Original Article

Development of Machine Learning Algorithms to Predict Being Lost to Follow-up After Hip Arthroscopy for Femoroacetabular Impingement Syndrome

Kyle N. Kunze, M.D., Robert A. Burnett, M.D., Elaine K. Lee, M.A., Jonathan P. Rasio, B.S., and Shane J. Nho, M.D., M.S.

Purpose: To determine factors predictive of patients who are at risk for being lost to follow-up after hip arthroscopy for femoroacetabular impingement syndrome (FAIS). **Methods:** A prospective clinical repository was queried between January 2012 and October 2017 and all patients who underwent hip arthroscopy for primary or revision FAIS with minimum 2-year follow-up were included. A total of 27 potential risk factors for loss to follow-up were available and tested for predictive value. An 80:20 random sample split of all patients was performed to create training and testing sets. Cross-validation, minimum Bayes information criteria, and adaptive machine-learning algorithms were used to develop the predictive model. The model with the best predictive performance was selected based off of the lowest postestimation deviance between the training and testing samples. The c-statistic is a measure of discrimination. It ranges from 0.5 to 1.0, with 1.0 being perfect discrimination and 0.5 indicating the model is no better than chance. A log-likelihood χ^2 test was used to evaluate the goodness-of-fit of the logistic regression model. **Results:** A total of 2113 patients were included. Inference of minimum Bayes information criteria model indicated that male sex (odds ratio [OR] 1.82, $P = .028$), non-white race (African American OR 2.41, $P = .013$; other non-white OR 1.42, $P = .042$), smoking (OR 1.07, $P = .021$), and failure to provide a phone number (OR 1.78, $P = .032$) increased the risk for being lost to follow-up. Furthermore, greater preoperative International Hip Outcome Tool 12-item component questionnaire (OR 1.03, $P = .004$), and modified Harris Hip Score (OR 1.05, $P = .014$) scores increased the risk of being lost to follow-up. The c-statistic was 0.76 (95% confidence interval 0.701-0.848). The log-likelihood indicated that the regression model as a whole was statistically significant ($P = .002$). **Conclusions:** Patients who are male, non-white, smokers, fail to provide a telephone number, and have greater preoperative modified Harris Hip Score and International Hip Outcome Tool 12-item component questionnaire scores are at an increased risk for being lost to follow-up 2 years after hip arthroscopy for FAIS. **Level of Evidence:** Level III, case control study

Between 2005 and 2013, the rate of hip arthroscopy procedures performed annually in the United States saw nearly a 5-fold increase.[1] As the number of procedures increase, it is imperative to continue to collect and report patient-reported outcome measures (PROMs) to validate procedural efficacy and identify at-risk populations for poor outcomes. Although PROMs are routinely used by hip arthroscopists and are

commonplace in the literature, there is increasing evidence that attrition rates for follow-up may be greater in certain populations, introducing marked response bias that affects the conclusions drawn in outcome studies.[2-4] Therefore, it is imperative to ensure that the completion of PROMs for patients who undergo hip arthroscopy is maximized to avoid such bias, as high loss to follow-up rates can hinder the validity of reported PROMs.[5]

In one loss to follow-up study that concerned anterior cruciate ligament reconstruction, discrepancies in follow-up were demonstrated to be dependent on routinely collected patient demographic information, including sex and race.[2] Follow-up after hip arthroscopy is inherently difficult, given the lack of incentive for patients who are doing well after surgery. On the contrary, patients who choose to transfer care to another provider as a result of a poor outcome may choose not to complete PROMs. Conclusions regarding the success of certain interventions in subgroup populations may be misinterpreted and much less generalizable when the reporting groups differs from those enrolled but lost to follow-up.[6] As reliance on PROMs continue to increase in the context of increasing surgical volumes and the implementation of value-based care across orthopaedics, both understanding why patients fail to complete PROMs, and which patients are at risk for failing to do so, will become of great clinical utility.

Despite the creation and use of PROM datasets incorporating diverse sets of variables and large patient samples, identifying factors that may predict loss to follow-up have not been well studied for hip arthroscopy.[7] Identifying such factors is important to better counsel populations who may be underrepresented in the published literature due to disparate rates of loss to follow-up. Furthermore, to obviate potential population health disparities and better understand patient outcomes, the hip arthroscopy community may use these factors to engage patients and encourage more adherent clinical follow-up. The purpose of this study was to determine factors predictive of patients who are at risk for being lost to follow-up after hip arthroscopy for femoroacetabular impingement syndrome (FAIS). The authors hypothesized that many routinely collected preoperative patient demographic factors, such as race and sex, would be able to predict those at risk for being lost to follow-up after hip arthroscopy for FAIS.

Methods

Patient Selection Criteria

Following institutional board approval, data stored in a secure clinical repository were queried for all patients who underwent hip arthroscopy for FAIS between January 2012 and October 2017. Inclusion criteria consisted of all patients during this time frame who had both clinical and radiographic signs of FAIS and subsequently underwent hip arthroscopy by the senior author after failure of conservative management (any combination of physical therapy, non-steroidal anti-inflammatory drugs, intra-articular hip injections of corticosteroids, and activity modification). Exclusion criteria were patients who underwent hip arthroscopy for other indications (gluteus medius repair, loose body removal, avascular necrosis, proximal hamstring repairs, subspine decompression, and psoas tendon release), radiographically determined osteoarthritis (Tönnis grade >1), and history of congenital hip disorders (developmental dysplasia of the hip, slipped capital femoral epiphysis, and Legg−Calve−Perthes disease).

Functional Outcome Evaluation

At baseline all patients completed various patient reported outcome measures, including the Hip Outcome Score (HOS)−Activities Of Daily Living (ADL),[8] HOS-Sports Subscale (SS),[9] modified Harris Hip score (mHHS),[10] International Hip Outcome Tool 12-component questionnaires (IHOT-12), short form (SF)−12 component questionnaires for mental (M) and physical (P) status, and visual analog scale (VAS) for pain.

Primary Outcome and Data Acquisition

The primary outcome measure was loss to follow-up at 2 years postoperatively. A patient was considered lost to follow-up if they did not complete at least 1 of the aforementioned PROMs at a minimum of 2 years postoperatively. The follow-up protocol at our institution uses an automated data-collection software system that regulates the postoperative time periods during which a patient can respond to an online patient-reported outcome survey (HOS-ADL, HOS-SS, mHHS, IHOT, VAS Pain, SF-12M, and SF-12P scores). When a patient completes these surveys, outcome scores are calculated on their respective scales. The clinical research coordinating site at our institution monitors the follow-up for these patients, and if patients fail to complete outcome surveys after the first automated notification, this staff has the opportunity to remind the patient or contact them by phone. If the a priori−determined time window to answer these questionnaires ended, then patients were locked out of answering the questionnaires for that postoperative time point. If this was the case for all outcome measures, then they were considered lost to follow-up at the particular time point.

Management of Missing Data and Pool of Covariate Prediction Variables

Variables were included only if they had less than 30% missing data, which is a threshold demonstrated to be acceptable and previous literature using machine learning.[11] Multiple imputation was applied for variables

Table 1. Baseline Patient Demographics and Potential Risk Factors Between Patients Who Completed Follow-Up and Those Who Were Lost to Follow-Up at 2 Years After Hip Arthroscopy for Femoroacetabular Impingement Syndrome

Risk Factor	Completed Follow-up (n = 1667)	Lost to follow-up (n = 446)	P Value
Age, y	32.6 ± 12.6	30.6 ± 11.9	**<.001**
BMI kg/m^2	25.1 ± 5.1	25.7 ± 5.3	**.01**
Race			**.003**
White/Caucasian	1505 (90.3%)	390 (87.4%)	
African American	35 (2.1%)	27 (6.0%)	
Other non-white/Caucasian	127 (7.6%)	29 (6.6%)	
Sex			**.008**
Male	537 (32.2%)	170 (38.1%)	
Female	1130 (67.8%)	276 (61.9%)	
Smoking status			.07
No	1207 (90.1%)	321 (86.8%)	
Yes	132 (9.9%)	52 (13.2%)	
Alcohol use			.052
No	273 (16.4%)	83 (18.7%)	
Yes	1394 (83.6%)	363 (81.3%)	
Hypertension			.82
No	1212 (90.6%)	396 (90.2%)	
Yes	126 (9.4%)	43 (9.8%)	
Diabetes (type I or II)			.06
No	1294 (96.9%)	416 (95.0%)	
Yes	41 (3.1%)	22 (5.0%)	
Autoimmune disease			.61
No	1630 (97.8%)	433 (97.3%)	
Yes	37 (2.2%)	13 (2.7%)	
Drug allergy			.20
No	820 (67.4%)	263 (68.7%)	
Yes	396 (32.6%)	120 (31.3%)	
Psychiatric illness			.68
No	1081 (85.0%)	357 (85.8%)	
Yes	191 (15.0%)	59 (14.2%)	
Previous orthopaedic surgeries			.43
No	1312 (78.7%)	359 (80.6%)	
Yes	355 (21.3%)	87 (19.4%)	
Chronic hip pain			**<.001**
No	967 (80.8%)	257 (67.6%)	
Yes	230 (19.2%)	123 (32.4%)	
Worker's compensation			.11
No	1303 (95.7%)	441 (93.8%)	
Yes	59 (4.3%)	29 (6.2%)	
Sports participation			.81
No	379 (25.8%)	113 (25.3%)	
Yes	1063 (74.2%)	333 (74.7%)	
Preoperative outcome			
HOS-ADL	64.5 ± 18.4	64.6 ± 17.7	.94
HOS-SS	41.6 ± 23.1	40.9 ± 22.8	.59
mHHS	58.3 ± 14.5	60.0 ± 14.9	**.046**
IHOT-12	35.5 ± 17.9	35.4 ± 17.8	.97
VAS Pain	61.9 ± 21.4	56.1 ± 22.3	**<.001**
SF-12M	53.1 ± 10.5	52.3 ± 10.4	.21
SF-12P	36.4 ± 9.8	35.5 ± 8.8	.15
Phone number provided			**.009**
No	890 (53.4%)	279 (62.5%)	
Yes	777 (46.6%)	167 (37.5%)	
E-mail address provided			.12
No	22 (1.5%)	25 (5.8%)	
Yes	1435 (98.5%)	403 (94.2%)	
Revision surgery			.081
No	1278 (92.8%)	306 (92.4%)	
Yes	90 (7.2%)	25 (7.6%)	

Table 1. Continued

Risk Factor	Completed Follow-up (n = 1667)	Lost to follow-up (n = 446)	P Value
Preoperative PT			.11
No	337 (25.5%)	83 (21.5%)	
Yes	987 (74.5%)	304 (78.5%)	
Preoperative CSI			**.001**
No	506 (38.6%)	188 (48.1%)	
Yes	806 (61.4%)	203 (51.9%)	

NOTE. Values are presented as means ± standard deviation or frequencies and percentages. Frequencies and percentages are representative of relative proportion of patients in cases in which all data were not available.

Differences were compared using independent *t* tests or χ^2 independence testing.

Bolded *P* values indicate statistically significant differences at the *P* < .05 level.

BMI, body mass index; CSI, corticosteroid injection; HOS-ADL, hip outcome score−activities of daily living; HOS-SS, hip outcome score−sports subscale; IHOT-12, international hip outcome tool−12 component questionnaire; mHHS, modified Harris hip score; PT, physical therapy; SF-12M, short-form 12 component questionnaire for mental health; SF-12P, short-form 12 component questionnaire for physical health; VAS, visual analog scale.

with less than 30% missing data.[12,13] Potential covariates included preoperative demographic variables routinely collected in the secure clinical repository. A total of 27 preoperative demographic variables were included age, body mass index, sex, race, smoking history, alcohol use history, hypertension, diabetes mellitus (type I or II), autoimmune conditions (systemic lupus erythematosus, etc.), history of one or more drug allergies, history of psychiatric condition, history of previous orthopaedic surgery, chronic ipsilateral hip pain (defined as a preoperative duration of FAIS associated symptoms for >2 years based off of previous literature),[14] workmen's compensation status, sports participation, preoperative HOS-ADL score, preoperative HOS-SS score, preoperative mHHS score, preoperative IHOT-12 score, preoperative VAS pain score, preoperative SF-12M score, preoperative SF-12P score, whether a phone number was provided in clinic, whether an e-mail address was provided in clinic, participation in preoperative physical therapy, preoperative corticosteroid injections. All candidate predictor variables were standardized as variables had different units of measurements and ranges of values. Missing data were diagnosed as missing at random but not missing completely at random, through Little's missing completely at random (MCAR) test, Little's covariate-dependent missingness test, and qualitative data exploration.[15]

Statistical Analysis and Development of Machine-Learning Models

The benefit of using a machine learning model to predict loss to follow-up is that doing so uses a statistically robust method of selecting only the features most predictive of the outcome from a large pool of potentially influential variables. Using such statistical methods allows the selection and regularization of a subset of variables from the initial variable pool by minimizing the number of variables through constraint such that overall prediction accuracy of the model is optimized.

An 80:20 stratified, random sample split was performed to create the training and testing sets, respectively. Least absolute shrinkage and selection operator (LASSO) analyses were conducted given the high dimensionality of our dataset. These processes use 10-fold cross validation to identify variables with the best predictive performance such that the final variable set corresponds to an optimally parsimonious model. Three LASSO models were fitted: (1) using the LASSO penalty term, λ, selected via cross-validation by minimizing deviance ("cross validation"); (2) using the LASSO penalty term, λ, that minimizes Bayes information criteria (BIC); and (3) adaptive selection. The training set was used to perform final variable selection, model building, and predictive performance assessment, whereas the testing set was used to determine performance of the final model to predict loss to follow-up.

The features selected by the LASSO model with the best performance (lowest deviance) were subsequently used to fit a logistic regression.[16] Discrimination is the ability of the selected machine learning model to efficiently distinguish between patients who were lost to follow-up and those who were not. Statistically, discrimination was assessed through generating a receiver operator curve and generating a c-statistic. A c-statistic of 1.0 indicates perfect discrimination, while a c-statistic of 0.5 indicates discrimination similar to chance.[17] Discrimination analysis of the logistic regression model was used to confirm its appropriateness. Probabilities of loss to follow-up for the testing dataset were calculated using the logistic regression model. Statistical analysis was performed using STATA version 16.1 (StataCorp, College Station, TX). Statistical significance was set at *P* < .05.

Results

A total of 2251 were identified in the initial query, of which 2113 (93.9%) patients were included in the final analysis. Of these patients, a total of 21.05% were lost

Table 2. LASSO-Selected Variables and Deviance Values for the 3 Models

	Cross-validation	Minimum BIC	Adaptive
Variables included			
Sex	x	x	x
Age	x		
BMI			x
Race	x	x	x
Smoking	x	x	x
Drug allergy	x		
Psychiatric illness			x
Chronic pain	x		
Worker's compensation			x
Sports participation	x		
HOS-SS			x
mHHS	x	x	
IHOT-12	x	x	x
Phone number	x	x	
Email address			x
CSI use			x
Revision surgery	x		
PT	x		
Deviance			
Training sample	0.91	1.55	0.91
Testing sample	1.88	1.45	1.85

NOTE. "X" indicates inclusion and estimation of variable within each respective model.

BIC, Bayes information criteria; BMI, body mass index; CSI, corticosteroid injection; HOS-SS, hip outcome score − sports subscale; IHOT-12, International Hip Outcome Tool 12-component questionnaire; mHHS, modified Harris hip Score; LASSO, least absolute shrinkage and selection operator; PT, physical therapy.

to follow-up. Statistically significance baseline differences were observed in age ($P < .001$), body mass index ($P = .01$), and race ($P = .003$), with patients who were lost to follow-up on average being older, weighing less, and composing a greater proportion of non-white patients. Additional baseline characteristics of patients in both groups are provided in Table 1.

Missing Data

Missing rates of data were as follows: Rates of missing data: smoking status: 401 (19.0%); hypertension: 336 (15.9%); diabetes: 340 (16.1%); drug allergy: 514 (24.3%); psychiatric illness: 425 (20.1%); chronic ipsilateral hip pain: 536 (25.4%); worker's compensation: 281 (13.3%); sports participation: 225 (10.6%); e-mail address: 228 (10.8%); revision surgery: 414 (20.0%; physical therapy: 402 (19.0%); corticosteroid injection: 410 (19.4%); SF-12P: 1112 (52.6%); SF-12M: 1117 (52.9%); HOS-ADL: 526 (24.9%); HOS-SS: 617: (29.2%); mHHS: 583 (27.6%); VAS Pain: 554 (26.2%); and iHOT-12: 482 (22.8%). As such, the short-form outcomes were excluded from the analysis.

Randomness of missing data was diagnosed using Little's MCAR test.[15] This test indicated that variables with missing data failed the assumption of being MCAR,

given that the resultant *P*-value $<.01$. It was subsequently determined that the data were missing at random (MAR), as performing Little's covariate-dependent missingness test with the primary outcome when adding potential auxiliary covariates of interest satisfied this assumption ($P = .76$), a case of MAR. Further exploration of the data revealed that no variable was completely dependent on another, and given that is not possible to differentiate between MAR and MNAR as the missing data is not capable of being obtained,[18] subsequent analysis was therefore conducted under the MAR assumption, and missing data was handled using a multivariate imputation chained approach.[19]

Algorithm Development and Performance

The cross-validation algorithm produced a model with 12 highly predictive variables. The minimum BIC algorithm produced a model with 6 highly predictive variables. The adaptive algorithm produced a model with 10 highly predictive variables (Table 2). The cross-validation method had the largest deviance between the training and testing sets, whereas the minimum BIC algorithm had the smallest deviance. Based on the performance of the minimum BIC algorithm, the following variables were included after variable selection from the minimum BIC model: sex, race, smoking status, providing a phone number preoperatively, preoperative IHOT-12 score, and preoperative mHHS.

The variables in this model were subsequently incorporated into a binary logistic regression analysis, the

Table 3. Statistically Significant Predictors of Loss to Follow-Up at 2 Years After Hip Arthroscopy for Femoroacetabular Impingement Syndrome Identified by a Machine-Learning Algorithm

Predictor of Loss to Follow-up	Odds Ratio	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	*P* Value
Sex				
Female	Reference			
Male	1.82	1.07	3.13	.028
Race				
White/Caucasian	Reference			
African American	2.41	1.63	7.17	.013
Other non-white/Caucasian	1.42	1.10	4.65	.042
Smoking				
Non-/past smokers	Reference			
Current smokers	1.07	1.04	1.12	.021
Phone Number				
Provided	Reference			
Did not provide	1.78	1.14	3.21	.032
Preoperative mHHS	1.05	1.02	1.08	.014
Preoperative IHOT-12	1.03	1.01	1.05	.004

NOTE. Loss of follow-up defined as failure to provide any patient-reported outcome measure at the 2-year postoperative time point.

IHOT-12, International Hip Outcome Tool 12-item component questionnaire; mHHS, modified Harris Hip Score.
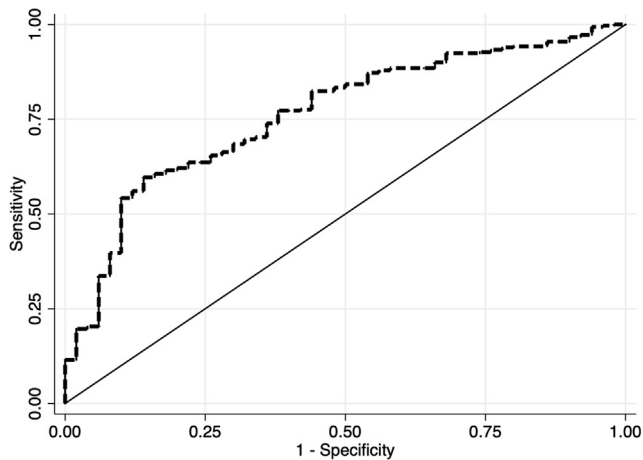
Fig 1. Receiver operator curve generated by discriminatory analysis for the logistic regression model.

results of which are displayed in Table 3. A log-likelihood χ^2 test used to evaluate the goodness-of-fit of the logistic regression model indicated that the model as a whole was statistically significant ($P = .002$). Furthermore, discriminatory analysis demonstrated that this model had good discriminatory performance (area under the curve = 0.76, 95% confidence interval 0.701-0.848, Fig 1). Inference of this model indicated that male sex (odds ratio [OR] 1.82; $P = .028$), non-white race (African American, OR 2.41, $P = .013$ and other non-white Caucasian, OR 1.42, $P = .042$), smoking (OR 1.07, $P = .021$), and failure to provide a phone number at the initial clinic visit (OR 1.78, $P = .032$) increased the risk for being lost to follow-up. Furthermore, greater scores on the IHOT-12 (OR 1.03, $P = .004$) and mHHS (OR 1.05, $P = .014$) questionnaires preoperatively increased the risk of being lost to follow-up.

Discussion

The main finding of the current study is that the final logistic regression model, using LASSO-selected features, conferred good discriminatory ability to predict which patients will be lost to follow-up after hip arthroscopy. The best performing model selected 6 variables with the strongest predictive value: sex, race, smoking, providing a phone number at initial clinic visit, preoperative IHOT-12 score, and preoperative mHHS. The identification of such variables is clinically significant in that it may allow for targeted intervention for patients undergoing hip arthroscopy for FAIS to ultimately minimize follow-up bias and to subsequently increase the generalizability of results in studies concerning the outcomes after hip arthroscopy. As such, identifying risk factors for loss to follow-up has become of recent interest in many different orthopaedic disciplines.[2,20-25]

The current study found that male patients have an 82% greater likelihood of being lost to follow-up than female patients, and that non-white/Caucasian patients

have a 141% (African American) and 42% (other non-white/Caucasian) greater likelihood of being lost to follow-up after hip arthroscopy for FAIS. Both of these risk factors are important to consider, as they are non-modifiable. Interestingly, these risk factors are in accordance with the recent study by Ramkumar et al.,[2] which sought to establish risk factors for loss to follow-up in patients who underwent (anterior cruciate ligament) anterior cruciate ligament reconstruction. The authors demonstrated that male subjects had an 80% increased likelihood of being lost to follow-up, where African American patients had a 364% increased likelihood of being lost to follow-up, whereas other non-white/Caucasian patients had an 81% increased likelihood. Male sex as a risk factor for loss to follow-up also has been demonstrated in the orthopaedic trauma[22,23] and knee ligament reconstruction[25] literature, whereas the associations of non-white race and decreased follow-up has also been widely reported throughout the arthroplasty literature.[7,26,27] The socioeconomic disparities of male sex and non-white race have also been highlighted in many other realms of medicine in terms of health outcomes and underrepresentation. Even within the hip arthroscopy literature, male and non-white patients have been demonstrated to experience inferior outcomes. These data should prompt hip arthroscopists to make greater efforts to engage with such patients during pre- and postoperative visits to increase the chance of collecting their patient-reported outcomes such that they are not underrepresented in the hip arthroscopy literature. Although this study cannot establish causation between socioeconomic status and loss to follow-up after hip arthroscopy, surgeons should be cognizant of these potential health inequalities such that follow-up is maximized and disparity is minimized.

In contrast to the aforementioned nonmodifiable risk factors for loss to follow-up, the current study also identified current smokers and those who did not provide a phone number at clinic as at-risk patients. Smoking also has been reported to be a risk factor for loss to follow-up in the orthopaedic trauma[22,23] and spine[24] literature. In the hip arthroscopy literature, smoking has been reported to be a known risk factor for inferior outcomes.[28,29] As such, the finding that these patients are also lost to follow-up makes it imperative that they are followed more closely and effort is made to engage with them to try to mitigate the potential to experience these inferior outcomes. Although causation cannot again be established, it is possible that the inferior outcomes experienced by this at-risk population is due in part to failure to follow-up whereby appropriate recommendations or adjustments in the postoperative course cannot be made by the treating surgeon.

It is both interesting and intuitive that patients who fail to provide their contact information in the form of a phone number are at risk of being lost to follow-up, as

this is one essential medium through which patients may be reached to fill out a patient-reported outcome survey. It is also interesting that the current study did not identify failure to provide an e-mail address as a risk factor; the more contact information a patient provides the more willing they may be to complete additional follow-up surveys.[2] Regardless, this finding is clinically relevant and suggests that hip arthroscopists and their administrative personnel should be persistent in trying to gather the most contact information possible.

The final variables that the current study identified to be significantly associated with the likelihood of a patient to follow-up were the preoperative IHOT-12 and mHHS scores. Specifically, a 1-point increase in preoperative IHOT-12 score elevates the risk of loss to follow-up by 3%, and a 1-point increase in the mHHS increased the likelihood by 5%. Therefore, a patient with a preoperative mHHS of 40 is 1.25 times more likely to be lost to follow-up than a patient with a preoperative mHHS of 35 (relative odds = OR*interval difference).[30] This corroborates findings reported by Ramkumar et al.[2] in which they described a lower preoperative Knee injury and Osteoarthritis Outcome Score pain score to be associated with an increased likelihood of continuing to follow-up. Although they noted that this finding was likely insignificant, as the OR was 0.98, and similarly our findings also may be insignificant, it is plausible that these patients were at risk for not meeting the minimal clinically significant improvement in function, given that greater preoperative outcome scores were associated with loss to follow-up.

As the minimal clinically important difference (MCID) is a function of overall change in outcome score, those with greater preoperative outcome scores would theoretically have a greater barrier to improve (less room to benefit) if starting at a relatively higher level of function preoperatively, and therefore they may not improve by the MCID. For example, it would be more challenging to improve by a theoretical MCID of 9.8 points for the mHHS if a patient had a preoperative mHHS of 90 compared with a patient who's preoperative mHHS was 20. This speculation was also presented in a study by Nwachukwu et al.[31] that reported lower preoperative iHOT-12 scores being predictive of achieving the MCID. This agrees with the logic the authors of this study propose—a greater preoperative iHOT-12 score may be less likely to achieve the MCID and therefore be dissatisfied with their outcome and fail to follow-up. However, given that this was not the primary aim of the current study and the MCID was not calculated, this potential reasoning is limited to speculation. Future research is warranted to investigate these relationships further, as this explanation cannot be confirmed, given the current study methodology and that psychometric variables such as the minimal clinically important difference cannot be calculated as the patients do not have postoperative outcome measures.

The results from the current study suggest that increased effort should be made to engage patients with the aforementioned risk factors by acknowledging health inequities to decrease the potential for selection bias and outcome underrepresentation in the hip arthroscopy literature. Understanding such risk factors will subsequently contribute to better understanding of disparities in patient-reported outcomes and which patients who present to hip arthroscopy clinics may be lost to follow-up. Having knowledge of such risk factors may allow for hip arthroscopists and associated health providers to target patients that fit such profiles preoperatively to increase the likelihood that they follow-up following their procedures. It may also allow for potential optimization to decrease the risk of being lost to follow-up. For example, based on the current results, it may be important to ensure that patients list their phone number at time of initial evaluation, and counseling patients to quit smoking may also prove beneficial to this end.

Limitations

Few limitations should be considered in the context of the study results. First, this is an analysis of a single site in a major metropolitan city, which may limit the generalizability of the findings to suburban and rural areas. The accessibility of resources like transportation may affect follow-up rates in some areas. Second, although we explored a comprehensive range of potential variables associated with loss to follow-up, such as insurance type, amount of co-pay, socioeconomic class, and employment status, which also may affect follow-up rates, they were not available for analysis because these variables are not routinely collected in the clinical repository. Other unexplored factors that are not routinely collected in our clinic, but may demonstrate relationships, are the presence of a support system and whether one lives alone. It is possible that some of these factors confounded the relationships identified in this study. Finally, the inability to follow the postoperative course of these patients, who may have switched providers and not followed up to reasons other than those which we identified, is a limitation. Dissatisfaction with care, social considerations such as career changes, and financial status may cause a patient to seek care at another hospital or clinic.[32] On the contrary, feeling well and not feeling the need to be seen also has been reported as a primary reason for failure to follow-up.[33]

Conclusions

Patients who are male, non-white, current smokers, fail to provide a telephone number, and have greater preoperative mHHS and IHOT-12 scores are at an increased risk for being lost to follow-up 2 years after hip arthroscopy for FAIS.

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