Does Femoral Osteoplasty Improve Long-term Clinical Outcomes and Survivorship of Hip Arthroscopy?

A 15-Year Minimum Follow-up Study

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Background: Although femoral osteoplasty is common practice in treating cam-type femoroacetabular impingement (FAI), long-term data are lacking that support the ability of this procedure to optimize outcomes and alter natural history.

Purpose: To compare long-term clinical outcomes and survivorship of treatment for symptomatic FAI via arthroscopic correction of labral or chondral pathology with and without femoral osteoplasty.

Study Design: Cohort study; Level of evidence, 3.

Methods: A retrospective cohort study was performed across 2 consecutive cohorts of patients with isolated cam-type FAI who underwent hip arthroscopic treatment of labral or chondral pathology without femoral osteoplasty (HS group) or with femoral osteoplasty (HS-OST group). These unique cohorts were established at a distinct transition time in our practice before and after adoption of femoral osteoplasty for treatment of FAI. Clinical outcomes were measured using the modified Harris Hip Score (mHHS). Kaplan-Meier analysis was used to assess for total hip arthroplasty (THA)–free and reoperation-free survivorship.

Results: The final HS group included 17 hips followed for 19.7 ± 1.2 years, and the final HS-OST group included 23 hips followed for 16.0 ± 0.6 years. No significant patient or morphological differences were found between groups. Compared with the HS group, the HS-OST group had significantly higher final mHHS (82.7 vs 64.7 for HS-OST vs HS, respectively; *P* = .002) and mHHS improvement (18.4 vs 6.1; *P* = .02). The HS-OST group also had significantly greater 15-year THA-free survivorship versus the HS group (78% vs 41%, respectively; *P* = .02) and reoperation-free survivorship (78% vs 29%; *P* = .003).

Conclusion: This study demonstrated superior long-term clinical outcomes and survivorship with combined arthroscopy and femoral osteoplasty compared with hip arthroscopy alone. These long-term data strongly support the practice of femoral osteoplasty in patients with cam FAI morphologies and suggest that this treatment alters the natural history of FAI at long-term follow-up.

Keywords: FAI; femoroacetabular impingement; arthroscopy; osteoplasty; long-term; THA

Femoroacetabular impingement (FAI), principally caused by a pathological abutment of the femur and acetabulum, is now recognized as a predominant cause of hip disability and early osteoarthritis (OA).[3,10,26] Implicated deformity can exist at the femur (cam-type), acetabulum (pincer-type), or both.[2,11,12,22,32] Cam-type FAI, in addition to being a high-prevalence morphological variant, has shown the strongest associations with labral disease, articular cartilage degeneration, and progression to secondary OA.[1,21,30] Currently, standard surgical treatment for cam-type FAI involves both addressing chondrolabral pathology and performing bony correction of the structural impingement deformity at the femoral head-neck junction via head-neck osteoplasty. This approach has demonstrated excellent clinical and functional outcomes at short- to midterm follow-up[17,24,25,31] as well as very high rates of return to play in the short term.[9] Despite a presumed importance of structural correction to altering the natural history of cam FAI, long-term data are lacking,[5,13,20,33] and some investigators have called the role of structural correction via femoral osteoplasty into question.[28] Thus, long-term clinical outcome and survivorship data are essential to fully assess the true role of femoral osteoplasty in the surgical treatment of symptomatic FAI. These data will facilitate surgical decision making and will provide improved information for patient counseling regarding treatment outcomes and hip joint survivorship.

The American Journal of Sports Medicine
1–7
DOI: 10.1177/03635465221123048

Previously, we reported short-term outcomes of a combined hip arthroscopy (HS) and femoral osteoplasty (HS-OST) treatment for symptomatic cam-type FAI and compared these with outcomes of an isolated HS treatment at 2-year follow-up.[19] In the early follow-up study, we found no difference in mHHS between the groups but did observe greater reoperation-free survivorship in the HS-OST group. Given the relatively young and active patient population undergoing FAI surgery, it is critically important to assess the long-term clinical outcomes of surgical treatments.[6] Such data are necessary to define the true hip preservation effect of these interventions.

Thus, the purpose of this study was to further assess the cohorts to compare long-term (minimum 15 years) clinical outcomes and survivorship of treatment for symptomatic FAI via arthroscopic correction of labral or chondral pathology with and without femoral osteoplasty.

METHODS

A retrospective comparative cohort study was performed at 15-year minimum follow-up. Institutional review board approval was obtained for this study and all patients provided informed consent. Previously, we retrospectively reviewed a prospective database to identify patients who underwent hip arthroscopy by a single surgeon (J.C.C.) to address symptomatic labral or chondral pathology between the years 2000 and 2005.[7] All patients underwent hip magnetic resonance imaging or magnetic resonance angiography for preoperative assessment of labral and cartilage pathology. All patients had preoperative radiographic evidence of cam-type FAI (alpha angle $>50^\circ$ on at least 1 radiographic view) and a lateral center-edge angle $>20^\circ$. Patients with nonisolated cam-type impingement (pincer-type impingement or combined cam- and pincer-type impingement) were excluded. Routine performance of combined HS-OST surgery was adopted in January 2003 such that all patients before this date were treated with isolated HS and all after were treated with HS-OST. Hips in both groups underwent arthroscopy via the same techniques for assessment and treatment of intra-articular pathology. For hips in the HS-OST group, femoral osteoplasty was additionally performed through a limited open approach, as previously published with excellent short-term results.[8]

During the study period, labral tears were treated with resection of the unstable segment, with preservation of the stable capsular remnant when possible. Labral tears were anterior or anterolateral in all patients. Articular abnormalities were treated with chondroplasty to remove the unstable margins of any articular lesions. Labral repair and microfracture were not used during this time. For patients who underwent head-neck osteoplasty, both fluoroscopic imaging and intraoperative examination were used to assess sufficiency of the osteoplasty and check for residual impingement. Operative findings were gathered from intraoperative notes and arthroscopic images. Acetabular and femoral head chondromalacia was described by Outerbridge classification.[23]

Routine preoperative radiographs were available for all included hips. For all hips in both groups, preoperative alpha angle[21] was measured on frog-leg lateral view. Preoperative OA was classified by the Tönnis OA grade[29] on anteroposterior pelvic view. All hips were Tönnis grade ≤ 2.

Clinical outcomes were assessed through pre- and postoperative patient-reported outcome (PRO) scores using the modified Harris Hip Score (mHHS). Reoperation was assessed, including revision surgery and total hip arthroplasty (THA). Postoperative scores used were those gathered at latest follow-up. For patients who underwent reoperation, latest scores available before reoperation were used. In patients who underwent reoperation before PRO collection (n = 11), an imputed postoperative mHHS was assigned and used in all subsequent analyses, as previously described.[18] Composite failure was defined as reoperation or failure to achieve either final mHHS >70 or an mHHS improvement from baseline of at least 8 points (the minimal clinically important difference.)[4]

Statistical comparisons were performed using SPSS software (IBM). Outcome scores were compared using Student t test. Composite failure rates were compared using chi-square test. Kaplan-Meier estimates of both THA-free and reoperation-free survival were calculated for each group and compared using log-rank test. $P < .05$ was considered significant.

RESULTS

A total of 47 hips (47 patients [22 HS, 25 HS-OST]) were identified from the original cohorts. A total of 5 patients were lost to follow-up despite extensive outreach efforts, and 2 patients died before 15-year follow-up. All of the remaining 40 (85%) patients had minimum 15-year clinical follow-up or reached a study endpoint (THA). In total, 23 hips were treated with HS-OST and followed for a mean ± SD of 16.0 ± 0.6 years, and 17 hips were treated with isolated HS and followed for a mean of 19.7 ± 1.2 years ($P < .001$).

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Presented at the annual meeting of the AOSSM, Colorado Springs, Colorado, July 2022.

Submitted January 25, 2022; accepted July 20, 2022.

One or more of the authors has declared the following potential conflict of interest or source of funding: J.J.N. has received royalties from Responsive Arthroscopy; consulting fees from Responsive Arthroscopy, Smith & Nephew, and Zimmer; and research support from Smith & Nephew and Zimmer. J.C.C. has received royalties from Microport; consulting fees from Microport Orthopedics, Smith & Nephew, and Zimmer; and speaking fees from Synthes GmbH. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

TABLE 1
Preoperative Group Characteristics[a]

Variable	HS (n = 17)	HS-OST (n = 23)	*P*
Patient			
Age, y	40.4 ± 14	33.5 ± 10	.09
Body mass index	25.2 ± 4	26.5 ± 4	.47
Preoperative mHHS	58.6 ± 14	64.3 ± 8	.10
Male	8 (47)	18 (74)	.08
Radiographic			
Tönnis grade 0	11 (65)	12 (52)	
Tönnis grade 1	5 (29)	5 (22)	
Tönnis grade 2	1 (6)	6 (26)	.11 (2 vs 0-1)
Mean alpha angle, deg	64.8	68.3	.41
Intraoperative			
Labral tear present	17 (100)	22 (96)	.84
Acetabular chondromalacia			
Absent	2 (12)	0 (0)	.36 (any)
Grade I	5 (29)	3 (13)	
Grade II	4 (24)	8 (35)	
Grade III	1 (6)	4 (17)	.29 (III-IV vs 0-II)
Grade IV	5 (29)	8 (35)	.71 (IV)
Femoral chondromalacia			
Absent	9 (53)	18 (78)	.09 (any)
Grade I	0 (0)	0 (0)	
Grade II	3 (18)	2 (9)	
Grade III	0 (0)	1 (4)	.20 (III-IV vs 0-II)
Grade IV	5 (29)	2 (9)	.11 (IV)

[a]Data are presented as mean ± SD or n (%) unless otherwise noted. Primary labral tears were anterior or anterolateral in all patients. HS, hip arthroscopy; HS-OST, hip arthroscopy with femoral head-neck osteoplasty; mHHS, modified Harris Hip Score.

At the time of surgery, patients in the HS-OST and HS groups were similar with respect to age (33.5 vs 40.4 years, respectively; *P* = .09), sex (male, 74% vs 47%; *P* = .08), body mass index (26.5 vs 25.2; *P* = .47), and preoperative mHHS (64.3 ± 7.6 vs 58.6 ± 13.8; *P* = .10). We found no differences in preoperative radiographic Tönnis OA grades (grade 2, 26% HS-OST vs 6% HS; *P* = .11) or alpha angles (68.3° HS-OST vs 64.8° HS; *P* = .41). Intraoperative chondromalacia severity was not significantly different between groups at either the acetabular rim (grade III-IV, 52% HS-OST vs 35% HS; *P* = .29) or the femoral head (grade III-IV, 13% HS-OST vs 29% HS; *P* = .20) between groups (Table 1).

THA conversion occurred before PRO collection in 8 patients with HS (mean preoperative mHHS, 52.4 ± 12.0) and 3 patients with HS-OST (59.8 ± 4.4). An imputed postoperative mHHS of 55 was assigned to these patients.

Compared with the HS group, the HS-OST group had higher final mHHS (82.7 vs 64.7 for HS-OST vs HS, respectively; *P* = .002) and significantly greater mHHS improvement (18.4 ± 17.6 vs 6.1 ± 14.0; *P* = .02). Rates of both non-THA reoperation (0% vs 24%, respectively) and THA conversion (22% vs 59%; *P* = .02) were markedly lower in the HS-OST group compared with the HS group (Table 2).

Composite failure (reoperation or failure to achieve either mHHS >70 or the mHHS minimal clinically important difference [8 points]) was significantly lower in the HS-OST group (35% vs 77%; *P* = .009) (Table 2). The total reoperation rate was 71% in the HS group, compared with 22% in the HS-OST group. There were 5 (22%) THA conversions in the HS-OST group, which occurred at a mean of 5.8 ± 2.5 years (range, 2.7-8.5 years) postoperatively, and 10 (59%) in the HS group at 7.1 ± 4.0 years (range, 0.8-12.5 years). No non-THA reoperations were performed in the HS-OST group. There were 4 non-THA reoperations in the HS group, all for symptom recurrence, which occurred at a mean of 6.8 ± 4.3 years (range, 1.7-13.6 years). A total of 2 patients underwent HS-OST (at 5.7 years and 13.6 years postoperatively) and had remained symptom-free at latest follow-up. One patient had persistent symptoms before our adoption of HS-OST (1.7 years postoperatively) and underwent HS with debridement-only before progressing to THA shortly thereafter (3.0 years postoperatively). The final patient underwent surgical hip dislocation to more comprehensively address femoral head asphericity (6.0 years postoperatively) before progressing to THA (6.5 years later).

At 15-year follow-up, Kaplan-Meier analysis demonstrated the HS-OST group's significantly greater THA-free survival (78% vs 41% for HS-OST vs HS, respectively; *P* = .02) and overall reoperation-free survival (78% vs 29%; *P* = .003) (Table 2; Figure 1). Rates were comparable between groups at 5 years (THA-free survival, 87% vs 76% for HS-OST vs HS, respectively; reoperation-free survival, 87% vs 71%) but began to diverge by 10 years (THA-free survival, 78% vs 59%; reoperation-free survival, 78% vs 53%).

In the HS-OST group, there were no differences between the patients who converted to THA and those who did not with respect to age, sex, body mass index, preoperative

TABLE 2
Reoperation and Clinical Outcomes[a]

	HS Group (n = 17)			HS-OST Group (n = 23)			P
Composite failure	77%			35%			.009
Reoperation	No. (%)	Time, y		No. (%)	Time, y		
THA or reoperation	12 (71)			5 (22)			.003
THA conversion	10 (59)	7.1 ± 4.0		5 (22)	5.8 ± 2.5		.02
Non-THA reoperation	4 (24)	6.8 ± 4.3		0			
Clinical outcomes	Preop	Delta	Postop	Preop	Delta	Postop	P
mHHS							
All patients	59 ± 14	6 ± 14	65 ± 18	64 ± 8	18 ± 18	83 ± 17	.002
No THA conversion	67 ± 10	16 ± 9	83 ± 11	66 ± 7	24 ± 14	90 ± 11	
THA conversion	52 ± 12	5 ± 16	57 ± 13	60 ± 6	5 ± 9	65 ± 9	
P	.02	.13	<.001	.16	.002	<.001	

[a]Data are presented as mean ± SD unless otherwise noted. mHHS scores were available preoperatively for all patients in both groups. The 15-year postoperative mHHS scores were available for all patients in both groups who did not undergo reoperation and were imputed for those without scores before reoperation. HS, hip arthroscopy; HS-OST, hip arthroscopy with femoral head-neck osteoplasty; mHHS, modified Harris Hip Score; Postop, postoperatively; Preop, preoperatively; THA, total hip arthroplasty.

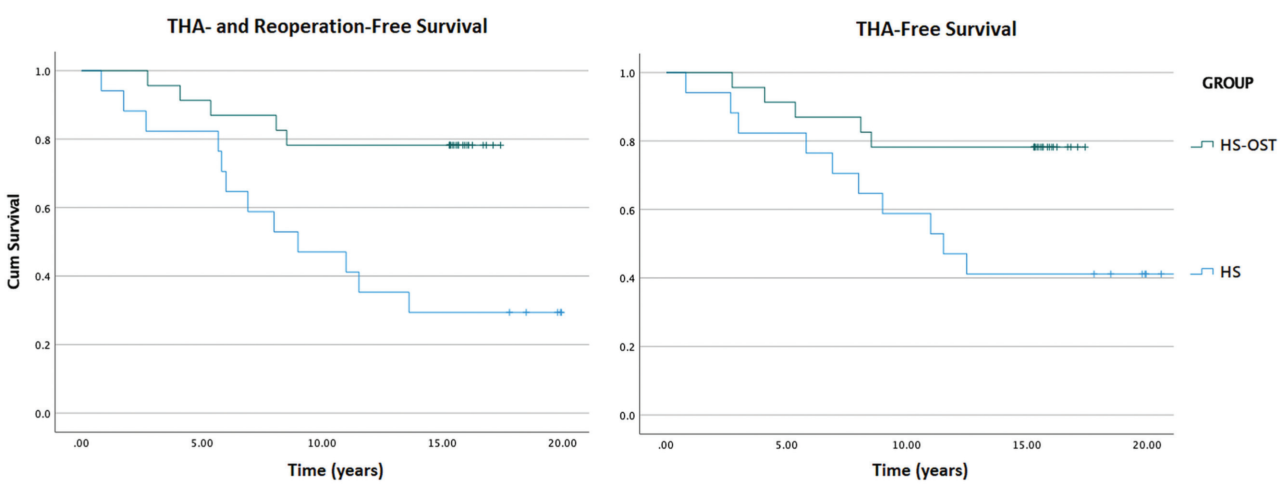

Figure 1. Survivorship. HS, hip arthroscopy; HS-OST, hip arthroscopy with femoral head-neck osteoplasty; THA, total hip arthroplasty.

mHHS, or pre- or postoperative alpha angle. The same was true for the HS group with the exception of preoperative mHHS, which was lower in those who converted (52.4 vs 68.9; P = .026). Although rates of THA conversion for hips with Tönnis grade 2 OA were similar between groups, fewer hips with Tönnis grade 0-1 OA in the HS-OST group converted (12%) than in the HS group (56%). Additionally, whereas hips in the HS-OST group with grade III-IV chondromalacia on the acetabulum or femur converted to THA at a rate of 25%, hips in the HS group with grade III-IV chondromalacia converted at a rate of 100% (Table 3).

DISCUSSION

FAI surgery is increasingly performed in patients with symptomatic labral or chondral pathology and underlying FAI morphology. This approach has demonstrated excellent clinical and functional outcomes at short- to midterm follow-up[17,24,25,31] as well as very high rates of return to play in the short term.[9] Although structural correction of cam-type FAI femoral head-neck deformity remains common practice across these surgical interventions, limited long-term data are available that support the ability of this procedure to optimize clinical outcomes and alter the natural history of cam-type FAI. In the current study, at a minimum of 15 years postoperatively, we demonstrated major differences in reoperation-free and THA conversion–free survivorship in hips treated with HS-OST compared with isolated HS. The long-term, direct-comparison results of the current study address this critical gap in the literature and strongly support the importance of structural correction of cam-type FAI to optimizing

TABLE 3
Patient Factors Associated With Conversion to THA by Group[a]

Variable	HS Group (n = 17)			HS-OST Group (n = 23)		
	THA Conversion (n = 10)	No THA Conversion (n = 7)	*P*	THA Conversion (n = 5)	No THA Conversion (n = 18)	*P*
Patient						
Age	40.4 ± 14	38.4 ± 17	.58	36.0 ± 9	32.8 ± 11	.56
Body mass index	26.2 ± 3	24.3 ± 5	.58	27.1 ± 4	26.3 ± 4	.76
Male	3 (37)	5 (63)	.09	3 (17)	15 (83)	.26
Female	7 (78)	2 (22)		2 (40)	3 (60)	
Preoperative mHHS	52.4 ± 12	68.9 ± 9	.03	60.3 ± 6	65.7 ± 7	.16
Radiographic						
Tönnis grade 0-1	9 (56)	7 (44)		2 (12)	15 (88)	
Tönnis grade 2	1 (100)	0 (0)	.86	3 (50)	3 (50)	.051
Tönnis grade 0	5 (45)	6 (55)		0 (0)	12 (100)	
Tönnis grade 1-2	5 (83)	1 (17)	.13	5 (48)	6 (52)	
Intraoperative						
Presence of grade III-IV chondromalacia on acetabulum or femur[b]	7 (100)	0 (0)		3 (25)	9 (75)	.69

[a]Data are presented as mean ± SD or n (%). Percentages are to be interpreted horizontally across table, rather than vertically. HS, hip arthroscopy; HS-OST, hip arthroscopy with femoral head-neck osteoplasty; mHHS, modified Harris Hip Score; THA, total hip arthroplasty.
[b]HS group: acetabulum (n = 6), femur (n = 5). HS-OST group: acetabulum (n = 12), femur (n = 3).

long-term outcomes. These data will facilitate surgeon and patient decision making and provide long-term data to guide expectations for clinical outcomes and hip joint survivorship.

In the absence of such data, intermittent observations of good short- to midterm outcomes without structural correction have encouraged some to call its role into question. Tjong et al[28] examined outcomes at minimum 2-year follow-up in 106 FAI hips treated with labral repair and isolated acetabuloplasty (without femoral osteoplasty). The investigators reported good to excellent outcomes with no revision surgeries at 3-year mean follow-up. They additionally found no correlation between alpha angle and any of their included postoperative outcome scores. However, a comparative group with adjunctive femoral osteoplasty was not included in the study.[28] Other studies have suggested that residual alpha angle abnormalities may play a role in the outcome of FAI surgery. Lansdown et al[15] examined 2-year outcomes in 707 cam-type FAI hips treated with labral repair and femoral osteoplasty and reported an approximately 0.5-point decrease in postoperative mHHS for every 1° increase in postoperative alpha angle on false-profile view, after controlling for joint space narrowing, symptom duration, and intraoperative cartilage grading. Such findings highlight the potential importance of residual cam deformity in influencing postoperative outcomes. However, long-term outcome data are extremely limited, and direct comparative studies at longer term intervals do not exist. In the current study, survivorship of the HS group and HS-OST group was similar at the 5-year postoperative timepoint but significantly different at the 10- and 15-year time points. This finding emphasizes the need for longer term investigations in the population with FAI where short-term outcomes may not demonstrate clinically important differences.

Although long-term outcomes have been reported for arthroscopic treatments of labral or chondral pathology without osteoplasty, these studies generally predated recognition of FAI and thus provided no confirmation of radiographic evidence of FAI, making direct comparisons with FAI osteoplasty cohorts difficult. Furthermore, long-term outcome data for arthroscopic FAI treatments (osteoplasty) remain extremely limited. A recent systematic review identified 13 articles reporting mid- to long-term outcomes of hip arthroscopy for labral or chondral pathology (mean follow-up range, 6-20 years).[14] Of these, only 1 article reported FAI treatment (osteoplasty) outcomes at ≥10-year mean follow-up. At 10-year mean follow-up in 154 patients, the authors reported median mHHS improvements ranging from 20 to 28 points across labral repair and debridement subgroups and a THA-free survivorship of 66% at 10 years.[16] In the current study at the 10-year time point, THA-free survivorship was 59% in the HS group and 78% in the HS-OST group.

To our knowledge, the current study represents the longest term direct-comparison report on the relative influence of femoral osteoplasty on clinical outcomes and hip survivorship. Collectively, our findings support structural correction as a key factor in optimizing long-term function of hips with symptomatic FAI. At 15-year-minimum follow-up, patients who underwent osteoplasty reported significantly greater improvement in hip function (mHHS, 18.4 vs 6.1 for HS-OST vs HS, respectively; P = .02) as well as final overall hip function (mHHS, 82.7 vs 64.7; P = .002). This contrasts with our previous report of outcomes at 2 years postoperatively, in which we found no group differences in mHHS.[19] However, the previous report did reveal significantly greater reoperation-free survivorship in the HS-OST group at latest (mean 2.1-year) follow-up (22%

greater [100% vs 78% for HS-OST vs HS, respectively; P = .02]). The current study found this survival differential to have increased considerably by the 10-year postoperative interval (25% survival difference at 10 years [78% vs 53%]; 49% survival difference at 15 years [78% vs 29%]). This divergence in clinical outcomes and survivorship beyond 10 postoperative years suggests that the effect of osteoplasty on the natural history of FAI may be most significant at intervals beyond which FAI surgical outcomes have largely been studied.

Although intervention groups in this study were not formally matched, characteristics previously reported to be key prognostic factors in arthroscopic FAI outcomes were similar between groups. There were, in fact, some trends toward more advanced disease in the HS-OST group (higher rates of Tönnis grade 2 OA and grade III-IV acetabular chondromalacia). In contrast, rates of grade III-IV femoral head chondromalacia were higher in the HS group. Overall, the 2 groups were relatively comparable in their baseline characteristics and demonstrated large differences in PRO scores and survivorship at a minimum 15-year follow-up. The lack of significant mHHS differences between groups at 2 years further helps isolate structural correction as the factor responsible for the observed long-term group differences. However, it remains possible that confounding differences exist between the groups despite not being detected in our analysis. A randomized controlled trial would certainly provide more definitive evidence. Simunovic et al[27] recently completed a randomized study comparing FAI surgery and sham surgery. Both the osteochondroplasty and sham groups with or without labral repair had significantly improved pain or function at 1 year, although the reoperation rate was significantly lower in the osteochondroplasty group by 2 years. Long-term follow-up of the current cohort in 15 to 20 years will provide definitive evidence of the role of osteoplasty. However, our historical adoption (distinct treatment change) of combined surgery halfway through the study period did allow for outcome comparisons in these unique patient cohorts without the confounding factor of each procedure being performed for distinct indications. Although this resulted in a difference in mean follow-up duration between groups, marked Kaplan-Meier survivorship differences were apparent between groups well before the final follow-up duration of both.

This study has several limitations. First, the current study focused only on the effect of cam-type FAI and its surgical correction. At the time of the surgical treatments, the definition of what deformity constituted a pincer-type FAI morphology was controversial and remains so, to some extent, today. The role of pincer-type FAI in the development of OA is also unclear across multiple studies. Second, all included surgeries reflect the early FAI treatment experience nearly 20 years ago and were performed before adoption of routine labral repair or capsular closure. The inclusion of more modern treatments might result in a larger or smaller difference than that observed in the current study. Third, it could be argued that the treating surgeon's arthroscopic proficiency improved between treatment periods for the 2 groups and that this may have contributed to group outcome differences. However, this would seem inconsistent with the finding of comparable PRO scores between groups at shorter term follow-up. Fourth, the patient populations during the study period and early FAI treatments were different from those currently treated with FAI surgery. As the role of early OA and advanced cartilage damage in suboptimal FAI surgical outcomes has become more clear, surgical candidates for modern FAI surgery are more carefully identified. This is reflected in the high rates of preoperative acetabular and femoral cartilage damage seen in both patient groups. Interestingly, the HS-OST group demonstrated extremely good outcomes (22% reoperation-free survival) at a 15-year minimum follow-up, despite the cohort's including 26% of patients with Tönnis grade 2 radiographic OA. Fifth, although the 2 treatment groups were found to be similar across the assessed patient, radiographic, and intraoperative factors, the statistical power of these comparisons was limited by the relatively small number of hips in each group. Overall, however, the groups were relatively comparable, and the large magnitude of differences in outcomes scores and survivorship was unlikely to have been due to any small baseline differences alone.

CONCLUSION

This study demonstrated superior long-term clinical outcomes and survivorship with combined arthroscopy and femoral osteoplasty compared with hip arthroscopy alone. These long-term data strongly support the practice of femoral osteoplasty in patients with cam FAI morphologies and suggest that this treatment alters the natural history of FAI at long-term follow-up.

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