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Research Article

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Arthroscopic surgery for global versus focal pincer femoroacetabular impingement: are the outcomes different?

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ABSTRACT

To determine outcomes from arthroscopic surgery for global pincer femoroacetabular impingement (FAI), a large multicenter prospective study investigating arthroscopic surgical outcomes was performed with minimum 2-year follow-up. Global (center-edge angle 40+ degrees) and Focal (center-edge angle 25–39 degrees) cohorts were based on pre-operative radiographs. Pre-operative and intra-operative findings, surgical procedures, post-operative nonarthritic hip score (NAHS) and satisfaction (5-point Likert scale), complications and conversion arthroplasties were compared. A nested case–control study was also performed. The Global cohort consisted of 15 patients (18 hips) of mean age 37.2 years. Pre-operative NAHS was 51.5 and 74.1 at 24+ months post-surgery. The change in NAHS was significant ($P = 0.01$). Mean satisfaction was 4.2. There was one total hip arthroplasty (THA) conversion (5.6%), no revision surgeries or complications. The Focal cohort consisted of 125 patients (129 hips) of mean age 39.8 years. Pre-operative NAHS was 54.8 and 77.8 at 24+ months post-surgery. The change in NAHS was significant ($P < 0.0001$). Mean satisfaction was 4.2. There were eight THA conversions (6.2%), three complications (2.3%) and two revision surgeries (1.5%). Cohort comparisons revealed no statistically significant difference in NAHS ($P = 0.30$), satisfaction ($P = 0.92$) or THA conversion rate ($P = 0.91$). The nested case–control study found mean post-operative change in NAHS was +22.2 and +20.4, respectively, at 24+ months ($P = 0.76$). Arthroscopic treatment of global pincer FAI is a safe and effective procedure. With outcomes comparable to those observed in the arthroscopic treatment of lesser focal deformities, arthroscopic surgery provides a less invasive option for the treatment of global pincer FAI.

INTRODUCTION

Femoroacetabular impingement (FAI) is recognized as a common affliction of the hip with motion-induced pathologic mechanical abutment often in young active patients with degenerative consequences. The cam subtype has a morphologic anomaly of the proximal femur [1], and the pincer subtype has varying amounts of acetabular overcoverage [2] with patients often having both components [3, 4]. Pincer FAI occurs in two forms: focal and global. Focal acetabular overcoverage may occur anterior or posterior, but the former is more common and characterized by a crossover sign where the anterior wall projects beyond the posterior wall in the cephalad region of the acetabulum [5]. (Fig. 1) Global pincer deformity may occur with coxa profunda (Fig. 2) or the relatively rare protrusio acetabuli, both conditions exhibiting deep sockets with general acetabular overcoverage. Coxa profunda has been radiographically defined by extension of the acetabular floor to or crossing the ilioischial line on anterior-posterior (AP) pelvis projection. Protrusio acetabuli occurs when the femoral head overlaps the ilioischial line medially [5]. Although focal pincer FAI is often treated with arthroscopic surgery, the more severe global pincer deformities are typically treated with open surgical dislocation [6–10]

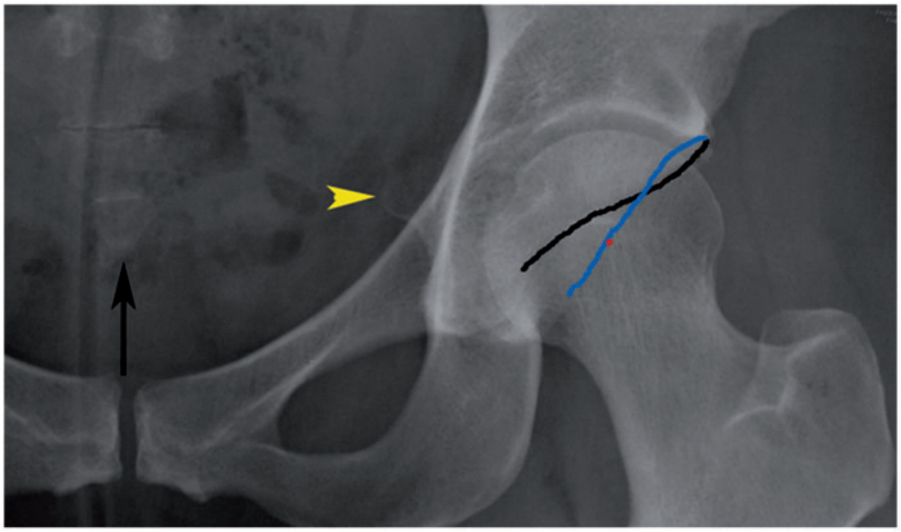

Fig. 1. Detail of an AP pelvis radiograph with representative findings of focal pincer subtype with cephalad crossover sign, CEA of 33 degrees and ischial spine sign (yellow arrow). Note the posterior wall (blue line) passing through center of femoral head (red dot) and the anterior wall (black line) lateral to the posterior wall proximal to the crossover point. The black arrow shows alignment of coccyx with pubic symphysis. Note that although floor of acetabular fossa meets ilioischial line which some would consider coxa profunda, this study classifies this hip as focal acetabular overcoverage.

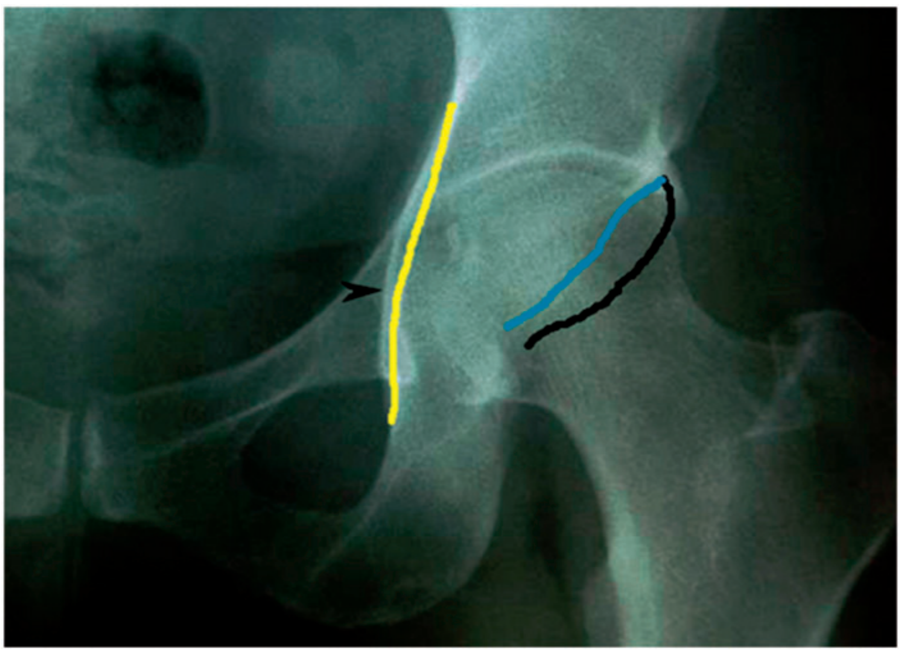

Fig. 2. Representative radiographic findings of global pincer subtype. Note the margins of the anterior (blue line) and posterior (black line) walls with the anterior rim passing through and the posterior rim lateral to the center of the femoral head without a crossover sign. The acetabular fossa floor is medial to the ilioischial (yellow) line consistent with true coxa profunda with a CEA of 43 degrees.

because of challenges with traction and access to the central compartment and posterior acetabular rim.

Despite a case report [10] and small case series [11] on the arthroscopic treatment of acetabuli protrusio and several case series investigating outcomes from open surgical dislocation surgery which include some patients with coxa profunda and/or protrusio acetabuli [6, 11, 12], review of the English-speaking orthopedic literature revealed no study comparing outcomes of the global versus focal pincer subtypes regardless of open or arthroscopic approach. Arthroscopic surgery has been shown to be at least as effective as open and mini-open methods with less major complications [13, 14] and is the focus of this study. The purpose of this study is to compare clinical efficacy and safety of arthroscopic treatment of global versus focal pincer FAI. We hypothesize that the global cohort, having more extensive acetabular overcoverage, will have poorer outcomes and more complications than the focal cohort.

MATERIALS AND METHODS

An internal review board (IRB)-approved prospective multicenter outcome study (one designated surgeon at each of three medical centers) using patient-reported outcome measures (PROMs) with minimum 2-year follow-up was performed on symptomatic patients that underwent arthroscopic surgery for FAI between March 2009 and June 2010. Review of pre-operative radiographs permitted patient assignment into either Global or Focal pincer cohorts. The providers were blinded to all PROMs and outcomes during this process. Retrospective review of the prospectively collected data was then performed, enabling a comparative outcome study of global versus focal pincer FAI. Radiographic inclusion criteria for the focal cohort were a center-edge angle (CEA) of Wiberg of 25–39 degrees with crossover sign; radiographic inclusion criteria for the global cohort were a CEA of 40+ degrees with the floor of the acetabular fossa medial to ilioischial line with or without crossover sign. Exclusion criteria included prior ipsilateral hip surgery, dysplasia (CEA < 25 degrees), acetabuli protrusio, Legg–Perthes disease, osteonecrosis, significant radiographic osteoarthritis (Tonnis 3), posterior wall sign indicative of posterior undercoverage or retroversion and inability to understand English. Pre-operative clinical and radiographic findings, intra-operative findings and surgical procedures, post-operative nonarthritic hip score (NAHS) at 3-, 12- and 24-post-operative months and satisfaction using a 5-point Likert scale (1 = very dissatisfied to 5 = very satisfied) were obtained via investigator-blinded methodology with all PROM forms mailed by the patients to an off-site research and evaluation department. Complications, revision surgeries and conversion hip arthroplasties were compared between groups.

Statistical analysis

Statistical analysis was performed in two parts with strict retention of all PROMs including scores from surgical failures (i.e. hip arthroplasty conversions). Multivariate linear regression analysis of patient demographics (age, gender and body mass index (BMI)), pre-operative factors (duration of pain before surgery), Tonnis grade, intra-operative findings (labral tear, Outerbridge chondral grade) and surgical procedures (labral debridement, repair, refixation, reconstruction, acetabuloplasty, femoroplasty) was performed. A nested case–control study with 1:1 ratio of controls (Focal) to Global patients was then performed with cohorts matched on age, gender, pre-operative NAHS, both acetabular and femoral osteoplasty and Tonnis grade. The latter eliminated any confounding effect from the very few Tonnis 2 Focal cohort patients. The purpose of the double design was to confirm the regression-based effect was still present and similar when the cases and controls were more closely matched. A regression comparison with indicator variable for group membership (Global versus Focal) and a predictive regression equation based on data from the Focal cohort were performed. Statistical significance was set at $P < 0.05$ utilizing SAS 9.2 (Cary, NC).

Post hoc power analysis was performed with significance set at power ≥ 0.80 and $P < 0.05$.

Surgical procedure

Supine hip arthroscopy under general anesthesia was performed via the anterolateral viewing portal and the modified midanterior working portal (mMAP) [15]. Typically more traction force was required in the global cohort to adequately distract the operative hip 1 cm for central compartment work. Both groups underwent initial diagnostic surveillance with a 70-degree arthroscope followed in sequence by acetabuloplasty and chondrolabral surgery (Table I), arthroscopic femoroplasty for cam decompression and dynamic arthroscopic testing with desired range of motion endpoints of 120 degrees flexion and 30 degrees minimal internal rotation on intra-operative anterior impingement testing. Both cohorts typically underwent acetabuloplasty of the superolateral and anterior rim, but the global cohort, having more extensive acetabular overcoverage, had more extensive rim trimming typically reducing the LCEA to approximately 35 degrees using intra-operative fluoroscopic templating, whereas the focal cohort typically had eradication of radiographic crossover sign and post-operative CEA of 25–30 degrees [16]. Moreover, posterior rim reduction was performed using a 5.5-mm burr via the mMAP, again using fluoroscopic templating so as to recontour the posterior rim (Figs. 3 and 4) so as to pass through the center of the femoral head on AP imaging recreating a neutral posterior wall sign. Labral refixation of the posterior rim (Fig. 5) was done via the mMAP, and on occasion, a curved guide was used with its concavity directed anterior so as to place small diameter suture-based suture anchors (Juggerknot, Biomet, Warsaw, IN) into this region avoiding posterior wall 'blow-out'. Further details of our

Table I. Demographics, intra-operative findings and procedures

	Focal (n = 127[a])	*Global* (n = 18)	P
Age	39.8 (13.5)	37.2 (11.3)	0.47
BMI	26.9 (5.0)	28.2 (5.6)	0.43
Females	67 (52%)	6 (33%)	0.14
Osteoarthritis	33 (26%)	3 (17%)	0.41
Tonnis 1	27 (21%)	3 (17%)	0.56
Tonnis 2	6 (5%)	0 (0.0%)	
Outerbridge class 0	4 (3%)	0 (0.0%)	0.52
1	28 (22%)	3 (18%)	
2	17 (14%)	1 (6%)	
3	54 (43%)	11 (65%)	
4	22 (18%)	2 (12%)	
Rim Trim	126 (99%)	18 (100.0%)	0.71
Labral debride	37 (30%)	8 (44%)	0.27
Labral refix	83 (65%)	8 (44%)	0.12
Labral recon	5 (4%)	2 (11%)	0.19
Femoroplasty	117 (92%)	17 (94%)	0.73

Age and BMI represented as mean and standard deviation. Debride, debridement; refix, refixation; recon, reconstruction.

[a]For males, tonnis and osteoarthritis: focal ($n = 129$) and all ($n = 147$); for Outer bridge class: focal ($n = 125$) and all ($n = 142$).

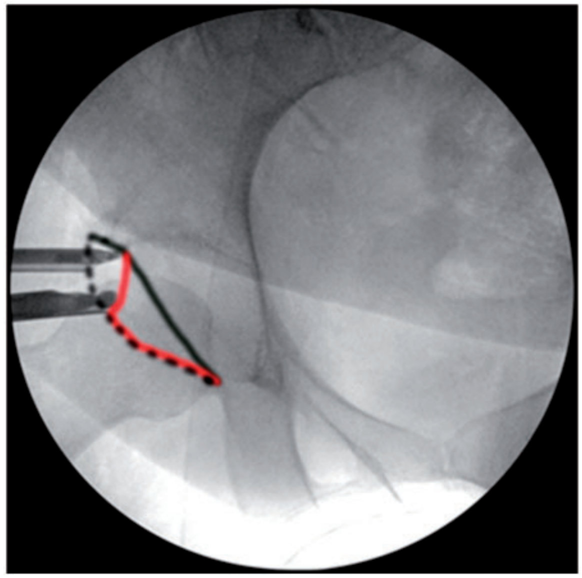

Fig. 3. An intra-operative fluoroscopic image of right hip during posterior acetabular rim trimming using the fluoroscopic templating technique.

surgical technique for arthroscopic surgery of global pincer deformities have recently been described [17].

Postoperative rehabilitation protocols were identical for both cohorts, with 2 weeks protected ambulation and early initiation of low-resistance exercise cycling. Swimming (freestyle) and running in a pool began as early as 2 weeks. Elliptical trainers were permitted at 6 weeks, and running was permitted as early as 3 post-operative months.

RESULTS

The Global cohort consisted of 15 patients (18 hips, 66.7% male) of mean age 37.2 (18.1–55.2) years. Mean NAHS was 51.5 (19–94) before surgery and 64.2, 66.0 and 74.1 at 3, 12 and 24+ months post-surgery of which the change in final NAHS (pre-operative to 24+ months) was significant ($P = 0.01$). Mean satisfaction on a Likert scale was 4.2 at 24+ months. There was one THA conversion (5.5%), no revision FAI surgeries or complications.

The Focal cohort consisted of 125 patients (129 hips, 48.5% male) of mean age 39.8 (13.0–73.6) years. Mean NAHS was 54.8 (9–93) before surgery and 68.2, 76.4 and 77.8 at 3, 12 and 24+ months post-surgery of which the change in final NAHS (pre-operative to 24+ months) was significant ($P < 0.0001$). Mean satisfaction on a Likert scale was 4.2 at 24 months. There were 8 THA conversions (6.2%), 3 complications (2.3% including 2 mild heterotopic ossification (Brooker grade 2) and 1 transient pudendal neuropraxia) and 2 revision FAI surgeries (1.5%).

Comparison between cohorts revealed no statistically significant difference in 3, 12 or 24+ month NAHS (Fig. 6). Comparison between cohorts revealed no statistically significant difference in 3, 12 or 24+ month satisfaction. Comparison between cohorts revealed no statistically significant difference in THA conversion rate. There were no statistically significant differences in the demographic variables (e.g. age, gender and BMI), findings (e.g. Outerbridge chondral grade and Tonnis grade) or rendered surgical procedures (i.e. acetabuloplasty/rim trimming, femoroplasty and labral procedure—refixation, debridement or reconstruction). Moreover, of the variables we investigated (i.e. age, gender, BMI, Outerbridge cartilage grade, Tonnis grade and time to surgery from pain onset), no variable was a statistically significant predictor of poorer outcomes in the change from pre-operative to 24 months model. The study findings are summarized in Tables I and II.

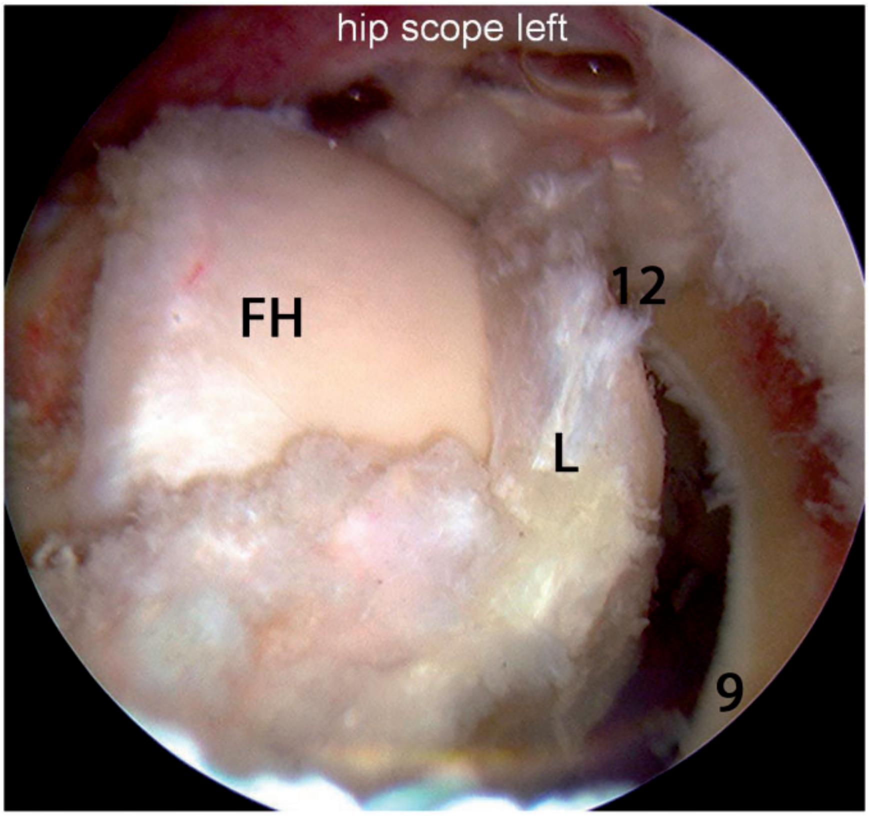

Fig. 4. Supine arthroscopic view from the anterolateral portal of a right hip after global acetabuloplasty and demonstrating posterior rim resection. Numbers correspond to generic clockface location with 12 being direct superior and 9 being direct posterior. FH, femoral head; L, labrum after labral takedown.

For the nested case–control study, the mean pre-operative NAHS was 51.5 for the global cohort and 55.1 for the focal cohort ($P = 0.45$). The mean post-operative change in NAHS was +8.0 and +12.6, respectively, at 3 months ($P = 0.51$), +13.1 and +20.5, respectively, at 12 months ($P = 0.22$) and +22.2 and +20.4, respectively, at 24+ months ($P = 0.76$). There were no statistically significant differences between the global and focal cohorts in pre-operative and post-operative NAHS. There was a trend toward more early improvement in the focal cohort, which disappeared at 24+ post-operative months.

This study was sufficiently powered with power = 0.87 and $P < 0.05$.

DISCUSSION

The main significance of this study is the relatively comparable and successful outcomes following arthroscopic surgery of global and focal pincer FAI. Our hypothesis was not supported by our findings. Multivariate analysis and nested case–control analysis demonstrated no significant differences in arthroscopic surgical outcome for global versus focal pincer FAI. Both groups had significant improvement in pain and function with moderately high satisfaction. Moreover, arthroscopic treatment of global pincer FAI is safe; complications were seen only in the focal cohort and these were relatively small in prevalence (2.3%) and severity. Surgical failures (via default definition of conversion to hip arthroplasty) were comparable in both cohorts.

The post-operative improvement or increase in NAHS was similar and significant in both cohorts; however, the mean pre-operative and mean post-operative scores were somewhat low. The former (in the 50s) indicates cohorts with relatively severe symptoms and functional deficits; the findings from our study do not support severe symptomology as a relative surgical contraindication. The latter may be attributable to the lower starting scores and the retention of surgical failures (e.g. hip arthroplasty conversions) in statistical analysis.

Lacking current consensus on the radiographic definitions of global and focal pincer morphology, we submit that our definitions of focal (i.e. CEA from 25 to 39 degrees with the presence of a crossover sign) and global pincer FAI (i.e. CEA 40+ degrees and acetabular fossa

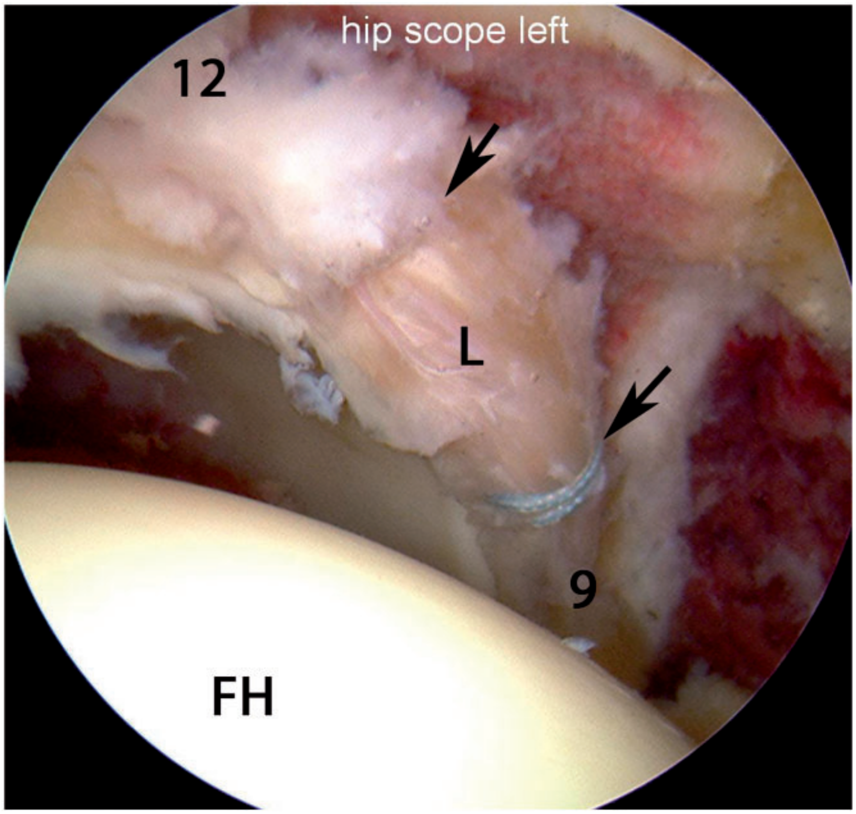

Fig. 5. Supine arthroscopic view from anterolateral portal with 70-degree arthroscope aimed inferiorly after global acetabuloplasty, femoroplasty and labral refixation. Arrows show suture refixation sites along posterior acetabular rim. FH, femoral head; L, labrum; 12, direct superior rim; 9, direct posterior rim.

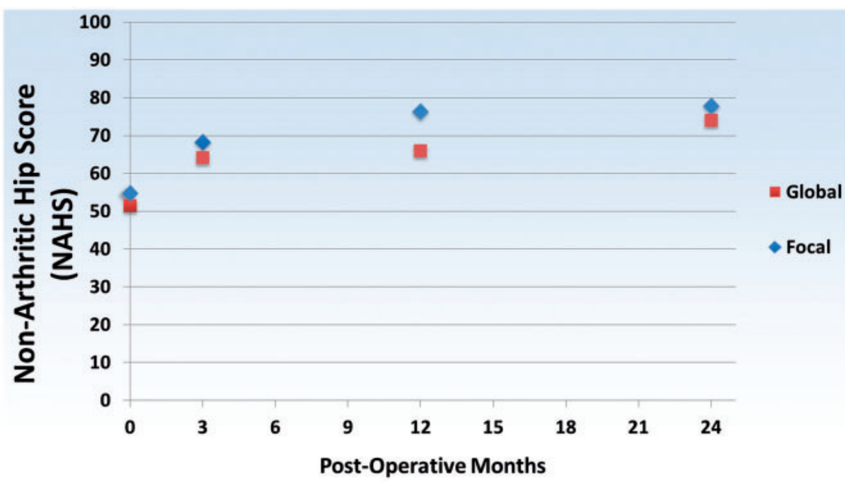

Fig. 6. Comparison of pre-operative and 3-, 12- and 24+-month post-operative NAHS for global versus focal cohorts.

floor medial to ilioischial line) are arbitrary but reasonable. The crossover sign is commonly used as an indicator of focal anterosuperior overcoverage or acetabular retroversion (when seen with a posterior wall sign); however, this radiographic marker may be seen in dysplasia (where it may be physiologic) [18] and in global pincer deformities with some degree of acetabular retroversion [5]. Furthermore, there is controversy as to whether a cephalad crossover

Table II. Outcomes

	Focal[a]	*Global*[a]	P
Pre-NAHS	55.5 (17.1)	51.5 (22.7)	0.46
3-month NAHS	67.9 (18.8)	64.2 (19.0)	0.43
12-month NAHS	76.3 (17.7)	66.0 (26.4)	0.22
24-month NAHS	77.3 (18.5)	74.1 (16.6)	0.30
24-month change in NAHS	21.5 (18.8)	22.2 (26.9)	0.95
24-month satisfaction	4.2 (1.3)	4.2 (1.2)	0.92

[a]Values are presented as mean (standard deviation).

sign with an acetabular retroversion index (the ratio of the cephalad crossover distance to the entire height of the acetabulum) <0.20 should be considered pathologic [19]. Coxa profunda, classically described as a form of global pincer deformity with a CEA of at least 35 degrees [20], may exist with much smaller CEAs and its presence has recently been questioned as obligatory evidence of global pincer FAI [21–23]. Furthermore, disagreement exists as to whether true global deformities require one or both walls to extend lateral to the femoral head center on AP pelvic radiograph. Recent radiographic measures of anterior overcoverage such as the anterior margin ratio [24] have been introduced, emphasizing the importance of anterior acetabular overcoverage even when superolateral overcoverage (measured by the lateral CEA [25]) is minimal; however, there is currently no quantitative definition of excess overcoverage in this region. The crossover sign may be caused by an aberrant anterior inferior iliac spine leading one to overestimate anterosuperior acetabular overcoverage [26]; however, this effect was minimized in our study using the fluoroscopic templating technique [16] (Fig. 4); fluoroscopic images of a metallic burr on the superolateral and anterior rim outline the true extent of anterosuperior overcoverage. Further radiographic refinement [27] and consensus regarding the definitions of focal and global pincer subtypes are needed.

At the other extreme, we used a CEA of 25 degrees as our inclusionary threshold for the focal cohort when a co-existing crossover sign suggested focal anterior overcoverage. Dysplastic acetabulae were excluded as dysplasia appears to respond less favorably to arthroscopic treatment and rim trimming is not recommended [28–31]. Although mild dysplasia is defined by a CEA < 20 degrees [32], we chose 25 degrees as the lowest amount of starting CEA prior to acetabular rim trimming as a buffer to minimize inclusion of post-operative dysplasia, which could negatively alter the outcomes of the focal cohort and compromise comparison with the global cohort. No patient was reduced below a CEA of 20 degrees post-operatively—considered the lowest recommended limit for superolateral rim reduction [7].

The global cohort consisted of patients with coxa profunda with maximal CEA of 59 degrees. We excluded protrusio acetabuli, the most severe form of global pincer FAI, because it may act via a different pathomechanism than the much more prevalent coxa profunda [33]; we cannot comment on the findings of this study as being generalizable to this relatively rare condition. A case report [10] and small case series [34] have recently reported successful short-term outcomes via arthroscopic treatment of protrusio. Since the conclusion of enrollment for this study, we have performed arthroscopic surgery for coxa profunda with CEA as high as 62 degrees and protrusio acetabuli with CEA as high as 70 degrees. However, we agree with Matsuda [10] that arthroscopic treatment of more extreme global acetabular overcoverage presents technical challenges best performed by experienced surgeons.

An inherent challenge in surgical outcome studies on FAI is the heterogeneity of associated subtypes, intra-operative findings and rendered procedures. Realizing that a majority of patients have combined FAI [3], we opted to include this important category rather than investigate only the minority that had pure pincer FAI. Although controlling for these potentially confounding variables may be difficult, there were no statistically significant difference between both groups in regards to demographic data, radiographic findings, chondrolabral and osteoplastic procedures (Table I) and pre-operative NAHS (Table II). The nested case–control study gives further evidence of statistically similar and significant improvements following arthroscopic surgery. Furthermore, similar amounts of femoroplasty and similar range of motion endpoints were used in both cohorts.

Although the chondrolabral and femoroplastic procedures were similar in both cohorts, the amount of acetabuloplasty was more extensive commensurate with the greater amount and global location of overcoverage. Safran and Epstein [34] recently reported a case series of patients with acetabuli protrusio successfully treated with arthroscopic acetabuloplasty limited to the superior and anterior rims. Whether the outcomes are generalizable without posterior acetabular treatment is unknown, meriting further investigation. A posterolateral portal was not added; however, we acknowledge that this is a reasonable option, particularly for posterior rim procedures. Also although one might assume greater chondrolabral pathology in patients with more severe global deformity, this study did not show a significant difference in maximal Outerbridge chondral grade or incidence of labral reconstructions between cohorts. Moreover, conversion arthroplasties in both cohorts occurred relatively early (within 2 years post-operative) and remained stable up to the maximal 5 years of study follow-up.

Regarding complications, one may argue that clinically insignificant heterotopic ossification (observed only in the focal cohort) is not a complication. We chose to report it as a complication, albeit a minor one. Perhaps more importantly, one might have expected at least some complications in the global cohort, especially in light of longer relative traction times and greater osteoplastic resection of the acetabulum (both in perimeter and in resection width). Moreover, posterior procedures closer to the sciatic nerve have the potential to cause direct or indirect injury, the latter via swelling and/or post-operative fibrosis.

Previous systematic reviews have demonstrated arthroscopic surgery for FAI to be at least as effective and with fewer complications compared with either open surgical dislocation or mini-open surgery [13, 14]. Open surgical dislocation is a powerful method but requires more soft tissue dissection and blood loss than the arthroscopic option and the trochanteric osteotomy may be problematic [2, 35]. Extending the arthroscopic method to the treatment of global pincer deformities provides similar benefits of outpatient surgery with less blood loss, fewer complications, improved cosmesis and quicker rehabilitation [13, 14].

Arthroscopic surgery for global deformities may be safely performed using arthroscopic techniques with successful outcomes comparable to those with lesser focal deformities. The historical need for open surgical dislocation for the surgical treatment of global deformities may be respectfully challenged with many patients with global pincer deformities benefiting from the less invasive nature of the arthroscopic method.

LIMITATIONS

Although not a formal hypothesis-driven prospective study, the data were prospectively obtained. The possible significance of the pincer FAI subtypes affecting surgical outcomes became recognized after the completion of the prospective study from which all PROMs were obtained. However, because the providers were unaware of this measure as a study variable during the prospective study and were blinded to all PROMs, there may be an inherent strength to the methodology with minimization of investigator bias. The use of pre-operative computed tomography with three-dimensional imaging may have permitted more accurate assessment of acetabular morphology and proximal femoral version. Another study weakness is the absence of routine post-operative radiographs to quantify the amounts of acetabular and femoral osteoplastic resection; however, dynamic arthroscopic examinations with similar range of motion endpoints plus fluoroscopic templating were used regardless of pincer subtype suggesting some degree of consistency in post-operative pincer and/or cam decompression. This study was not designed to compare outcomes from arthroscopic versus open surgery (open surgical dislocation) of global pincer FAI.

CONCLUSION

Arthroscopic treatment of global pincer FAI is a safe and effective procedure. With outcomes comparable to those observed in the arthroscopic treatment of lesser focal deformities, arthroscopic surgery provides a less invasive option for the treatment of global pincer FAI.

CONFLICT OF INTEREST STATEMENT

None declared.

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