Femoroacetabular Impingement: Have We Hit a Global Tipping Point in Diagnosis and Treatment? Results From the InterNational Femoroacetabular Impingement Optimal Care Update Survey (IN FOCUS)

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Purpose: This international survey was conducted to assess the perceptions of orthopaedic surgeons regarding the diagnosis and management of femoroacetabular impingement (FAI) as well as to explore the current demographic characteristics of surgeons performing FAI surgery. **Methods:** A survey was developed using previous literature, focus groups, and a sample-to-redundancy strategy. The survey contained 46 questions and was e-mailed to national orthopaedic associations and orthopaedic sports medicine societies for member responses. Members were contacted on multiple occasions to increase the response rate. **Results:** Nine hundred orthopaedic surgeons from 20 national and international organizations completed the survey. Surgeons responded across six continents, 58.2% from developed nations, with 35.4% having sports fellowship training. North American and European surgeons reported significantly greater exposure to hip arthroscopy during residency and fellowship training in comparison to international respondents (48.0% and 44.5% respectively, *v* 25.6%; $P < .001$). Surgeons performing a higher volume of FAI surgery (> 100 cases per year) were significantly more likely to have practiced for more than 20 years (odds ratio [OR], 1.91; 95% confidence interval [CI], 1.01 to 3.63), to be practicing at an academic hospital (OR, 2.25; 95% CI, 1.22 to 4.15), and to have formal arthroscopy training (OR, 46.17; 95% CI, 20.28 to 105.15). High-volume surgeons were over two-fold more likely to practice in North America and Europe (OR, 2.26; 95% CI, 1.08 to 4.72). **Conclusions:** The exponential rise in the diagnosis and surgical management of FAI appears to be driven largely by experienced surgeons in developed nations. Significant variability exists regarding the diagnosis and management of FAI. Our analysis suggests that although FAI management is early in the innovation cycle, we are at a tipping point toward wider uptake and use.

Femoroacetabular impingement (FAI) is increasingly being recognized as a cause of hip pain and a possible cause of early osteoarthritis in the young adult.[1] FAI is caused by the abnormal shape of the femoral head and neck (cam type) or the acetabulum (pincer type) (or both), resulting in damage to the acetabular labrum and articular cartilage.[1]

Hip arthroscopy has emerged as a minimally invasive approach to correct this condition and is now one of the fastest growing fields in orthopaedic surgery.

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The number of hip arthroscopy procedures performed in the United States by American Board of Orthopaedic Surgery candidates increased 18-fold from 1999 to 2009.[2]

A recent systematic review on sources and quality of literature available for hip arthroscopy indicated that despite a five-fold increase in publications related to hip arthroscopic procedures from 2005 to 2010, Level IV and Level V studies accounted for more than half of the available literature, with no randomized controlled studies identified.[3] There is documented inconsistency regarding radiographic and clinical indications for arthroscopic and open management of FAI.[4] In addition, there are limited data on the natural history of FAI and no long-term studies on the effect of surgical treatment.[5]

Given the inconsistency of data available regarding the incidence, prevalence, and global treatment regimens of FAI, we sought to identify current perceptions of orthopaedic surgeons on FAI as well as explore the demographic characteristics of surgeons managing this condition. We hypothesized that significant radiographic and clinical variability in the diagnosis and assessment of FAI, as well as variability in indications for management methods, would exist. We also hypothesized that there would be an increased prevalence and incidence of FAI procedures in more developed nations and that a lack of awareness would be present among surgeons regarding quality of available evidence informing practice.

Methods

Questionnaire Development

A focus group was developed, consisting of fellowship-trained orthopaedic surgeons who manage hip pain in the young adult (United States and Canada) and a statistician to determine key areas of interest to be evaluated through the survey. Previous orthopaedic surveys were reviewed to ensure that item generation was comprehensive and appropriate.[6] Questions were tailored to examine respondent's demographic characteristics, surgical indications, and management preferences, as well as perceptions of the current available evidence for FAI surgery. We used the "sample-to-redundancy" approach, by which we surveyed new surgeons until no new items for the questionnaire emerged.[7]

The survey was pretested to ensure face and content validity with an independent group of four orthopaedic surgeons specializing in managing hip pathology. The final questionnaire consisted of 46 questions using both Likert and nominal scales as well as limited commentary and open responses in certain sections of the survey.

Questionnaire Administration

Two reviewers independently conducted comprehensive Internet searches using various combinations of keywords including "sports," "hip," "orthopaedic," "organization," and "association" along with country names to identify potential national and international orthopaedic sports medicine organizations eligible for participation in the survey. Organizations were eligible for inclusion in the survey if (1) they were national or international orthopaedic associations or sports medicine organizations and (2) membership consisted primarily of orthopaedic surgeons. Nonsurgical sports medicine organizations were excluded from this survey. A list of eligible organizations was combined from each reviewer, and contact information was sought for each eligible organization.

Individualized e-mail invitations were dispatched to each organization inviting all member orthopaedic surgeons to participate in the survey. After acceptance by the organization to participate, a unique electronic link was sent to each organization along with a standardized invitation and description of the survey for distribution to its membership. The survey was administered electronically through SurveyMonkey from January 1 through November 5, 2014. Restrictions were in place to ensure that we received only one response per computer and single responses per individual. Only individuals who surgically manage hip pathology were eligible to fill out the survey. All involved organizations agreed to dispatch two reminder e-mails to their memberships to maximize the response rate following the initial e-mail, each spaced 2 weeks apart.

Statistical Analysis

Statistical analysis was performed in consultation with a statistician (K.M.). Summary statistics were calculated as dichotomous or categorical variables and presented as percentages. We conducted a multinomial logistic regression analysis of demographic characteristics of surgeons performing no FAI surgery, a low volume of FAI surgery (1 to 100 cases per year), and a high volume of FAI surgery (> 100 cases per year) (Appendix Table 1, available at www.arthroscopyjournal.org). This study received ethics approval from the McMaster University/Hamilton Health Sciences Research Ethics Board (REB No. 13-404).

Results

One hundred seven orthopaedic organizations were eligible for inclusion in the survey, and contact information was available for 81 organizations (Appendix Table 2, available at www.arthroscopyjournal.org). Twenty organizations agreed to participate in the survey.

Demographic Characteristics

Nine hundred orthopaedic surgeons from 20 national and international organizations participated (Appendix Table 3, available at www.arthroscopyjournal.org). Most respondents were from Europe (40.7%), South America (29.3%), and North America (14.0%). Most of the North American respondents were in private practice (66.7%), followed by a university-affiliated position (31.7%). Internationally, non–North American responding surgeons had similar practice patterns (53.9% in private practice and 38.9% in a university-affiliated role). North American sports fellowship–trained surgeons were generally in practice for fewer years, with 32.6% in practice for less than 5 years and 7.0% in practice for greater than 25 years. The overwhelming majority of respondents (96.8%) regularly treated patients with hip pathology (Table 1).

Training in Hip Arthroscopy

Most international respondents completed fellowship training in arthroplasty (53.1%), followed by sports medicine (35.6%). North American respondents' fellowship training results were similar (47.6% in arthroplasty and 34.1% in sports medicine). Most graduating North American surgeons (74.4%) gained hip arthroscopy experience during residency.

Dedicated or formal training in hip arthroscopy was received by 36.4% of international and 48.0% of North

Table 1. Demographic Characteristics

	North America	South America	Europe	Asia	Africa	Australia
Years in practice	126 respondents	263 respondents	366 respondents	88 respondents	24 respondents	31 respondents
<5	13 (10.3%)	3 (1.1%)	18 (4.9%)	2 (2.3%)	3 (12.5%)	4 (12.9%)
5	25 (19.8%)	44 (16.7%)	47 (12.8%)	14 (15.9%)	4 (16.7%)	8 (25.8%)
5-10	14 (11.1%)	41 (15.6%)	65 (17.8%)	9 (10.2%)	3 (12.5%)	4 (12.9%)
11-20	17 (13.5%)	73 (27.8%)	112 (30.6%)	33 (37.5%)	6 (25.0%)	5 (16.1%)
21-25	10 (7.9%)	40 (15.2%)	50 (13.7%)	16 (18.2%)	4 (16.7%)	5 (16.1%)
>25	47 (37.3%)	62 (23.6%)	74 (20.2%)	14 (15.9%)	4 (16.7%)	5 (16.1%)
Practice type	126 respondents	263 respondents	366 respondents	88 respondents	24 respondents	31 respondents
Academic	40 (31.8%)	63 (24.0%)	177 (48.4%)	39 (44.3%)	10 (41.7%)	11 (35.5%)
Private	84 (66.7%)	179 (68.1%)	167 (45.6%)	43 (48.8%)	12 (50.0%)	15 (48.4%)
Other	2 (1.6%)	21 (8.0%)	22 (6.0%)	6 (6.8%)	2 (8.3%)	5 (16.1%)
Subspecialty training	126 respondents	263 respondents	366 respondents	88 respondents	24 respondents	31 respondents
Arthroplasty	60 (47.6%)	95 (36.1%)	239 (65.3%)	42 (47.7%)	12 (50.0%)	22 (71.0%)
Sports	43 (34.1%)	86 (32.7%)	140 (38.3%)	23 (26.1%)	10 (41.7%)	16 (51.6%)
None	20 (15.9%)	15 (5.7%)	18 (4.9%)	9 (10.2%)	3 (12.5%)	3 (9.7%)
Trauma	13 (10.3%)	93 (35.4%)	115 (31.4%)	36 (40.9%)	9 (37.5%)	7 (22.6%)
Pediatrics	5 (4.0%)	18 (6.8%)	17 (4.6%)	10 (11.4%)	2 (8.33%)	2 (6.5%)
Formal training in hip arthroscopy	123 respondents	253 respondents	356 respondents	85 respondents	22 respondents	30 respondents
Yes	59 (48.0%)	69 (27.8%)	159 (44.5%)	13 (15.3%)	5 (22.7%)	13 (43.3%)
No	64 (52.0%)	184 (72.7%)	197 (55.5%)	72 (84.7%)	17 (77.3%)	17 (56.7%)
Type of formal training	59 respondents	69 respondents	158 respondents	12 respondents	5 respondents	13 respondents
Fellowship	35 (59.3%)	9 (13.0%)	43 (27.2%)	3 (25.0%)	2 (40.0%)	10 (76.9%)
Residency	23 (39.0%)	16 (23.2%)	43 (27.2%)	1 (8.3%)	1 (20.0%)	3 (23.1%)
Courses	40 (67.8%)	58 (84.1%)	126 (79.8%)	8 (66.7%)	3 (60.0%)	8 (61.5%)
Mentor visits	24 (40.7%)	27 (39.1%)	90 (57.0%)	3 (25.0%)	2 (40.0%)	4 (30.8%)
Annual FAI diagnosis	122 respondents	250 respondents	354 respondents	84 respondents	22 respondents	30 respondents
None	12 (9.8%)	15 (6.0%)	34 (9.6%)	17 (20.2%)	8 (36.4%)	3 (10.0%)
1-30	72 (59.0%)	191 (76.4%)	241 (68.1%)	60 (71.4%)	12 (54.6%)	18 (60.0%)
31-50	22 (18.0%)	24 (9.6%)	35 (9.9%)	4 (4.8%)	1 (4.6%)	4 (13.3%)
>50	16 (13.1%)	20 (8.0%)	44 (12.4%)	3 (3.6%)	1 (4.6%)	5 (16.7%)
Perform arthroscopic FAI surgery	122 respondents	249 respondents	354 respondents	84 respondents	22 respondents	30 respondents
Yes	54 (44.2%)	56 (22.5%)	142 (40.0%)	16 (19.1%)	3 (13.6%)	16 (53.3%)
No	68 (55.7%)	193 (77.5%)	212 (60.0%)	68 (81.0%)	19 (86.4%)	14 (46.7%)
Perform open FAI surgery	115 respondents	247 respondents	330 respondents	84 respondents	22 respondents	26 respondents
Yes	29 (25.2%)	68 (27.5%)	112 (33.9%)	28 (33.3%)	8 (36.3%)	12 (46.2%)
No	86 (74.8%)	179 (72.5%)	218 (66.0%)	56 (66.7%)	14 (63.6%)	14 (53.9%)

FAI, femoroacetabular impingement.

American respondents. A significant number of surgeons considered formal training as mentor visits (47.5%) or participation in hip arthroscopy courses (76.9%). African and Asian responding surgeons had significantly less formal training in hip arthroscopy (22.7% and 15.3%, respectively).

Among North American respondents, formal training was identified as postgraduate fellowship training by 59% and as mentor visits by 40% of respondents. More than 67% of North American respondents had participated in hip arthroscopy courses independent of fellowship training. Among international respondents, formal training consisted of postgraduate fellowship training (26.1%), arthroscopic courses (79.0%), mentor visits (49.0%), and residency training (24%) (Table 1).

Clinical Assessment

The essential finding on clinical history for FAI was reported to be pain with hip rotation (73.6%), followed by groin-based pain (65.2%). The FADIR (flexion–adduction–internal rotation) clinical test was considered necessary by most responding surgeons (87.9%). Most surgeons (97.9%) routinely ordered plain radiographs, with the anteroposterior pelvis radiograph (69.7%) and cross-table lateral radiograph (37.0%) most commonly used. The most important radiographic measurement was the alpha angle (48.7%); however, 22.8% of respondents were unsure as to the optimal measurement. The radiographic assessment most frequently performed for pincer FAI was the crossover sign (49.4%), followed by the lateral center-edge angle (36.6%). Confirmatory testing after radiographic diagnosis was primarily performed by magnetic resonance imaging (66.0%) (Table 2).

Diagnosis and Surgical Volume

Internationally, the annual FAI diagnosis was fewer than 30 cases for 70.4% of respondents and over 50 cases for 9.8%. Fewer than 10 arthroscopic cases annually were performed by 37.8% of international surgeons and over 100 cases by 12.9%. Among international surgeons, 58.2% reported an annual open procedure volume of fewer than 10 cases and 10.9% reported a volume of over 100 cases (Appendix Fig 1, available at www.arthroscopyjournal.org). In comparison, 59.0% of North American surgeons diagnosed fewer than 30 cases annually and 13.1% diagnosed more than 50 cases annually. Among North American surgeons performing hip arthroscopy, 22.2% performed fewer than 10 cases annually and 13.0% performed over 100 cases. Regarding open procedures, 50% of North American surgeons reported performing fewer than 10 cases per year and 8.3% performed over 100 cases. We found that respondents from Africa and Asia were more likely to diagnose no FAI cases (34.6%

Table 2. Perceptions Regarding Diagnosis (749 Respondents)

	Response %
Essential finding on clinical history	
Groin pain	65.2%
Trochanteric pain	7.5%
Pain with hip rotation	73.6%
Gluteal pain	6.9%
Pain radiating anterior to knee	13.2%
Unsure	2.9%
Other	4.9%
Essential finding on clinical examination	
Impingement test (FADIR test)	87.9%
Log roll	6.3%
Faber test	14.8%
C-sign	25.4%
Unsure	7.1%
Other	3.6%
Essential radiographic examination for FAI diagnosis	
AP pelvis	69.7%
Cross-table lateral	37.0%
Dunn view	33.2%
False-profile view	22.7%
Unsure	5.7%
Do not routinely order radiographs	3.1%
Other	8.0%
Essential radiographic measure for cam FAI	
Alpha angle	48.7%
Beta angle	10.3%
Head-neck offset	39.3%
Head-neck ratio	18.7%
Unsure	22.8%
Other	3.2%
Essential confirmatory test for FAI	
Radiographs only	30.4%
CT scan	28.8%
MRI	66.0%
Intra-articular injection	21.0%
Unsure	3.1%
Other	5.5%
Initial treatment for FAI	
Rest	43.9%
Physiotherapy	69.6%
Viscosupplementation injection	6.8%
Surgery	20.7%
Anesthetic hip injections	21.4%
Unsure	3.2%
Primary indication for surgical management	
Persistent groin pain	62.6%
Mechanical hip symptoms (catching, locking)	58.6%
Failure of nonoperative management	73.4%
Decreased level of sports performance	25.4%
Findings on imaging	27.1%
Unsure	2.4%
Other	2.0%
Essential radiographic measure for pincer FAI	
Lateral center-edge angle	36.8%
Crossover sign	49.4%
Ischial spine sign	13.0%
Posterior wall sign	19.8%
Tönnis angle	9.3%
Acetabular inclination	16.3%
Unsure	24.8%
Other	2.8%

AP, anteroposterior; CT, computed tomography; FADIR, flexion–adduction–internal rotation; FAI, femoroacetabular impingement; MRI, magnetic resonance imaging.

and 20.2%, respectively) in comparison to North American and European responding surgeons.

When compared with surgeons who performed no FAI surgery, surgeons who performed a low volume of FAI surgery were significantly more likely to have practiced for more than 20 years (odds ratio [OR], 1.55; 95% confidence interval [CI], 1.12 to 2.16), to be practicing at an academic hospital (OR, 1.65; 95% CI, 1.19 to 2.29), and to have formal arthroscopy training (OR, 10.45; 95% CI, 7.23 to 15.10). Surgeons performing a high volume of FAI surgery were significantly more likely to have practiced for more than 20 years (OR, 1.91; 95% CI, 1.01 to 3.63), to be practicing at an academic hospital (OR, 2.25; 95% CI, 1.22 to 4.15), to have formal arthroscopy training (OR, 46.17; 95% CI, 20.28 to 105.15), and to be practicing in North America or Europe (OR, 2.26; 95% CI, 1.08 to 4.72).

Management and Indications

Respondents indicated that the initial treatment after a diagnosis of FAI should consist of physiotherapy (69.7%) and rest (43.9%). The use of a confirmatory intra-articular hip injection was more widespread among North American sports fellowship–trained surgeons (51.4%) in comparison to international respondents (21.0%) (Table 2).

FAI was treated by all-arthroscopic approaches by 33.3% of respondents, either arthroscopic or open approaches by 24.7%, and open surgical dislocation by 12.2%. North American surgeons managed FAI arthroscopically in 44.5% of cases compared with 31.5% of international surgeons, and 25.2% performed open management compared with 32.2% internationally. The indications for an open approach were reported to be large head-neck deformities (9.8%), acetabular dysplasia (8.7%), acetabular retroversion (7.7%), or "rarely in isolated cases" (25.2%; e.g., posterior cam impingement, extreme over-coverage, short varus neck, or overgrown trochanter). Arthroscopic indications also varied, with 18.7% of respondents reporting arthroscopy as essential for large head-neck deformities, 18.7% for acetabular dysplasia, 3.7% for acetabular retroversion, or 12.8% "rarely in isolated cases" (e.g., small labral tears or localized cam deformity). Access to the central compartment was carried out through partial capsulotomy by 48.3% of responding surgeons, complete capsulotomy by 11.0%, or no capsulotomy by 5.7% (Table 3).

Labral-Capsular Management

Isolated and complete labral tears were managed with suture repair by 56.8% of respondents and with debridement by 19.4%. Focal pincer lesions were treated by labral detachment, pincer decompression, and refixation of the labrum (41.4%); pincer decompression and fixation of the labrum (23.8%);

Table 3. Perceptions Regarding Surgical Management (664 Respondents)

	Response %
Management of FAI	
Open surgical dislocation	12.2%
All-arthroscopic procedure	33.3%
Arthroscopic-assisted procedure	5.7%
Either open or arthroscopic approach	24.7%
Other	24.1%
Indication for open FAI management	
Large head-neck deformities	9.8%
Dysplastic acetabulum	8.7%
Acetabular retroversion	7.7%
All of the above	21.4%
Rarely in isolated cases	25.2%
Unsure	19.7%
Other	7.5%
Indication for arthroscopic FAI management	
Large head-neck deformities	18.7%
Dysplastic acetabulum	3.6%
Acetabular retroversion	3.5%
All of the above	21.5%
Rarely in isolated cases	12.8%
Unsure	24.7%
Other	15.2%
Arthroscopic capsular management preference	
Regularly close capsule	12.3%
Never close capsule	36.0%
Close capsule in patients in specific cases	15.8%
Respondent only performs open FAI surgery	17.5%
Other	18.4%
Access to central compartment	
Complete capsulotomy	11.0%
Partial capsulotomy	48.3%
No capsulotomy	5.7%
Unsure	29.7%
Other	5.3%
Open capsular management preference	
Regularly close capsule	41.4%
Never close capsule	8.7%
Close capsule in patients in specific cases	11.4%
Respondent only performs arthroscopic surgery	20.5%
Other	17.9%
Method by which definitive FAI treatment is best accomplished	
All-arthroscopic approach	43.8%
Open surgical dislocation	9.9%
Arthroscopically assisted mini-open approach	14.8%
Nonoperative means	5.4%
Unsure	15.2%
Other	10.8%
Ideal management for isolated complete labral tear	
Mechanical debridement	19.4%
Suture repair	56.8%
Heat ablation	3.5%
Observation	6.2%
Unsure	9.9%
Other	4.2%
Ideal management for focal pincer lesion	
Pincer decompression	14.9%
Labral detachment, pincer decompression, and refixation of labrum	41.4%
Pincer decompression and fixation of labrum	23.8%
Unsure	15.8%
Other	4.1%

FAI, femoroacetabular impingement.

and isolated pincer decompression (14.9%). Uncertainty regarding optimal management of focal pincer lesions was indicated by 15.8% of respondents (Table 3).

Arthroscopic capsular management consisted of never closing the capsule (58.6%), regularly closing the capsule (11.4%), and performing capsular closure in specific cases (23.2%). Open capsular management consisted of routine capsular closure (41.4%) or closure in specific cases (8.7%). Among surgeons performing a higher volume of arthroscopic cases (50 to > 100), 60.6% did not perform capsular closure compared with 15.2% reporting routine closure.

Outcome Tools

Clinical outcome scores should be used to evaluate FAI surgical outcomes according to 80.7% of responding surgeons. Radiographic correction (33.6%) and magnetic resonance imaging analysis (28.2%) were also selected as important postoperative measures. Successful management of FAI radiographically was evaluated through alpha angle correction by 48.1% of respondents. The most commonly used clinical parameter to assess successful operative management was pain relief (76.3%), followed by lack of impingement sign (59.0%), improved range of motion (53.5%), and return to sport (45.8%). The most commonly used outcome scores were the Western Ontario and McMaster Universities Arthritis Index (21.1%) and Harris Hip Score (22.6%); however, 34.9% of respondents did not use postoperative outcome scores (Appendix Table 4, available at www.arthroscopyjournal.org).

Perceptions Regarding Level of Evidence

Evidence supporting the best clinical test and the best radiographic parameter for the diagnosis of FAI was rated as moderate by 35.8% and 38.9% of respondents, respectively. Evidence supporting the use of diagnostic intra-articular injections was rated as moderate by 33.9%. Evidence for nonoperative management of FAI was rated as weak by 34.7% (Appendix Table 5, available at www.arthroscopyjournal.org).

Evidence for the superiority of a surgical intervention or approach was varied, with 33.8% of respondents reporting that an arthroscopic, open, or mini-open approach was superior, followed by 28.5% who were unsure and 23.4% who disagreed. Evidence supporting the treatment effect of a corrective osteoplasty for cam impingement and a pincer lesion resection was believed to be moderate by 34.8% and 38.2% of respondents, respectively. Evidence regarding the surgical treatment of labral pathology was generally considered moderate by 36.6% of respondents and strong by 24.6% (Appendix Table 5, available at www.arthroscopyjournal.org).

Evidence suggesting positive outcomes after FAI surgery was rated as moderate by 41.0% of respondents. Evidence related to the commonly described association between FAI and future development of hip osteoarthritis was considered moderate by 33.6% of respondents and strong by 32.6%. Of respondents, 86.0% agreed or strongly agreed that preoperative hip arthritis is a predictor of negative clinical outcome after FAI surgery (Appendix Table 4, available at www.arthroscopyjournal.org).

Discussion

Key Findings

Our survey results suggest that FAI surgery has reached a tipping point toward increased uptake and use. The development and uptake of surgical procedures follow a well-described cycle of innovation.[8] Early stages of innovation begin with the development of a surgical technique by pioneers. During the development phase, early adaptors and key opinion leaders begin performing the procedure. As uptake continues, indications broaden, volumes increase, measurements become increasingly objective, technical refinements occur, and early trials begin. At this development stage, with approximately 20% innovation uptake, a tipping point is suggested toward further use.[9] High-volume surgeons in developed nations are driving FAI surgical volumes, and indications for arthroscopic surgery are increasing. Randomized controlled trials have begun, a focus on clinical outcome assessment is present, and over 30% of responding surgeons indicated that they have performed hip arthroscopy[4,10,11] (Fig 1).

We identified that high-volume surgeons were significantly more likely to have been in practice for more than 20 years and to be practicing at an academic hospital in North America or Europe with formal arthroscopic training (Appendix Table 1, available at www.arthroscopyjournal.org). We found that North American and European respondents performed more arthroscopic cases and reported more formal training in arthroscopic techniques in comparison to Asian and African responding surgeons; however, both groups equally responded regarding performing open FAI surgery when required (Fig 2). Most FAI cases were managed arthroscopically in agreement with recent reviews on global FAI management.[12] We identified the increased North American exposure to hip arthroscopy during residency and fellowship training as likely an important factor in the rapidly increasing number of hip arthroscopy cases performed annually in North America as opposed to potential geographic variability in FAI prevalence.[2,12]

Pain with hip rotation and groin-based pain as commonly described were identified by responding surgeons as essential to the clinical history.[13] Although

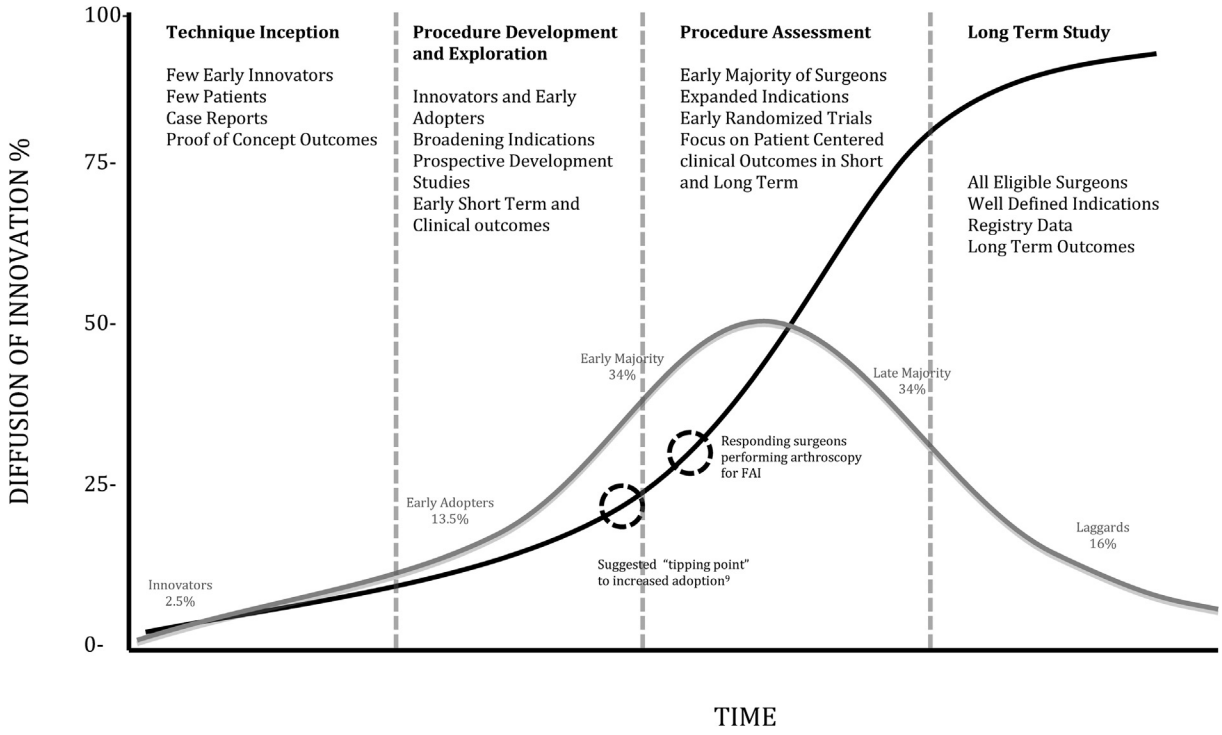


Fig 1. Diffusion and uptake of innovation with respect to femoroacetabular impingement (FAI) arthroscopic intervention. The gray line indicates the process of adoption of innovation (FAI surgery) over time according to previously defined adopter groups. The black line depicts increased uptake of innovation over time. Corresponding stages of innovation are presented with descriptors.

the diagnostic value of the FADIR test has been disputed, results from our survey support its use.[6,14,15] Almost all respondents used plain radiographs, with the alpha angle most commonly measured. The alpha angle has been correlated with labral and chondral damage and decreased range of movement.[16,17] Despite recent data to suggest little predictive value regarding short-term functional outcomes, we found intra-articular hip injection to be widely used particularly by North American respondents[18] (Table 2).

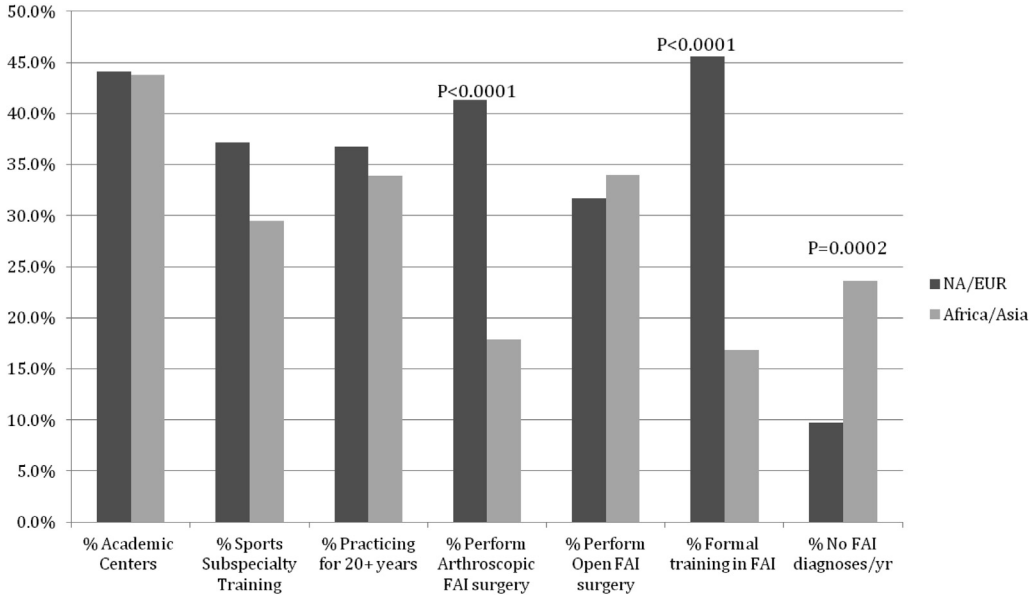


Fig 2. Demographic comparisons between North American (NA)/European (EUR) and African/Asian responding surgeons. (FAI, femoroacetabular impingement.)

We found significant variation and discrepancy regarding specific indications for open or arthroscopic management of FAI, with almost a quarter of responding surgeons indicating that they were unsure of specific indications for either (Table 3). This has been highlighted by recent reviews suggesting a lack of clinical and radiographic criteria by which management is selected.[11,19] A number of responding surgeons identified the extent of bony deformity as a guiding factor toward open or arthroscopic management. Recent studies have furthered our understanding of specific indications for open and arthroscopic approaches. Bedi et al.[20] evaluated the efficacy of arthroscopic and open surgery regarding alpha angle measurement and concluded that deformities such as posterolateral cam lesions may be better managed by open approaches. Zaltz et al.[21] suggested that FAI occurring in a setting of deficient acetabular coverage, significant coxa valga, or certain acetabulum-sided deformities such as protrusio acetabuli and coxa profunda may be more easily, more safely, and more completely treated through an open approach.

Capsular management has been an area of interest and controversy recently. It has been suggested that failure to close the capsule can result in subtle hip instability, which can negatively affect outcomes, yet we found that most responding surgeons indicated that their practice does not include routine capsular closure (Table 3).[22-24] Labral management has moved toward suture repair as opposed to mechanical debridement in the literature, and this is reflected by the majority of responding surgeons indicating this as their practice.[25]

The vast majority of responding surgeons (80.7%) believed that clinical outcome scores should play a role in the evaluation of FAI surgical outcomes, although there was significant variability regarding which clinical outcome tool to use, as well as which combination of radiographic, clinical, and advanced imaging studies was ideal (Appendix Table 4, available at www.arthroscopyjournal.org). Patient-centered outcomes, primarily pain relief, were shown to be principal to identifying success after FAI surgery. Future research determining which combination of outcome scores and radiographic and advanced imaging findings is most beneficial and, potentially, future advances in cartilage biomarkers have been identified in the literature as the next steps forward in assessing successful surgical interventions.[4,26]

Future Directions

In general, most respondents agreed that weak to moderate evidence exists regarding the diagnosis and treatment of FAI. A significant proportion of respondents were unsure regarding the quality of evidence related to open or arthroscopic management of FAI pathology, as well as specific management of the labrum and treatment effect of osteochondroplasty/pincer resection. A number of randomized controlled trials evaluating FAI management are currently under way and will be essential to providing high-quality evidence to clinicians managing FAI and hip pathology.[10,27]

Limitations

The design of the survey was rigorous to ensure face and content validity. Significant effort was made to distribute this survey globally. Electronic measures were used to ensure single responses from respondents, and multiple reminder e-mails were distributed to improve the response rate. A limitation of this survey is our inability to accurately identify the response rate of participants, which ranged from 0.0% to 18.9% based on data available from 13 organizations. Formal calculation of the response rate is difficult given the involvement of multiple international organizations with widespread distribution and variable membership access to the Internet, and the response rate per organization may be underestimated. In addition, the use of an electronic survey may provide an element of nonresponder bias, as does access to computer technology, given that this survey was electronically administered. The survey was administered in the English language for standardization purposes; however, this leads to potential for language response bias. The distribution of respondents varied significantly among regions, which limits detailed analysis; however, the significantly large number of responding surgeons of varying backgrounds provides valuable data to guide further study. A strength of the statistical analysis is that we used multinomial logistic regression as opposed to simple logistic regression. This approach allows for the use of an outcome variable with more than two levels (i.e., none, low volume, and high volume) while preserving efficiency.

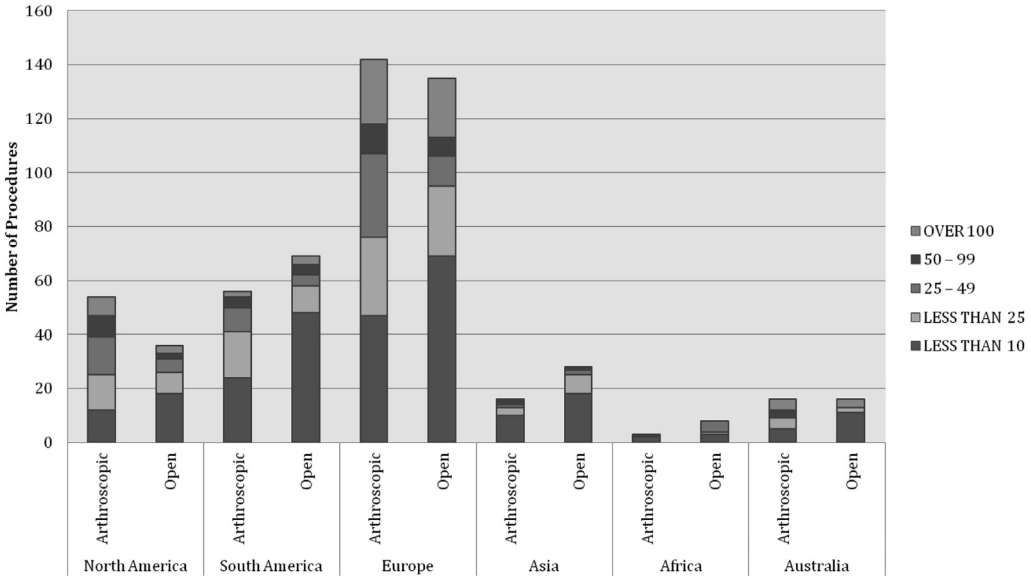
Conclusions

The exponential rise in the diagnosis and surgical management of FAI appears to be driven largely by experienced surgeons in developed nations. Our analysis suggests that although FAI management is early in the innovation cycle, we are at a tipping point toward wider uptake and use. The results of this survey will help guide further research and study.

References

1. Alradwan H, Khan M, Grassby MH, Bedi A, Philippon MJ, Ayeni OR. Gait and lower extremity kinematic analysis as an outcome measure after femoroacetabular impingement surgery. *Arthroscopy* 2015;31:339-344.
2. Colvin AC, Harrast J, Harner C. Trends in hip arthroscopy. *J Bone Joint Surg Am* 2012;94:e23.

3. Ayeni OR, Chan K, Al-Asiri J, et al. Sources and quality of literature addressing femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc* 2013;21:415-419.
4. Hetaimish BM, Khan M, Crouch S, et al. Consistency of reported outcomes after arthroscopic management of femoroacetabular impingement. *Arthroscopy* 2013;29:780-787.
5. Collins JA, Ward JP, Youm T. Is prophylactic surgery for femoroacetabular impingement indicated? A systematic review. *Am J Sports Med* 2014;42:3009-3015.
6. Ayeni OR, Belzile EL, Musahl V, et al. Results of the PeRception of femOroaCetabular impingEment by Surgeons Survey (PROCESS). *Knee Surg Sports Traumatol Arthrosc* 2014;22:906-910.
7. Bhandari M, Fong K, Sprague S, Williams D, Petrisor B. Variability in the definition and perceived causes of delayed unions and nonunions: A cross-sectional, multinational survey of orthopaedic surgeons. *J Bone Joint Surg Am* 2012;94:e1091-e1096.
8. McCulloch P, Altman DG, Campbell WB, et al. No surgical innovation without evaluation: The IDEAL recommendations. *Lancet* 2009;374:1105-1112.
9. Wilson CB. Adoption of new surgical technology. *BMJ* 2006;332:112-114.
10. Femoroacetabular Impingement RandomiSed Controlled Trial (FIRST). Available at https://clinicaltrials.gov/ct2/show/NCT01623843. Accessed December 30, 2014.
11. Ayeni OR, Wong I, Chien T, Musahl V, Kelly BT, Bhandari M. Surgical indications for arthroscopic management of femoroacetabular impingement. *Arthroscopy* 2012;28:1170-1179.
12. Yeung M, Khan M, Schreiber VM, et al. Global discrepancies in the diagnosis, surgical management, and investigation of femoroacetabular impingement. *Arthroscopy* 2014;30:1625-1633.
13. Bedi A, Kelly BT. Femoroacetabular impingement. *J Bone Joint Surg Am* 2013;95:82-92.
14. Tijssen M, van Cingel R, Willemsen L, de Visser E. Diagnostics of femoroacetabular impingement and labral pathology of the hip: A systematic review of the accuracy and validity of physical tests. *Arthroscopy* 2012;28:860-871.
15. Martin RL, Kelly BT, Leunig M, et al. Reliability of clinical diagnosis in intraarticular hip diseases. *Knee Surg Sports Traumatol Arthrosc* 2010;18:685-690.
16. Khan M, Ranawat A, Williams D, et al. Relationship between the alpha and beta angles in diagnosing cam-type femoroacetabular impingement on frog-leg lateral radiographs. *Knee Surg Sports Traumatol Arthrosc* 2015;23:2595-2600.
17. Ross JR, Nepple JJ, Philippon MJ, Kelly BT, Larson CM, Bedi A. Effect of changes in pelvic tilt on range of motion to impingement and radiographic parameters of acetabular morphologic characteristics. *Am J Sports Med* 2014;42:2402-2409.
18. Ayeni OR, Farrokhyar F, Crouch S, Chan K, Sprague S, Bhandari M. Pre-operative intra-articular hip injection as a predictor of short-term outcome following arthroscopic management of femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc* 2014;22:801-805.
19. Ayeni OR, Naudie D, Crouch S, et al. Surgical indications for treatment for femoroacetabular impingement with surgical hip dislocation. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1676-1683.
20. Bedi A, Zaltz I, De La Torre K, Kelly BT. Radiographic comparison of surgical hip dislocation and hip arthroscopy for treatment of cam deformity in femoroacetabular impingement. *Am J Sports Med* 2011;39:20S-28S (suppl).
21. Zaltz I, Kelly BT, Larson CM, Leunig M, Bedi A. Surgical treatment of femoroacetabular impingement: What are the limits of hip arthroscopy? *Arthroscopy* 2014;30:99-110.
22. Bedi A, Galano G, Walsh C, Kelly BT. Capsular management during hip arthroscopy: From femoroacetabular impingement to instability. *Arthroscopy* 2011;27:1720-1731.
23. Nepple JJ, Byrd JW, Siebenrock KA, Prather H, Clohisy JC. Overview of treatment options, clinical results, and controversies in the management of femoroacetabular impingement. *J Am Acad Orthop Surg* 2013;21:S53-S58 (suppl 1).
24. Harris JD, Slikker W III, Gupta AK, McCormick FM, Nho SJ. Routine complete capsular closure during hip arthroscopy. *Arthrosc Tech* 2013;2:e89-e94.
25. Ayeni OR, Adamich J, Farrokhyar F, et al. Surgical management of labral tears during femoroacetabular impingement surgery: A systematic review. *Knee Surg Sports Traumatol Arthrosc* 2014;22:756-762.
26. Bedi A, Lynch EB, Sibilsky Enselman ER, et al. Elevation in circulating biomarkers of cartilage damage and inflammation in athletes with femoroacetabular impingement. *Am J Sports Med* 2013;41:2585-2590.
27. Palmer AJ, Ayyar-Gupta V, Dutton SJ, et al. Protocol for the femoroacetabular impingement trial (FAIT): A multicentre randomised controlled trial comparing surgical and non-surgical management of femoroacetabular impingement. *Bone Joint Res* 2014;3:321-327.



Appendix
Figure 1. Global comparison of arthroscopic and open procedures.

Appendix Table 1. Multinomial Logistic Regression (n = 868)

Characteristic	Odds Ratio	95% CI	*P* Value
Low volume (< 100 cases/yr) *v* no FAI surgery			
Practicing for > 20 yr	1.55	1.12-2.16	.009
Practicing in North America or Europe	0.87	0.63-1.20	.387 (NS)
Practicing at academic hospital	1.65	1.19-2.29	.003
Has arthroscopy training	10.45	7.23-15.10	< .001
High volume (> 100 cases/yr) *v* no FAI surgery			
Practicing for > 20 yr	1.91	1.01-3.63	.048
Practicing in North America or Europe	2.26	1.08-4.72	.030
Practicing at academic hospital	2.25	1.22-4.15	.009
Has arthroscopy training	46.17	20.28-105.15	< .001

CI, confidence interval; FAI, femoroacetabular impingement; NS, not significant at $P < .05$ level.

Appendix Table 2. Contacted National and International Organizations

American Association of Hip and Knee Surgeons
American Association of Orthopaedic Surgeons
American Orthopaedic Society for Sports Medicine
APAS: Asia Pacific Arthroplasty Association
Argentine Arthroscopy Association
Asia Pacific Orthopaedic Society for Sports Medicine
Asia-Pacific Knee, Arthroscopy and Sports Medicine Society
Association of Orthopaedists and Traumatologists of the Russian Federation
Australian Orthopaedic Association
Austrian Orthopaedic Society
Bangladesh Orthopedic Society
Bolivian Society of Orthopaedics and Traumatology
Brazilian Orthopedic Association (SBOT)
Brazilian Society of Orthopaedics and Traumatology
British Hip Society
British Orthopaedic Association
Bulgarian Orthopaedic Association
Bulgarian Orthopaedics and Traumatology Association
Canadian Orthopaedic Association
Chinese Orthopaedic Association
Columbian Society of Orthopaedics and Traumatology
Croatian Orthopaedic and Traumatology Association
Czech Republic Society of Orthopaedics and Traumatology
Danish Orthopaedic Association
Eastern Orthopaedic Association
Egyptian Orthopaedic Association
ETOS: Estonian Association of Traumatology and Orthopaedics
European Hip Society
European Society of Sports Traumatology, Knee Surgery & Arthroscopy
Finnish Orthopaedic Association
French Society of Orthopaedics and Traumatology
German Orthopedic Association (DGOOC)
German Society for Orthopaedics and Orthopaedic Surgery
Hawaiian Orthopaedic Association
Hellenic Association of Orthopaedic Surgery and Traumatology
Hong Kong Orthopaedic Association
Hungarian Orthopaedic Association
Indian Orthopaedic Association
Indonesian Orthopaedic Association
International Congress for Joint Reconstruction
International Society for Hip Arthroscopy
International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine
Iranian Orthopaedic Association
Israel Orthopaedic Association
Italian Society of Orthopaedics and Traumatology
Japanese Orthopaedic Association
Korean Orthopaedic Association
Lebanese Orthopaedic Association
Lithuanian Society of Orthopaedics and Traumatology
Macedonian Association of Orthopaedics and Traumatology
Magyar Ortoped Tarsasag
Malaysian Orthopaedic Association
Mexican Society of Orthopaedics
Nepal Orthopaedic Association
New Zealand Orthopaedic Association
Nordic Orthopaedic Federation
Orthopaedic and Traumatology Surgeons Association of Bosnia and Herzegovina
Pakistan Orthopaedic Association
Pan Arab Orthopaedic Association
Paraguay Society of Orthopaedics and Traumatology
Peruvian Society of Orthopaedics and Traumatology
Philippine Orthopaedic Association
Polish Orthopaedic Association
Polish Orthopaedic Society
Portugal Society of Orthopaedics and Traumatology
Puerto Rico Society of Orthopaedics and Traumatology
Romanian Orthopaedic Association
Royal College of Orthopaedic Surgeons of Thailand
Sancheti Group
Saudi Orthopaedic Association
Singapore Orthopaedic Association
Slovenian Orthopedic Association
Slovenian Orthopaedic Society
Society of Orthopaedics and Traumatology in the East
South African Orthopaedic Association
Southern Orthopaedic Association
Spanish Association of Arthroscopy
Spanish Society of Orthopaedic Surgery and Traumatology
Sri Lankan Orthopaedic Association
Sweden Orthopaedic Federation
Swiss Orthopedic Association
Swiss Society of Orthopaedics and Traumatology
The Hip Society
Turkish Society of Orthopaedics and Traumatology
Western Orthopaedic Association
Yemeni Orthopaedic Association

Appendix Table 3. Participating National and International Organizations and Response Rate

	Response Rate
American Orthopaedic Society for Sports Medicine	UA
Canadian Orthopaedic Association	21/1,200
European Hip Society	75/400
Sancheti Group	UA
Australian Orthopaedic Association	10/1,500
Danish Orthopaedic Association	9/1,050
Croatian Orthopaedic and Traumatology Association	18/165
German Orthopedic Association (DGOOC)	8/600
European Society of Sports Traumatology, Knee Surgery & Arthroscopy	UA
Slovenian Orthopedic Association	1/134
Lebanese Orthopaedic Association	UA
Japanese Orthopaedic Association	UA
Swiss Orthopedic Association	29/656
New Zealand Orthopaedic Association	7/280
South African Orthopaedic Association	UA
Hellenic Association of Orthopaedic Surgery and Traumatology	UA
Brazilian Orthopedic Association (SBOT)	253/6,700
International Congress for Joint Reconstruction	159/9,000
Saudi Orthopaedic Association	12/1,000
British Hip Society	72/426

UA, unavailable.

Appendix Table 4. Perceptions of Evidence Related to Outcomes (607 Respondents)

	Response %
Evidence supporting positive outcomes following FAI surgery	
Unsure	7.9%
Very weak	6.1%
Weak	15.0%
Moderate	41.0%
Strong	26.4%
Very strong	3.6%
Evidence for a positive association between FAI and OA development	
Unsure	5.8%
Very weak	5.9%
Weak	11.7%
Moderate	33.6%
Strong	32.6%
Very strong	10.4%
Preoperative hip arthritis is a predictor of a negative clinical outcome following FAI surgery	
Strongly agree	40.7%
Agree	45.3%
Unsure	10.4%
Disagree	2.6%
Strongly disagree	1.0%
Method by which FAI should be evaluated	
Clinical outcome scores	80.7%
Radiographic correction of FAI	33.6%
Biomarkers of cartilage degradation	10.7%
Gait analysis	8.7%
MRI analysis of hip cartilage	28.2%
Operative success is measured with the following radiographic parameters:	
Alpha angle	48.1%
Beta angle	11.4%
Degenerative changes	38.2%
Center-edge angle	24.5%
Head-neck offset	34.9%
Crossover sign	27.2%
Other	18.0%
Operative success is measured with the following clinical parameters:	
Range of motion	53.5%
Impingement signs	59.0%
Return to sport	45.8%
Pain relief	76.3%
Other	12.5%
Arthroscopic operative success is measured using the following outcome scores:	
IHOT-33: International Hip Outcome Tool	10.4%
WOMAC: Western Ontario and McMaster Universities Arthritis Index	21.1%
NAHS: Non-Arthritic Hip Score	12.2%
HHS: Harris Hip Score	22.6%
SF-12: Short Form Survey	11.7%
MHHS: Modified Harris Hip Score	13.5%
Postel–Merle d'Aubigné score	6.1%
HOS: Hip Outcome Score	4.4%
Do not use scores	34.9%
Other	14.2%

FAI, femoroacetabular impingement; MRI, magnetic resonance imaging; OA, osteoarthritis.

Appendix Table 5. Perceptions of Evidence Related to Diagnosis and Treatment (637 Respondents)

	Response %
Evidence supporting a best clinical test	
Unsure	11.6%
Very weak	10.0%
Weak	28.6%
Moderate	35.8%
Strong	13.0%
Very strong	0.9%
Evidence supporting a best radiographic parameter	
Unsure	8.9%
Very weak	6.9%
Weak	17.4%
Moderate	38.9%
Strong	25.7%
Very strong	2.0%
Evidence supporting the use of diagnostic intra-articular injections	
Unsure	12.2%
Very weak	11.6%
Weak	23.7%
Moderate	33.9%
Strong	16.3%
Very strong	2.2%
Evidence for nonoperative management of FAI	
Unsure	12.4%
Very weak	14.9%
Weak	34.7%
Moderate	29.2%
Strong	8.3%
Very strong	0.5%
Evidence for a superior surgical intervention (open *v* arthroscopic)	
Strongly agree	10.0%
Agree	33.8%
Unsure	28.5%
Disagree	23.3%
Strongly disagree	4.3%
Evidence supporting the treatment effect of corrective osteoplasty	
Unsure	12.6%
Very weak	6.0%
Weak	17.6%
Moderate	34.8%
Strong	23.7%
Very strong	5.5%
Evidence supporting the treatment effect of pincer resection	
Unsure	10.1%
Very weak	7.9%
Weak	24.2%
Moderate	38.2%
Strong	17.1%
Very strong	2.6%
Evidence supporting the surgical treatment of labral pathology	
Unsure	8.1%
Very weak	7.9%
Weak	19.3%
Moderate	36.6%
Strong	24.6%
Very strong	3.5%
Evidence supporting the surgical treatment of labral and bony pathology concurrently	
Unsure	10.8%
Very weak	8.1%
Weak	20.0%
Moderate	35.9%
Strong	20.6%
Very strong	4.7%

FAI, femoroacetabular impingement.