

Five-Year Follow-up After Hip Arthroscopic Surgery in the Horsens-Aarhus Femoroacetabular Impingement (HAFAI) Cohort

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Background: Patients with femoroacetabular impingement syndrome (FAIS) are offered hip arthroscopic surgery to decrease hip pain, improve their function, and decrease development of hip osteoarthritis (OA). Nonetheless, long-term follow-up data are few.

Purpose: To investigate patient-reported outcomes, clinical tests, reoperations, and radiographic status 5 years after primary hip arthroscopy in patients with FAIS.

Study Design: Case series; Level of evidence, 4.

Methods: A total of 60 patients (age, 36 ± 9 years; 63% female) diagnosed with FAIS were included in the study and followed for 5 years after hip arthroscopy. Follow-up included Copenhagen Hip and Groin Outcome Score (HAGOS); Hip Sports Activity Scale; and clinical tests (flexion, adduction, internal rotation [FADIR]; flexion, abduction, external rotation [FABER]; and psoas muscle/tendon major pain provocation). Radiographic evaluation included lateral joint-space width (LJSW) and Tönnis classification for hip OA. Reoperations and conversion to total hip replacement (THR) were recorded. We calculated the proportion of patients who exceeded the minimal important change (MIC), achieved the Patient Acceptable Symptom State (PASS), and were within the 95% reference interval of age- and sex-matched persons with no hip problems. Changes were investigated using paired *t* tests.

Results: Compared with preoperatively, all HAGOS subscales were improved substantially 5 years after surgery (mean, ≥21 points; $P < .001$), and 67% to 89% of patients reported improvements exceeding MIC. Between 56% and 80% achieved PASS, but only 7% to 24% reached the 95% reference interval for the HAGOS subscales. A total of 36% had a positive FADIR test and 25% had a positive FABER test, which were improvements compared with preoperatively ($P < .001$ for both). Patients with a positive FADIR test had significantly worse HAGOS subscales. Six patients (10%) had a THR since their primary hip arthroscopy. In the remaining patients, the mean LJSW was decreased (-0.4 mm; $P = .043$), and hip OA had worsened in 9 patients (23%; $P = .003$).

Conclusion: Five years after surgery, the majority of patients experienced HAGOS improvements exceeding MIC while also showing an acceptable PASS. However, clinical tests, participation in physical activities, and quality of life indicated that many patients still experience hip problems.

Registration: NCT04590924 (ClinicalTrials.gov identifier).

Keywords: clinical tests; femoroacetabular impingement; hip arthroscopy; hip osteoarthritis; patient-reported outcomes; total hip replacement

Femoroacetabular impingement syndrome (FAIS) is a motion-related, clinical disorder that may cause a triad of hip motion—related discomfort, clinical impingement signs, and radiographic signs of FAIS.⁵ In some cases, surgical

treatment of the bony morphology and repair of labral tears is deemed necessary. In previous papers, we have reported patient-reported outcomes (PROs), muscle strength, physical activity, and radiological measures^{11,14-16} from before to 1 year after hip arthroscopic surgery in the Horsens-Aarhus Femoroacetabular Impingement (HAFAI) cohort of patients with FAIS.¹³ While several studies have investigated rate of reoperation and/or conversion to total hip replacement

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(THR), current knowledge on the long-term effects of surgery in patients with FAIS is sparse.^{3,23,29} A small number of studies have investigated PROs 5 years after surgery, indicating that patients' pain, function, and quality of life are improved after surgery but also suggesting that PROs are still below the level of healthy controls at this point.^{3,7,15,25} Hence, it is of relevance to patients and clinicians to conduct further evaluation of outcomes at 5-year follow-up, including analyses of how many of the patients will eventually achieve minimal important change (MIC) and Patient Acceptable Symptom State (PASS) and be within the reference interval of healthy persons.

Clinical tests are used to examine the hip joint and diagnose patients with FAIS. Specifically, tests for flexion, adduction, internal rotation (FABIR) and flexion, abduction, external rotation (FABER) are used to diagnose intra-articular pathology.^{18,21} In addition, patients with FAIS may experience psoas-related pain.³⁰ Hence, identifying the number of patients with postoperative pain related to the psoas muscle may identify an important problem after surgery. The FADIR test is especially limited by high sensitivity; hence, there is a risk of several false-positive findings.²⁷ However, when combined with imaging findings and symptom state, they are indicators of hip problems. Hence, performing clinical tests along with imaging and questionnaires postoperatively could help identify patients with consistent problems in the hip area after surgery.

Last, patients with cam morphology are reported to be at increased risk of developing hip osteoarthritis (OA).¹ Joint-space narrowing is an indicator of decreasing cartilage thickness of the hip joint and could therefore be a marker of progression toward hip OA in patients with FAIS.⁴ However, to the best of our knowledge, no study has reported imaging data in combination with clinical tests of patients and PROs 5 years after surgery, which could expand further our understanding of the long-term outcomes of surgery.

The aim of this study was to investigate PROs, clinical tests, reoperations, and radiographic outcomes in the HAFAI cohort at 5 years after hip arthroscopic surgery for FAIS.

METHODS

Design and Procedures

In 2015 and 2016, a total of 60 patients (age, 36 ± 9 years; 63% female; body mass, $76 \text{ kg} \pm 15$; fat percentage, $27\% \pm 10\%$) scheduled for hip arthroscopic surgery agreed to participate in the HAFAI cohort.¹³ The study was a prospective

study with a consecutively included cohort of patients evaluated from before surgery to 1 year postoperatively. All patients signed an informed consent form and were asked if they were amenable to being contacted for further follow-up in the future.

We registered the follow-up study on ClinicalTrials.gov (ClinicalTrials.gov identifier: NCT04590924), and 5 years after surgery, we sent out emails with hip-specific PRO measures and invited patients to a follow-up at Horsens Regional Hospital. The follow-up included a clinical examination by a single surgeon (B.L.) and a standing antero-posterior (AP) pelvic radiograph (except for the affected leg for patients who had a THR) for assessment of the lateral joint-space width (LJSW) and degree of hip OA. We extracted data on reoperations from the PRO measures or from the 5-year consultation. The study was conducted in accordance with the Helsinki Declaration and received institutional review board approval. We registered the study at the Regional Data Protection Agency (reference No. 1-16-02-293-19) and followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.³³

Patients

Patients were included in the HAFAI cohort if they had (1) cam and/or pincer morphology identified on an anterior-posterior (AP) and/or axial radiograph (alpha angle, $>55^\circ$; center-edge angle, $>25^\circ$; no crossover sign; no ischial spine sign)¹³; (2) LJSW >3 mm on an AP radiograph; and (3) clinical and functional hip issues according to the Warwick Agreement.⁵ Exclusion criteria have been published previously,¹³ but in brief, patients were excluded if they had previous hip surgery, contraindications to radiography, other systemic conditions that could limit their functional level, and more.

All patients had hip arthroscopic surgery performed by a single, experienced surgeon (B.L.). Surgical treatment of the bony morphology was osteochondroplasty using a motorized bur.¹⁴ None of the patients had their capsule closed; 57 patients had labral repair, 3 had labral resection, and 3 had microfracture.¹¹ Patients followed the standard home-based rehabilitation program postoperatively.¹⁴

Outcome Measures

Patients completed the Copenhagen Hip and Groin Outcome Score (HAGOS; 0-100 [best]) developed for, and

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Ethical approval for this study was obtained from the Committee on Biomedical Research for Middle Region of Denmark (ref No. 1-10-72-239-14 and 1-10-72-1-19).

TABLE 1
HAGOS Subscale Values for Analysis of MIC, PASS, and 95% Reference Interval^a

	HAGOS Subscale					
	Pain	Symptoms	ADL	Sport	PA	QoL
MIC	6	10	9	9	1	9
PASS	68.8	62.5	82.5	60.9	43.8	42.5
95% reference interval	97.5-100	89.3-100	100	90.6-100	87.5-100	95-100

^aADL, activities of daily living; HAGOS, Copenhagen Hip and Groin Outcome Score; MIC, minimal important change; PA, participation in physical activities; PASS, Patient Acceptable Symptom State; QoL, hip-related quality of life.

validated in, a group of patients with hip/groin pain consisting of the subscales pain, symptoms, activities of daily living (ADL), sport, participation in physical activities, and hip-related quality of life. Furthermore, patients completed the Hip Sports Activity Scale (HSAS) (0-9, where 0 is no participation in any activities and 9 is the level of an athlete) regarding their current level of participation in physical activities.²⁴ PRO measures were emailed to the patients via the Procordo database used in the Danish Hip Arthroscopic Register or using RedCap.¹⁷

At the outpatient clinic, patients underwent the FADIR and FABER tests for pain^{18,21}; in addition, the psoas muscle/tendon unit was palpated to investigate if known pain was reproduced (psoas test).^{19,28} The FADIR test has a sensitivity of 80% and specificity of 24%, while the FABER test has a sensitivity of 54% and specificity of 38%.²⁶ Reoperations and conversions to THR were registered either from PRO measures or from medical records at 5-year follow-up. Radiographic outcomes included LJSW, which was measured by 2 raters (S.K. and B.L.). The intraclass correlation coefficient (3,1) ranged from 0.67 to 0.87 for the measurements (preoperatively, postoperatively, affected and contralateral legs). Furthermore, the degree of OA on radiographs was classified using the Tönnis grade (0 [none] to 3 [severe]).^{2,32}

Data Analysis

All data were inspected visually using histograms, and normality was tested using the Shapiro-Wilk test. Normally distributed data were reported as means and SDs, and statistical tests comparing data from before surgery to the 5-year follow-up were performed using paired *t* tests. Nonparametric data were reported as medians and interquartile ranges, and data from before surgery to the 5-year follow-up were compared using the Wilcoxon signed rank test. We calculated MIC based on numbers from Kemp et al¹⁰ and PASS based on values from Ishøi et al⁹ (Table 1). The HAFAI cohort was age and sex matched with a group of persons without hip pain (healthy volunteers).¹⁵ These persons also completed HAGOS. Using the same method as Thorborg et al,³¹ we calculated a reference interval for HAGOS scores from our healthy volunteers based on 95% of their scores (termed 95% reference interval).

Differences between the clinical tests before surgery and at the 5-year follow-up were tested using the McNemar test

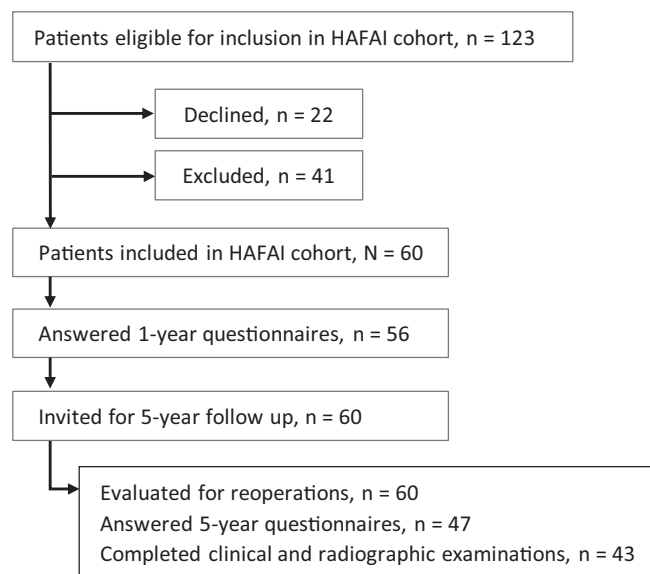


Figure 1. Flow of patients from before hip arthroscopic surgery to the 5-year follow-up in the Horsens-Aarhus femoroacetabular impingement (HAFAI) cohort; 7 of 10 patients requiring reoperation and 2 of 6 patients who underwent total hip replacement completed the 5-year patient-reported outcome measures.

for paired data. We examined the difference in PROs between patients having positive or negative clinical tests and patients with or without THR using the Wilcoxon rank sum test for unpaired data.

The significance level was set at .05, and Stata 13 (StataCorp, College Station, TX) was used for all statistical analyses.

RESULTS

From baseline to 5-year follow-up, 47 of the 60 included patients completed the PRO measures, and 43 completed the clinical and radiographic examinations (Figure 1).

We had complete follow-up data (60/60) for reoperations in the period from before primary surgery to 5-year follow-up: 6 patients (10%) had undergone THR of the affected hip, while 12 patients (20%) had additional hip arthroscopic

surgery of the affected hip. In total, 16 patients (27%) had additional surgery of the affected hip after their primary hip arthroscopic surgery (Table 2).

The results of the PROs, clinical tests, and radiographic examinations are presented in Table 3.

Patient-Reported Outcomes

All HAGOS subscales improved significantly from before to 5 years after surgery (Figure 2). The majority of patients experienced a change exceeding the MIC (67%-89%) and PASS (56%-80%) 5 years after surgery. Between 7% and 24% reached healthy reference levels of HAGOS subscales measured in age and sex-matched persons without hip pain (Table 4).

TABLE 2
Surgeries Undertaken Between Primary Hip Arthroscopy and 5-Year Follow-up^a

Procedure	n (%)
Joint preserving reoperation	10 (17)
Joint preserving reoperation + THR	2 (3)
THR	4 (7)
Total	16 (27)

^aTHR, total hip replacement.

Clinical Test Outcomes

The proportion of patients with positive clinical test results is presented in Table 3. Significantly fewer patients had a positive FADIR and FABER 5 years after surgery compared with preoperatively ($P < .001$ for both). Figure 3 illustrates differences in the HAGOS subscale values between those testing positive versus negative on the clinical tests 5 years after surgery.

Reoperations and Conversion to THR

While no differences were observed in preoperative HAGOS subscales or age between patients having or not having additional hip surgery, clear differences were found between patients who had THR and persons with preserved hips. Those who had a THR were older (age, 46 vs 36 years; $P = .022$) and had significantly worse preoperative HAGOS symptoms score (29 vs 50; $P = .009$) and HAGOS ADL score (30 vs 50; $P = .023$).

Radiographic Outcomes

Radiographic assessment was available in 43 patients before surgery and at 5-year follow-up. For patients who had preserved their hip at follow-up, a slight but significant decrease in LJSW was observed compared with preoperatively (-0.4 mm; $P = .043$). This was not seen for the

TABLE 3
PROs, Clinical Tests, and Radiographic Assessments at Baseline, 1-Year, and 5-Year Follow-up^a

	Before Surgery	1-y Follow-up	5-y Follow-up	Before Surgery vs 5-y Follow-up		1-y vs 5-y Follow-up	
				Mean Change (95% CI)	<i>P</i>	Mean Change (95% CI)	<i>P</i>
HAGOS, median [IQR] ^b							
Pain	53 [40 to 65]	76 [63 to 88]	78 [65 to 93]	25 (19 to 30)	<.001	5 ^c	.051 ^d
Symptoms	46 [34 to 59]	64 [50 to 79]	71 [57 to 86]	21 (16 to 27)	<.001	4 ^c	.24 ^d
ADL	50 [38 to 70]	80 [63 to 95]	85 [65 to 100]	26 (18 to 33)	<.001	5 ^c	.004^d
Sport	31 [20 to 48]	59 [41 to 78]	66 [50 to 84]	29 (25 to 36)	<.001	6 ^c	.096 ^d
PA	13 [0 to 31]	25 [13 to 56]	50 [25 to 75]	27 (17 to 36)	<.001	13 ^c	.023^d
QoL	30 [23 to 40]	50 [35 to 70]	60 [45 to 80]	27 (20 to 34)	<.001	10 ^c	.041^d
HSAS	1 [0 to 3]		2 [1 to 3]		.038^d		
Positive FADIR test, %	95	84	36	-59 (-77 to -41)	<.001	-52 (-76 to -28)	<.001
Positive FABER test, %	85	48	25	-61 (-83 to -39)	<.001	-7 (-38 to 23)	.79
Positive psoas test, %			53				
LJSW, mm, mean ± SD							
Affected leg	4.5 ± 0.8		4.2 ± 1.3	0.4 (0.01 to 0.7)	.043		
Contralateral leg	4.6 ± 0.8		4.6 ± 0.8	0 (-0.1 to 0.1)	.831		
Tönnis grade, % (n)							
0	74 (29)		51 (20)				
1	21 (8)		41 (16)				
2	5 (2)		8 (3)				

^aBoldface *P* values indicate statistical significance ($P < .05$). ADL, activities of daily living; FABER, flexion, abduction, external rotation; FADIR, flexion, adduction, internal rotation; HAGOS, Copenhagen Hip and Groin Outcome Score; HSAS, Hip Sports Activity Scale; IQR, interquartile range; LJSW, lateral joint-space width; PA, participation in physical activities; QoL, hip-related quality of life.

^bNot all HAGOS subscales were normally distributed; hence, all are presented with medians and IQRs.

^cAll HAGOS changes from 1- to 5-year follow-up were non-normally distributed; hence, they are presented as median change and *P* values calculated using Wilcoxon signed rank test.

^dNonparametric test (Wilcoxon signed rank test).

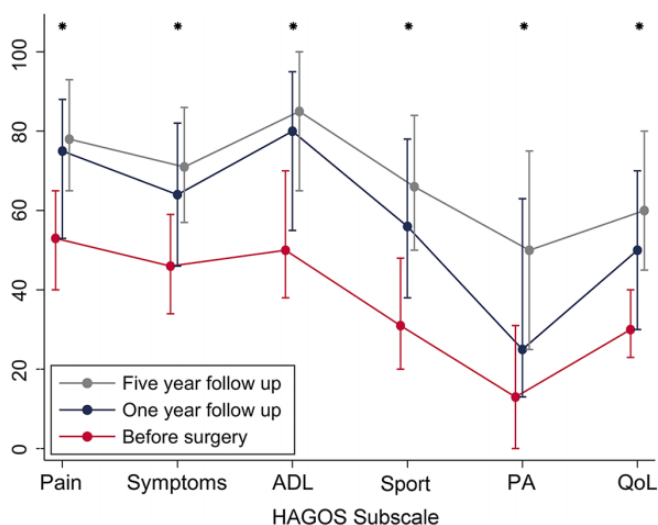


Figure 2. HAGOS subscale values (0 = worst imaginable, 100 = no problems) before, 1 year after, and 5 years after surgery for femoroacetabular impingement syndrome in the Horsens-Aarhus femoroacetabular impingement cohort. *Statistically significant difference from before to 5 years after surgery. ADL, activities of daily living; HAGOS, Copenhagen Hip and Groin Outcome Score; PA, participation in physical activities; QoL, hip-related quality of life.

TABLE 4

Percentage of Patients Who Exceeded MIC, Achieved PASS, and Were Within the 95% Reference Interval of HAGOS Subscales, 5 Years After Hip Arthroscopy^a

	HAGOS Subscale					
	Pain	Symptoms	ADL	Sport	PA	QoL
Exceeded MIC	89	78	82	84	67	82
Achieved PASS	67	69	56	58	56	80
Within 95% reference interval	13	9	24	18	11	7

^aADL, activities of daily living; MIC, minimal important change; PA, participation in physical activities; PASS, Patient Acceptable Symptom State; QoL, hip-related quality of life.

contralateral hip (Table 3). The distribution of the Tönnis grades is shown in Table 3. A total of 9 patients (23%) had progressed in Tönnis grade of hip OA at 5 years after surgery ($P = .003$).

DISCUSSION

The main findings at 5-year follow-up in the HAFAI cohort were that (1) all HAGOS subscales improved substantially, 67% to 89% of patients experienced improvements exceeding HAGOS MIC, 56% to 80% had an acceptable PASS, and 7% to 24% reached levels within the reference area for healthy controls (95% reference interval); (2) the number of patients who tested positive on the FADIR and the

FABER tests was markedly decreased; (3) a total of 10% of patients had received a THR of their affected leg since their primary hip arthroscopic surgery; and (4) while LJSW decreased 0.4 mm (95% CI, 0.01-0.7 mm) in the affected leg and 23% of patients had an increase in Tönnis grade, LJSW was preserved in patients who did not convert to THR 5 years after surgery.

In the current study, we observed that the improvement in pain was stable 5 years after hip arthroscopic surgery for FAIS. Similar results were found by Öhlin et al²⁵ and Domb et al³ 5 years after surgery. The majority of patients experienced a change exceeding HAGOS MIC, while 56% to 80% had an acceptable PASS. This is somewhat higher than in a follow-up study of 1 to 2 years after surgery, where 46% of patients had a PASS at 1 to 2 years in the Danish Hip Arthroscopy Register,⁹ and in the randomized controlled trial of Griffin et al,⁶ where approximately 50% had an acceptable symptom state. One reason for the increase in number of patients reaching PASS could be that a common indication for surgery is that patients experience hip problems when participating in sports. Several studies have noted that, although patients return to some level of sports, it is not at the same level as before surgery.^{8,31,34} In our cohort, we saw clinically relevant improvements in sports and participation from before to 1 year after surgery. Importantly, the subscale “participation in physical activities” was further improved from 1- to 5-year follow-up (Figure 2). Thus, at the 5-year follow-up, patients had either improved more or may have decided to come to terms with the physical activity level they were currently capable of having. There was no clinically relevant change in the actual sports score from 1- to 5-year follow-up. Hence, it is interesting that “participation in physical activities” was substantially improved. The HSAS score indicated that the typical patient can participate in recreational sports at a low level. Consequently, the patients have not returned to high-level sports but seem more satisfied with their level of participation at the 5-year follow-up compared with at the 1-year follow-up.

Interestingly, >50% of the participants had a positive psoas test at the 5-year follow-up. Muscle- and tendon-related pain could be a contributing factor to consistent lower ratings in sports and participation in this patient group. However, our explorative analyses showed no statistically significant differences between the patients having a positive versus negative psoas test in any of the HAGOS subscales except for a small difference in the ADL score. Hence, our data do not support a painful psoas muscle as an explanation of reduced hip function. Instead, having pain at the FADIR test was associated with poorer HAGOS subscales. During the FADIR test, the intra-articular structures are squeezed together. The test is very sensitive (80%), but not very specific.²⁶ Hence, persons without FAIS could also have positive results in this test, and optimally, it should be conducted only in concert with other screening tools. In our patient group, a radiographic analysis was also included, and patients were enrolled in the study only if they had a triad of symptoms, radiographic findings, and positive clinical tests, thereby ensuring that they fulfilled the diagnostic criteria for FAIS. Hence, it is interesting that

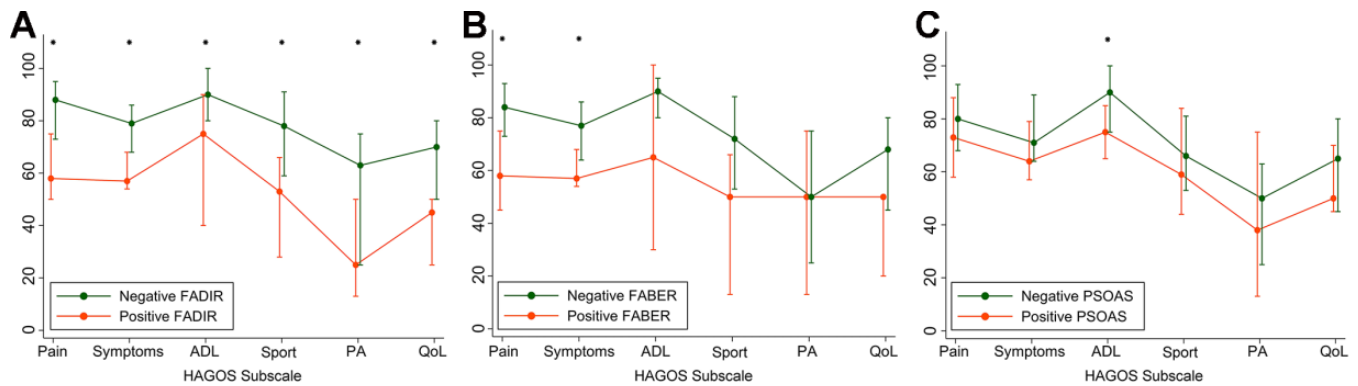


Figure 3. HAGOS subscale values (0 = worst imaginable, 100 = no problems) for positive (ie, abnormal test result) and negative (ie, normal test result) ratings of (A) flexion, adduction, internal rotation (FADIR) test, (B) flexion, abduction, external rotation (FABER) test, and (C) psoas test. *Statistically significant difference ($P < .05$). ADL, activities of daily living; HAGOS, Copenhagen Hip and Groin Outcome Score; PA, participation in physical activities; QoL, hip-related quality of life.

patients having a positive test 5 years after surgery also have lower HAGOS scores, and it should be investigated further how these patients should be optimally managed.

A total of 27% (16 patients) had reoperations and/or THR. Although patients were included in the HAFAI cohort only when their LJSW was at least 3 mm, indicating preserved cartilage, 10% of the cohort converted to THR. The rate of conversion in our study is partially in line with previously reported rates of 15% and 25% when assessed 5 years after surgery.^{3,29} In these studies, patients were also operatively treated if they had joint spaces <3 mm, which might offer some explanation for their higher conversion rates.

While we found no factors discriminating patients having joint-preserving hip reoperations from those having only primary hip arthroscopies, we observed a clearer trend in patients having a THR: patients who converted to a THR differed from the remaining part of the cohort in terms of PROs and patient age at hip arthroscopic surgery. Similarly, a 5-year study of 466 patients having hip arthroscopic surgery found that patients who later converted to THR were older and had worse preoperative ADL scores (measured via the Hip Outcome Score).^{22,29} This may indicate that patients with FAIS of older age and/or with low ADL function may already have developed hip OA and it is questionable if they will benefit from hip-preserving surgery. The typical patient with FAIS reports problems in the HAGOS ADL subscale but does not report an ADL subscale score as low as some of the other subscale scores.¹² Hence, it should be investigated further in a well-powered study if clinicians can use age and low patient-reported ADL to identify patients not suitable for hip arthroscopic surgery.

Agricola et al¹ found an increased risk of development of hip OA during 5 years in patients with cam morphology. Hence, it is of great interest to investigate if hip arthroscopic surgery postpones development of hip OA. In our cohort, we observed a decreased LJSW of the affected hip and an increase in patients with hip OA 5 years after surgery, as measured using the Tönnis classification. Furthermore, 6 patients converted to THR. The decrease in LJSW

could be of clinical importance since the measurement was performed by an experienced rater (B.L.) and the difference was >0.3 mm.²⁰ However, the mean LJSW was still 4.2 ± 1.3 mm in the remaining patients, which is quite wide. One year after surgery, we found that the patients in the study had a mean surgical reduction of 5° of the alpha angle.¹⁶ Hence, it should be further investigated if there is an association between a reduction in alpha angle and a decreased development of hip OA. If so, this could explain why many patients still have a wide hip joint-space 5 years after surgery.

The strength of the current study is the prospective study design with consecutive data collection from well-characterized patients with FAIS undergoing surgery. However, there are also several limitations to keep in mind when interpreting the results. First, the study has no control group, hence we cannot draw conclusions on causality. Second, the sample size was calculated for the original study, explaining why certain analyses of this 5-year follow-up could be underpowered. Third, preoperative radiographs were taken at different radiological departments using different equipment, which is suboptimal when measuring LJSW but not as important when assessing Tönnis classification. Moreover, we investigated the inter-rater reliability of the measurement of LJSW and found the reliability to be moderate to good. As the affected and the contralateral hip were measured in the same way and we observed differences in LJSW only for the affected hip, this provides confidence in the results from the measurements. It is a limitation that we did not assess reliability of the Tönnis scale. As suggested by Maheu et al,²⁰ a highly experienced rater of radiographs performed the analysis. Despite this, there could be a systematic error in these measurements.

CONCLUSION

Five years after surgery, all HAGOS subscales were improved substantially, and the majority (67%-89%) of patients experienced a change exceeding HAGOS MIC

while also having acceptable HAGOS PASS in many cases (56%-80%). However, clinical tests and scores on participation in physical activities and hip-related quality of life indicated that some patients still experience hip problems. Furthermore, those with persistent positive FADIR test 5 years after surgery reported significantly lower HAGOS subscales, and only 7% to 24% patients were within the 95% reference interval for healthy volunteers. A total of 10% of the cohort converted to THR. For those with preserved hips 5 years after surgery, there was a 0.4 mm decrease in LJSW, and 23% experienced progression in hip OA. The findings of the current study highlight that patients experience an improvement after surgery but are not reaching healthy reference levels. Consequently, there is a need for further research investigating how to identify the patients with FAIS who are most likely to benefit from hip arthroscopic surgery.

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