. Acetabular index angle, a measure of the lateral slope of the acetabular roof in the coronal plane.
- iii. Anterior-sector angle and the posterior-sector angle, measurements of the anterior and the posterior coverage of the femoral head measured in the trans-axial plane.

- iv. Acetabular-anteversion angle, measured in the trans-axial plane through the centres of the femoral heads.

In a previous study [11], repeated measurements of the angles were performed by the same, experienced musculoskeletal radiologist who participated in this study. In that study, intra-rater reliability of the angles by this particular radiologist was investigated and found to be high with an intra-class correlation coefficient of ≥ 0.96 (0.96–0.99).

Patient-reported outcomes

HAGOS consists of six subscales: pain, symptoms, activities of daily living function, sport function, participation in sport and hip-related quality of life. HAGOS is reliable and responsive and have been used in patients with FAIS and in patients undergoing hip arthroscopy [6, 12].

Sample size and statistical analysis

The sample size calculation was based on the HAGOS scores from Thomee *et al.* [13] who were the only ones who had published pre- and post-operative data with HAGOS in patients with FAIS at study initiation [7].

For the statistical analysis, data were inspected using the Shapiro–Wilkinson’s test and visually by qq-plots. Pre- to post-operative comparisons were made using paired *t*-tests. Investigations of associations between CT angles and PROs were made using linear regression analysis. Fit of data was inspected plotting residuals in qq-plots. All statistical analyses were made using STATA[®] 13.

RESULTS

Demographics

Patient demographics and surgical procedures are presented in Table I.

Outcomes

The alpha angle was reduced in patients after surgery and the acetabular index angle was increased (Table II). HAGOS results have been published before [9, 10], but briefly, on average all HAGOS subscores improved more than the minimal clinically relevant changes [14] 1 year after surgery and for comparison for the reader, the numbers are provided in Table III.

Associations between angles and HAGOS subscales

Neither baseline angles nor changes in angles from before to after hip arthroscopic surgery were associated with any of the HAGOS subscales at baseline or with changes in HAGOS subscales 1 year after surgery. When investigating

Table I. Pre-operative demographics and surgical procedures (n = 60)

Demographics	Age at surgery (years)	36 ± 9
	Gender distribution (% females)	63
	Body mass (kg)	76 ± 15
	Height (cm)	174 ± 8
	Fat mass (%)	27 ± 10
	Comorbidities (%)	25
	Proportion of patients using daily pain killers (%)	58
	Bilateral surgery before 1-year follow-up (n)	15
Intraoperative findings	Cartilage damage Grades 0–4	Grade 3 (0–4)
	Patients having microfracture, n (%)	3 (5)
	Labral resection, n (%)	1 (1.7)
	Anchors used for labral repair (median, range)	2 (2–3)
	Number of patients having femoral osteoplasty	59
	Millimetre bone removed from femoral head (median, range)	3 (0–8) ^a
	Number of patients having acetabular osteoplasty	60
	Millimetre bone removed from acetabular rim (median, range)	3 (2–5)

Mean ± SD or median (range).

^aAll but one patient had femoral osteoplasty.

if this was different among genders or age groups <30 versus 30+, there were still no significant associations.

DISCUSSION

The main findings of this study were that patients with FAIS demonstrated changes in CT angles and PROs 1 year after hip arthroscopic surgery, but that neither baseline CT angles nor changes in them were associated with the PROs.

Table II. Femoral and acetabular angles from CT before and 1 year after hip arthroscopic surgery for both the affected and the contralateral leg in FAIS patients

		Baseline angles° (n = 55)	One-year follow-up angles° (n = 42)	Change from pre-surgery° (n = 42)	
		Mean ± SD	Mean ± SD	Mean change ± SD	95% CI
Affected leg	Alpha angle	51.7 ± 9.6	46.8 ± 7.7	-5.4 ± 6.8	-7.5 to -3.3
	Femoral anteversion	27.5 ± 10.5	27.7 ± 11.1	-0.2 ± 1.7	-0.8 to 0.3
	Lateral centre edge angle	33.1 ± 5.6	32.4 ± 5.6	-0.7 ± 2.8	-1.6 to 0.1
	Acetabular index angle	2.8 ± 6.0	3.6 ± 5.1	1.2 ± 2.7	0.3 to 2.0
	Anterior-sector angle	59.2 ± 6.6	59.8 ± 6.7	0.1 ± 2.7	-0.7 to 1.0
	Posterior-sector angle	94.9 ± 6.8	93.7 ± 7.6	-0.7 ± 3.1	-1.7 to 0.2
	Acetabular anteversion	18.0 ± 4.7	17.0 ± 4.9	-0.5 ± 1.9	-1.1 to 0.0
Contralateral leg	Alpha angle	51.8 ± 9.6	49.6 ± 9.5	-3.1 ± 7.9	-5.5 to -0.6
	Femoral anteversion	27.5 ± 10.6	28.9 ± 10.4	0.1 ± 1.8	-0.5 to 0.6
	Lateral centre edge angle	33.3 ± 5.5	33.5 ± 5.4	-0.2 ± 2.6	-1.1 to 0.6
	Acetabular index angle	3.1 ± 6.2	2.4 ± 5.5	-0.2 ± 2.6	-1.0 to 0.6
	Anterior-sector angle	59.4 ± 6.4	60.3 ± 5.4	0.5 ± 3.0	-0.5 to 1.4
	Posterior-sector angle	94.4 ± 7.0	93.8 ± 7.4	-0.2 ± 1.9	-0.8 to 0.3
	Acetabular anteversion	17.8 ± 4.4	17.1 ± 4.7	-0.2 ± 1.4	-0.7 to 0.2

SD, standard deviation; CI, confidence interval.

Table III. Copenhagen Hip and Groin Outcome scores

		Baseline, n = 60 (median, 25th; 75th quartile)	One-year follow-up, n = 57 (median, 25th; 75th quartile)	Change from pre-surgery, mean difference and 95% CI
Affected leg	Pain	53 (40; 65)	76 (63; 88)	19 (14-23), P < 0.001
	Symptoms	46 (34; 59)	64 (50; 79)	16 (10-21), P < 0.001
	Activities of daily living	50 (38; 70)	80 (63; 95)	18 (13-24), P < 0.001
	Sport	31 (20; 48)	59 (41; 78)	22 (16-28), P < 0.001
	Participation in physical activities	13 (0; 31)	25 (13; 56)	17 (8-25), P < 0.001
	Quality of life	30 (23; 40)	50 (35; 70)	19 (14-25), P < 0.001
Contralateral leg	Pain	85 (69; 100)	93 (80; 100)	5 (1-11), P = 0.1262
	Symptoms	80 (61; 93)	89 (79; 95)	4 (3-11), P = 0.2190

In this study, patients demonstrated significant alterations in the alpha angle and the acetabular index angle. The alpha angle was reduced 5 degrees. This alteration is in line with the surgical description of all patients but one had removal of bone from the femoral head–neck junction. In the literature [15, 16], it has been discussed which cut off point that should be used for an abnormal alpha angle: should it be 50, 55, 60 degrees or even higher? In this study, the mean pre-operative alpha angle was 51.7 degrees. With the reduction of 5 degrees 1 year after surgery, the mean patient enters the normal area for the alpha angle. Surprisingly, an almost identical alpha angle was seen for the contralateral leg: 51.8 degrees. Some of this might be explained by the fact that 15 patients had bilateral FAIS and had surgery on the contralateral hip during the study period, but 45 patients did not undergo bilateral surgery between the measurements and the standard deviations for the alpha angles (affected leg: 9.6 and contralateral leg: 9.6) did not show a larger variation in the alpha angle for the contralateral leg. We collected separate HAGOS pain and symptoms scores for the contralateral leg and here the median score for pain of the contralateral leg was 85 points, whereas the symptom score was 80 points. These scores are close to normal values [10, 17] and higher than patients reached for their affected leg 1 year after surgery. When combining the normalized HAGOS pain and symptoms scores of the contralateral leg with the lack of association between PROs and CT angles or changes in PROs and changes in CT angles, one has to consider the importance of radiographic measures in regard to patient-reported symptoms. Furthermore, it underlines the conclusions of the Warwick agreement stating that ‘a patient needs to have FAIS and not only FAI before undergoing surgical treatment [1].

In this study, the acetabular index angle was reduced 1 year after surgery which is in accordance with the surgeon’s operation description having removed bone from the acetabular rim. The centre edge angle was not altered 1 year after surgery, but in this study this angle was not particularly high, hence angle changes should accordingly be small in magnitude.

There were no significant changes in the femoral anteversion, acetabular sector angles or the acetabular anteversion which was as expected because these angles should not be altered by the surgical procedure. The angles were measured in order to characterize patients with FAIS further. A reference study was conducted by Mechlenburg *et al.* [11] describing CT angles of 170 reference hips measured by the same, experienced musculoskeletal radiologist as in this study. The acetabular sector angles and acetabular anteversion for patients with FAIS are similar to the ones

found in reference persons [11], except that the anterior acetabular sector angle is slightly increased compared with the reference females. A reason for this may be that the female patients showed a more pincer-like shape in the frontal plane (larger centre edge angles and acetabular index angles compared with the male patients) than our male patients which is then visible in the horizontal plane as well (Supplementary Table S1).

Valera *et al.* [18] conducted measurements corresponding to this study in persons with healthy hips and in persons with early hip OA. They found that patients with early hip OA had larger acetabular sector angles. Hence, they suggested that this could be important in relation to development of early OA. When comparing our patient data with those from Valera *et al.* [18], our acetabular sector angles correspond to the healthy reference persons in Valera *et al.* [18] As our patients were only included if they had no or very little OA (lateral joint space of >3 mm), our patients seem ‘OA’ healthy according to the description by Valera *et al.* [18]. However, the results from Valera *et al.* [18] are based on a cross sectional study and hence the time factor is uncertain. At the moment, it is also uncertain if patients with pincer impingement develop hip OA or not or whether it is the combination with cam morphology that drives the aetiology. Hence, further research in this area is needed before conclusions can be drawn.

In this study, radiographic abnormalities and alterations in them after surgery did not explain the variation in PROs. Having larger abnormalities did not equal greater impairment. Furthermore, reduction of large abnormalities did not result in larger changes in PROs. When diagnosing diseases from radiography, it is a well-known phenomenon that what is seen on imaging does not necessarily reflect the patient’s symptoms. Hence, patient history and imaging should be interpreted together and not as separate entities. The findings from this study showed the same tendency: PROs are not necessarily worsened by extreme values found by imaging. It has earlier been found that there is a relation between high alpha angles and hip OA [3]. Hence, having more abnormal scores might have an impact on later disease progression, but from this study, it does not seem to affect patient symptoms. As a diagnostic tool, imaging should be used to identify if cam and/or pincer morphology is present in order to guide the treatment choice for patients as well as to separate patients with FAIS from patients with other conditions of the hip and groin.

The change in alpha angle and acetabular index angle was not associated with improvement in PROs. Hence, in future studies, it is of little interest to measure these values after surgery as the change in PROs must have originated

from another underlying mechanism. This could be the repair of the torn labrum and cartilage, the rehabilitation or multiple other factors. No study has to date in a randomized placebo controlled trial shown what effect surgery has on PROs in patients with FAIS. Studies have compared surgery with physiotherapy and found that both treatment options improve PROs [19, 20]. This might seem surprising since one is invasive addressing the bony morphology and labral damage while the other one does not. In consequence, this raises the question ‘how much of the benefit from the surgical procedure is actually placebo’, which is currently addressed in an ongoing study [21].

A limitation of this study is that we did not have a large proportion of patients with very large alpha angles. However, in a recent publication [22], in patients with very large alpha angles, there was no association with PROs. Furthermore, we saw a change in the alpha angle and the acetabular index angle but not the centre edge angle. Hence, our patient group might differ from others. However, today, there is no consensus on how to quantify pincer deformity. Another limitation of the study is that the study sample size was not powered to investigate unilateral versus bilateral patients.

In conclusion, we found that patients with FAIS demonstrated changes in alpha angles and acetabular index angles 1 year after surgery. However neither these changes nor baseline CT angles were associated with changes in PROs or PROs at baseline.

SUPPLEMENTARY DATA

Supplementary data are available at *Journal of Hip Preservation Surgery* online.

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CONFLICT OF INTEREST STATEMENT

None declared.

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