Predictors of Hip Pain and Function in Femoroacetabular Impingement

A Prospective Cohort Analysis

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Background: Validated patient-reported outcome measures (PROMs) of hip pain and function at the time of arthroscopy could be predictors of the final outcome. Little is known about how patient factors or pathologic intra-articular findings relate to hip pain or function at the time of surgery for those presenting with femoroacetabular impingement (FAI).

Purpose: To evaluate all patient and operative factors that contribute to hip pain and dysfunction in patients with FAI.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A prospective cohort of patients undergoing hip arthroscopy for FAI were electronically enrolled between February 2015 and September 2016. Baseline PROMs were collected, including Hip disability and Osteoarthritis Outcome Score (HOOS) for pain, HOOS–Physical Function Shortform (HOOS-PS), Veterans RAND 12-Item Health Survey (VR-12), and University of California–Los Angeles (UCLA) Activity Score. Surgeons documented intra-articular operative findings and treatment. Multivariable linear regression models were created for continuous scores of HOOS pain, HOOS-PS, and VR-12 Physical Component Score as outcome measures. Risk factors included patient characteristics and intraoperative anatomic and pathologic findings.

Results: During the study period, 396 patients underwent arthroscopic hip procedures, and 373 (94%) completed preoperative PROMs; 331 patients were undergoing arthroscopic surgery for FAI. The mean patient age was 32.91 ± 12.49 years, mean body mass index was 26.22 ± 4.92 kg/m^2, and 71% were female. Multivariate analyses demonstrated female sex, lower education levels, smoking, lower mental health scores, and lower activity-level scores predicted HOOS pain preoperatively. According to multivariate analysis, patient factors associated with worse baseline HOOS-PS include smoking, additional years of education, lower mental health, and activity scores. Lower baseline VR-12 functional scores were predicted by female sex, elevated body mass index, smoking, and lower activity levels. For all baseline PROMs, there was no instance where an arthroscopic variable or pathologic finding proved statistically significant after the important patient covariates were controlled for.

Conclusion: Patient factors, including mental health, activity level, sex, and smoking, are more predictive of baseline hip pain (as measured by HOOS) and function than are intra-articular findings (eg, status of the labrum or articular cartilage) during hip arthroscopy for FAI. Future studies evaluating patient outcomes after surgery for FAI should consider adjusting for these identified patient factors to accurately interpret the effect of treatment on patient-reported outcomes after surgery.

Keywords: hip; FAI; patient reported outcome; mental health

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Femoroacetabular impingement (FAI) is an increasingly recognized clinical entity affecting young active patients.[8,21] When left untreated, FAI has been demonstrated to predict development of osteoarthritis.[19] Surgical procedures to address FAI aim to decrease hip pain and improve hip function. The baseline measurement of joint pain and function at the time of surgery is a predictor of the final outcome.[6,24] It is important to understand which patient factors (including mental health) and arthroscopic characteristics of FAI contribute to hip pain and function. While similar studies have been performed on the shoulder,[25] knee,[3,6,10] and spine,[9] no comprehensive study inclusive of patient factors and intra-articular findings has been performed on

baseline predictors of hip pain and function among patients with FAI.

Little is known about what factors contribute to symptom severity in the FAI population. Using univariate analysis, Nepple et al[17] evaluated differences in hip pain measurements between men and women at the time of presentation. They determined that women had worse baseline hip function and pain scores despite less severe anatomic and operative findings. Potter et al[23] found that, after adjusting for important patient comorbidities, the patient's distress risk negatively affected baseline hip pain and function scores. Their study did not, however, evaluate or adjust for intra-articular pathology observed at the time of hip arthroscopy.

The purpose of the present study was to comprehensively evaluate patient and operative factors that contribute to hip pain and dysfunction in patients with FAI. We hypothesized that patient factors, including smoking and mental health, would more strongly correlate with validated patient-reported outcome measures of hip pain and function as compared with the presence or extent of the intra-articular hip pathology (eg, status/presence of damage to the cartilage or labrum) in patients undergoing surgery for FAI.

METHODS

The study was approved by the Cleveland Clinic Foundation's Institutional Review Board and was Health Insurance Portability and Accountability Act compliant. Patients undergoing hip arthroscopy for treatment of FAI (with alpha angles >50°) were prospectively enrolled in a longitudinal cohort, and those undergoing surgery between February 2015 and September 2016 at the Cleveland Clinic Sports Health Center were included. Exclusion criteria included dysplasia, infection, isolated psoas release, and isolated gluteus medius repair.

Patient Data Collection

On the day of surgery, patients were requested to complete the Hip disability and Osteoarthritis Outcome Score (HOOS)[13-15,20] for pain, the HOOS–Physical Function Shortform (HOOS-PS),[4] the University of California–Los Angeles (UCLA) Activity Score,[2,12] and the Veterans RAND 12-Item Health Survey (VR-12) Mental Component Score (MCS) and Physical Component Score (PCS) as baseline measures. Demographic information and major risk factors were recorded and included sex, age, body mass index, smoking status, and years of education. Data were electronically collected via tablet by the OME system (OrthoMiDaS Episode of Care) and stored in a REDCap (Research Electronic Data Capture)[11] database managed by the Cleveland Clinic Foundation's Musculoskeletal Outcomes Research Center. A mean data collection time of 6 minutes per patient was observed, and complete preoperative data were collected on 94% of patients undergoing hip arthroscopy during the study period.

Surgeon Data Collection

With enrollment of patients into the prospective cohort, the OME system generated an automatic email for each case and sent it to the surgeon; this contained a link that allowed for mobile data entry immediately following each hip arthroscopy case. These data collection forms employed branching logic to efficiently capture operative variables believed to be important predictors of outcome, including the status of the labrum and articular cartilage and the presence and characteristics of cam and/or pincer deformities (Appendix). The mean data collection time for surgeons was <2 minutes per case. Data for each surgical case were stored in the same REDCap database and linked with the patient-reported data.

Patient-Reported Outcome Measures

The validated patient-reported outcome measure used to evaluate baseline hip pain was the HOOS pain subscale.[4,13-15,20] This is a 0- to 100-point scale, where 100 represents the absence of hip pain and a lower number represents worse hip pain. The HOOS-PS[22] was used to assess hip function; it is reported on a 0- to 100-point scale, where a score of 100 represents perfect hip function and lower scores represent worse hip function. The UCLA Activity Score[2,12] grades physical activity on a scale of 1 to 10, where 1 is a low activity level and 10 is a high activity level. The VR-12 MCS and PCS are norm-based scales where 50 represents the mean score of a nonpatient population, higher scores indicate better health, and every 10 points represents 1 standard deviation.

Variables and Statistical Methods

Multivariate ordinary least squares (OLS) regression models were constructed via backward selection according to the Bayesian information criterion. These regression models were created for continuous scores of baseline HOOS pain, HOOS-PS, and VR-12 PCS as dependent variables. The candidate predictor set included all patient characteristics, including terms representing interactions between patient age and education, as well as all arthroscopic findings. For each outcome (HOOS pain, HOOS-PS, and VR-12 PCS), the selected model was composed of the predictor variables that together were best able to explain the outcome and so was considered the outcome's "reference" model. Each reference model was then used as a multivariate context in which to test for a relationship between each arthroscopic finding and the outcome (ie, to test for a relationship while controlling for the important predictor variables present in the model). This was accomplished by adding, one by one, each arthroscopic finding variable to the reference model, checking for significance, and removing it. All analyses were performed with R software (v 3.2.3). All testing was 2-sided and considered significant at the 5% level ($P < .05$).

RESULTS

During the study period, 396 patients underwent hip arthroscopy, and 373 (94.2%) completed preoperative

TABLE 1
Baseline Scores and Characteristics of Patients Undergoing Hip Arthroscopy for Femoroacetabular Impingement[a]

Variable	No.	Mean	SD	Min	P25	Median	P75	Max
HOOS								
Pain	331	46.36	17.5	0	37.5	47.5	57.5	90
PS	331	59.19	18.23	9.2	49.2	62.3	73.1	100
VR-12								
PCS	331	32.09	10.12	8.84	25.36	31.77	39.29	55.99
MCS	331	52.53	12.18	11.95	45.65	55.37	61.63	73.3
UCLA Activity Score, 1-10 scale[b]	324	5.1	2.6	1	3	4	6	10
Age at date of surgery, y	331	32.91	12.49	13	21.5	33	43	67
Body mass index	327	26.22	4.92	15.8	22.66	25.4	28.77	46.29
Years of education	331	13.8	3.37	0	12	14	16	23

[a]HOOS, Hip disability and Osteoarthritis Outcome Score; MCS, Mental Component Score; P25/P75, 25th/75th percentile; PCS, Physical Component Score; PS, Physical Function; UCLA, University of California–Los Angeles; VR-12, Veterans RAND 12-Item Health Survey.
[b]Activity score: 1 = low, 10 = high.

TABLE 2
Documented Intra-articular Pathologic Variables
Identified Upon Diagnostic Arthroscopy

Factor	No.	%
Revision surgery		
No	268	80.97
Yes	17	5.14
Labral tear		
No	15	4.53
Yes	316	95.47
Pincer deformity		
None	99	29.91
Yes, without contrecoup	159	48.04
Yes, with contrecoup	73	22.05
Chondrolabral separation		
No	257	77.64
Yes	74	22.36
Cartilage lesion grade		
No cartilage lesion or grade I or II	289	87.31
Grade III or IV	42	12.69
Cam lesion		
No	22	6.65
Yes	309	93.35

patient-reported outcome measures; after exclusion of isolated psoas tendon releases and gluteus medius repairs, 331 patients were identified to have undergone arthroscopic surgery for FAI and were enrolled. The mean patient age was 32.91 ± 12.49 years; the body mass index was 26.22 ± 4.92; and 71% were female. The mean baseline scores were 46.36 ± 17.50 for HOOS pain 59.19 ± 18.23 for HOOS-PS, and 32.09 ± 10.12 for VR-12 PCS (Table 1). Intra-articular findings are documented in Table 2.

Risk Factors for Hip Pain (HOOS Pain)

When controlling for the other covariates, the multivariate OLS regression "reference" model indicated that men tend to have higher HOOS pain scores than women ($P < .001$) and smokers have lower scores than nonsmokers ($P < .001$).

Patients with more years of education also tended to have higher HOOS pain scores ($P < .001$), but this relationship varied with the age of the patient, as represented in the model via an education × age group interaction. Patients aged 20 to 49 years showed an expected 1.05-point increase in HOOS pain score for every year of education. Among patients aged 13 to 19 years, the relationship was stronger, with an expected increase of 1.66 points for every year of education. For patients aged ≥50 years, the relationship was weaker, with an expected increase of 0.50 points for every year of education. There was also a positive association between HOOS pain and VR-12 MCS ($P = .003$) and UCLA Activity Score ($P < .001$) (Figure 1).

In the context of important patient factors in the model, surgical factors, including revision surgery ($P = .564$), chondrolabral separation ($P = .099$), and cartilage lesion grade III or IV ($P = .188$), failed to show a significant association with hip pain (Appendix).

Risk Factors for Hip Function (HOOS-PS)

When controlling for the other covariates, the multivariate OLS regression "reference" model indicated that smokers have lower HOOS-PS scores than nonsmokers ($P < .001$). There was a positive association between HOOS-PS and VR-12 MCS ($P = .005$) and UCLA Activity Score ($P < .001$) (Figure 2). For most patients in most age groups, there was no statistically significant relationship between education and HOOS-PS. However, for patients aged ≥50 years, there was a negative relationship between education and HOOS-PS. Operative variables did not predict hip function at the time of surgery in the context of important patient factors in the model (Appendix).

Risk Factors for Low VR-12 PCS

When controlling for the other covariates, the multivariate OLS regression "reference" model indicated that smoking ($P < .001$) and elevated body mass index ($P = .003$) predict lower VR-12 PCS. Factors that predict higher VR-12 PCS were higher UCLA Activity Score ($P < .001$) and male sex
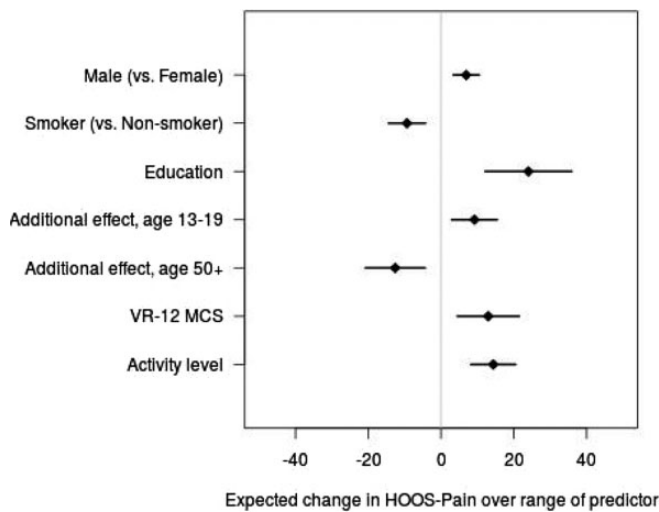
Figure 1. Baseline predictors of hip pain (HOOS pain). The plot depicts the expected difference in HOOS pain for a "full scale" difference in each predictor variable, holding the other predictor variables in the model constant. "Full scale" means increasing the value of a variable from its minimum to its maximum (or "absent" to "present" for a binary variable). Male sex, more years of education (especially for patients aged 13-19 years but not as much for patients ≥50 years old), higher VR-12 MCS, and higher activity levels are associated with higher HOOS pain scores (less pain); smoking was associated with lower HOOS pain scores (more pain). Values are presented as changes to the HOOS-Pain score (range, 0-100). HOOS, Hip disability and Osteoarthritis Outcome Score; VR-12 MCS, Veterans RAND 12-Item Health Survey Mental Component Score.

($P = .001$) (Figure 3). Operative variables (including revision hip arthroscopy, cartilage, and labral status) did not predict VR-12 PCS at the time of surgery in the context of important patient factors in the model (Appendix).

DISCUSSION

The present study determined that patient characteristics had stronger relationships with the response variables (hip pain and function) than did the intraoperative variables observed during hip arthroscopy, including the status of the labrum and articular cartilage. Indeed, no intra-articular findings variable proved to be statistically significant in the context of the selected patient characteristics for any of the 3 outcomes. When controlling for other important predictors, smoking was associated with worse hip pain and function, and higher patient activity levels were associated with less pain and improved functional scores. Interestingly, patients presenting for revision hip arthroscopy did not have worse baseline scores when compared with the primary FAI surgical cohort. Additionally, male sex and high VR-12 MCS were each associated with less severe hip pain and improved function on 2 of the 3 outcomes. Several of these findings warrant further discussion.
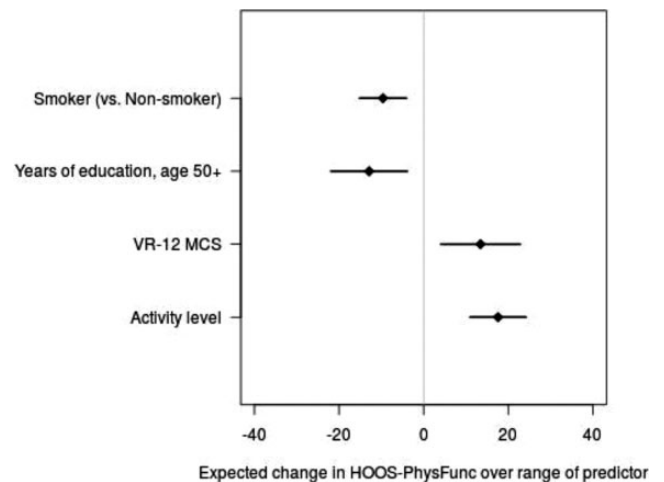

Figure 2. Baseline predictors of hip function (HOOS-PS). The plot depicts the expected difference in HOOS-PS for a "full scale" difference in each predictor variable, holding the other predictor variables in the model constant. "Full scale" means increasing the value of a variable from its minimum to its maximum (or "absent" to "present" for a binary variable). Higher VR-12 MCS and higher activity levels are associated with higher HOOS-PS (improved hip function); smoking and fewer years of education for patients ≥50 years old predict lower HOOS-PS scores (worse function). Values are presented as changes to the HOOS-PS score (range, 0-100). HOOS-PS, Hip disability and Osteoarthritis Outcome Score—Physical Function Shortform; VR-12 MCS, Veterans RAND 12-Item Health Survey Mental Component Score.

Smoking and patient activity levels have a profound impact on validated patient-reported measures of hip pain and function. We determined that current smoking had negative impacts on hip pain and function as measured by HOOS and VR-12 PCS after correcting for all pertinent patient and surgical factors. The present study corroborates the previously demonstrated association between smoking and lower baseline measures of hip pain and function.[23] Also, using multivariate analysis, Kamath et al[12] found smoking to negatively affect patient-reported outcomes 4.8 years after hip arthroscopy. Smoking therefore has been demonstrated to have meaningful impacts on patient-reported assessments of hip pain before and after surgery. Kamath et al also determined that higher UCLA Activity Scores at the time of surgery portended improved patient-reported outcomes. Our data suggest that patients with higher activity levels and/or nonsmoking status likely had higher baseline scores prior to surgery, and this could partially explain the positive difference in 5-year outcomes. Smoking status and activity level are important predictors of hip pain, function, and outcome; this information can be used clinically to counsel patients, and these factors should be corrected for use with multivariate analysis in the evaluation of outcomes after arthroscopy for FAI.

Recent studies have reported that patients undergoing revision hip arthroscopy have lower baseline scores and outcomes at 2 years.[5,18] Domb et al[5] evaluated 107 cases
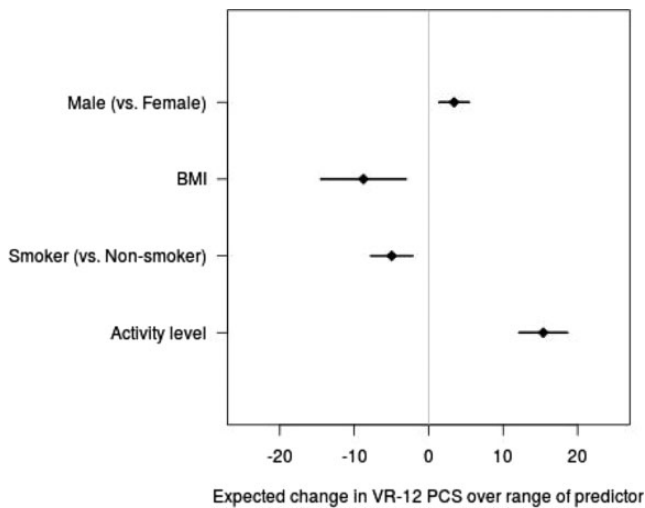
Figure 3. The plot depicts the expected difference in VR-12 PCS for a "full scale" difference in each predictor variable, holding the other predictor variables in the model constant. "Full scale" means increasing the value of a variable from its minimum to its maximum (or "absent" to "present" for a binary variable). Male sex and higher activity levels are associated with higher VR-12 PCS scores; smoking and elevated BMI predict lower VR-12 PCS scores. Values are presented as changes to the VR-12 PCS score (range, 0-100). BMI, body mass index; VR-12 PCS, Veterans RAND 12-Item Health Survey Physical Component Score.

of revision hip arthroscopy and compared these with a large cohort of patients who underwent primary hip arthroscopy. They determined that patients undergoing revision hip arthroscopy had worse measures of joint pain and function at all time points measured. A limitation of their analysis is the use of univariate methods and the inability to control for important patient factors that the present study has highlighted. Newman et al[18] reported worse baseline and 2-year follow-up scores in revision hip arthroscopy. Interestingly, they found that a patient undergoing a first revision was similar to a primary, but when second or greater revisions were being undertaken, this profoundly influenced outcomes. Again, no patient factors were corrected for (smoking, education, mental health) in their matched-cohort design. In the present study, there was no statistically significant evidence to support worse baseline scores among patients undergoing revision surgery in either a univariate or multivariate context. Although the subset of patients undergoing multiple revisions in the present study was low and may have lacked the power to be statistically significant, we urge that future studies evaluating the influence of revision surgery on patient pain and function should correct for important patient factors, including sex, smoking, activity level, and some measure of mental health to accurately assess the impact on patient outcome.

Patient age and sex have been cited as important predictors of outcomes following hip arthroscopy.[7,17] Nepple et al[17] compared baseline hip pain and functional scores between men and women using univariate analysis based on 100 patients. They determined that women had worse pain (measured by HOOS, Western Ontario and McMaster Universities Arthritis Index, and modified Harris Hip Score) and lower functional scores as measured by the SF-12 when compared with men prior to surgery despite less severe radiographic measurements. They did not control for age or smoking, and no multivariate analysis was used. While the present study assessed preoperative measures of hip pain and function, it corroborates sex as an important predictor of baseline hip pain, more so than anatomic or pathologic findings at the time of hip surgery. Frank et al[7] evaluated the outcomes of 150 patients who underwent hip arthroscopy for FAI and determined that advanced age and female sex had adverse influences on Hip Outcome Score and modified Harris Hip Score 34 months from surgery. Our study determined that age was not a significant predictor of baseline hip pain or function when controlling for other important patient factors.

Mental health is an important determinant of self-reported hip pain and function and is infrequently evaluated in the FAI literature.[23] Our study found that a patient's mental health status was associated with clinically important differences in hip pain and function. Mental health has been evaluated as a predictor of outcome in other orthopedic conditions.[1,3,25] Brander et al[3] prospectively evaluated 116 patients undergoing knee arthroplasty and found that preoperative depression or anxiety was associated with worse knee pain 1 year after surgery. They also determined that worse preoperative pain scores were associated with slower recovery after surgery and more frequent need for knee manipulations. In a cross-sectional study of baseline shoulder pain and function in patients with rotator cuff tears, Wylie et al[25] found that mental health more strongly correlated with self-reported shoulder pain and function than did rotator cuff tear characteristics. Similarly, our study found that the status of a patient's mental health more strongly correlated with hip pain and function than did any intra-articular findings, including labrum and cartilage status, adjusting for all important patient variables. Future studies evaluating outcomes after surgery for FAI should correct for baseline mental health to accurately determine the treatment effect on outcome.

The present study has several strengths. It is a prospective cohort with enrollment of 98%, thereby avoiding patient selection bias inherent to current studies evaluated during literature review. We utilized validated outcome instruments for hip pain, function, and activity level, including the HOOS, which performs well in hip arthroscopy study populations.[13] Finally, we used multivariate analysis to control for all important patient and surgical factors that have been cited to influence patient outcome. This is the first comprehensive study to determine baseline predictors of hip pain and function in the FAI population that was able to control for patient characteristics (smoking, education, activity level, sex) and intra-articular findings diagnosed on arthroscopy (cartilage and labral status, cam and pincer deformities).

This study does have some limitations. First, it measured baseline hip pain and function and did not assess

the influence of these factors on outcomes after surgery. Follow-up is currently being collected on this cohort of patients. Data were captured on the day of surgery in our study. Many of the comparable studies utilized data capture at different time points (weeks to months) prior to surgery; this may influence how baseline measures of joint pain and function are interpreted. Also, as all patients had committed to a surgical procedure for correction of a hip injury or pathologic anatomy, there was no control group without intra-articular hip pathology; if this cohort were compared with patients with asymptomatic hips, it would be expected that intra-articular findings, such as labral tears and chondral damage, would be associated with worse pain and function. Also, no radiographic assessments were made, and these may contribute to findings on hip arthroscopy.[16] A greater number of cases could improve the power of the study, and enrollment continues. Workers' compensation status was not evaluated and could be a factor contributing to patient-reported measures of health. Last, the study was performed in a single hospital network and may not be generalizable to all populations.

CONCLUSION

Patient factors, including mental health, sex, education, activity level, and smoking status, are important predictors of patient-reported hip pain and function in FAI. Conversely, for all outcome variables, there was no instance where an arthroscopic variable or finding proved statistically significant after the important covariates were controlled for. Future studies should correct for these important identified patient variables to accurately assess the outcome of patients treated operatively for FAI.

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APPENDIX

Variables collected by the surgeon after each hip arthroscopy case:

- Patient height/weight
- Prior surgical history of the hips
- Examination under anesthesia (range of motion)
- Labrum
  - Diagnosis
  - Labral tear repair type
  - Implants
- Acetabulum defects
- Articular cartilage
  - Chondrolabral separation/treatment
  - Isolated lesions/treatment
- Femur
  - Cam lesion/treatment
  - Capsulotomy/treatment
- Additional surgical procedures
- Anesthesia
- Traction time

HOOS Pain

After backward variable selection, the model presented in Table A1 was selected as the reference predictive model for HOOS pain. Note that, although they were available to the backward variable selection algorithm, no arthroscopic findings variables were selected for inclusion in the model.

Next, each arthroscopic findings variable is considered in the context of the reference predictive model. Table A2 shows the coefficient, standard error, 95% CI, and P value for each arthroscopic findings variable were it to be added to the reference model. That is, it shows the results for the test

TABLE A1
HOOS Pain: Multivariate Reference Model[a]

Term	Coefficient	SE	95% CI on Coefficient	P Value
Intercept	11.4	5.07	1.45 to 21.4	.025
Male (vs female)	6.92	1.82	3.34 to 10.5	<.001
Smoker (vs nonsmoker)	−9.38	2.58	−14.5 to −4.3	<.001
Education (per year)	1.05	0.264	0.526 to 1.56	<.001
Additional effect for 13- to 19-y-olds	0.612	0.213	0.193 to 1.03	.004
Additional effect for ≥50-y-olds	−0.549	0.182	−0.907 to −0.191	.003
VR-12 MCS (per unit)	0.212	0.0707	0.0724 to 0.351	.003
Activity level (per UCLA unit)	1.59	0.348	0.91 to 2.28	<.001

[a]Model: multiple $R^2 = 0.31$, $F_{7,316} = 20.3$, $P < .001$. UCLA, University of California–Los Angeles Activity Score; VR-12 MCS, Veterans RAND 12-Item Health Survey Mental Component Score.

for an association between each variable and HOOS pain, controlling for all the variables in the reference model.

HOOS-PF

After backward variable selection, the model presented in Table A3 was selected as the reference predictive model for HOOS-PF. Note that, although they were available to the backward variable selection algorithm, no arthroscopic findings variables were selected for inclusion in the model.

TABLE A2
HOOS Pain: Testing Arthroscopic Findings Variables in Context of Multivariate Reference Model[a]

Term	Coefficient	SE	95% CI on Coefficient	P Value
Revision surgery	—	—	—	.737
Yes vs no	−2.16	3.73	−9.49 to 5.18	.564
No tear was repaired vs no	1.14	2.54	−3.86 to 6.14	.653
Labral tear (yes vs no)	−6.9	3.9	−7.73 to 0.673	.078
Pincer deformity	—	—	—	.276
Yes, without contrecoup	0.0018	1.97	−3.87 to 3.88	.999
Yes, with contrecoup	−3.2	2.4	−7.93 to 1.53	.184
Chondrolabral separation (yes vs no)	−3.53	2.13	−7.73 to 0.673	.099
Cartilage lesion				
Grade (III or IV vs none, I, or II)	−3.5	2.65	−8.71 to 1.71	.188
Location (cartilage lesion vs none)	−0.305	2.45	−5.12 to 4.51	.901
Cam lesion (yes vs no)	2.23	3.29	−4.24 to 8.71	.498

[a]Note that none of the arthroscopic findings variables showed a statistically significant association with the response variable in the context of the reference model. This means that there is no evidence that any arthroscopic findings variable adds information above what is available in the reference model for understanding or predicting HOOS pain. See the Discussion section for a note on power as a limitation of this result.

TABLE A3
HOOS-PF: Multivariate Reference Model[a]

Term	Coefficient	SE	95% CI on Coefficient	P Value
Intercept	39.8	4.2	31.5 to 48	<.001
Smoker (vs nonsmoker)	−9.61	2.82	−15.2 to −4.07	<.001
Years of education for patients aged ≥50 y	−0.56	0.2	−0.953 to −0.167	.005
VR-12 MCS (per unit)	0.219	0.0776	0.0665 to 0.372	.005
Activity level (per UCLA unit)	1.95	0.373	1.22 to 2.69	<.001

[a]Model: multiple $R^2 = 0.209$, $F_{4,319} = 21.11$, $P < .001$. UCLA, University of California–Los Angeles Activity Score; VR-12 MCS, Veterans RAND 12-Item Health Survey Mental Component Score.

Next, each arthroscopic findings variable is considered in the context of the reference predictive model. Table A4 shows the coefficient, standard error, 95% CI, and *P* value for each arthroscopic findings variable were it to be added to the reference model. That is, it shows the results for the test for an association between each variable and HOOS-PF, controlling for all the variables in the reference model.

VR-12 PCS

After backward variable selection, the model presented in Table A5 was selected as the reference predictive model for VR-12 PCS. Note that, although they were available to the backward variable selection algorithm, no arthroscopic findings variables were selected for inclusion in the model.

Next, each arthroscopic findings variable is considered in the context of the reference predictive model. Table A6

shows the coefficient, standard error, 95% CI, and *P* value for each arthroscopic findings variable were it to be added to the reference model. That is, it shows the results for the test for an association between each variable and VR-12 PCS, controlling for all the variables in the reference model.

TABLE A5
VR-12 PCS: Multivariate Reference Model[a]

Term	Coefficient	SE	95% CI on Coefficient	*P* Value
Intercept	30.5	2.85	24.9 to 36.1	<.001
Male (vs female)	3.41	1.03	1.38 to 5.43	.001
Body mass index	−0.288	0.0958	−0.476 to −0.0992	.003
Smoker (vs nonsmoker)	−4.97	1.43	−7.79 to −2.15	<.001
Activity level (per UCLA unit)	1.71	0.184	1.35 to 2.07	<.001

[a]Model: multiple $R^2 = 0.318$, $F_{4, 315} = 36.8$, $P < .001$. UCLA, University of California–Los Angeles Activity Score.

TABLE A4
HOOS-PF: Testing Arthroscopic Findings Variables
in Context of Multivariate Reference Model[a]

Term	Coefficient	SE	95% CI on Coefficient	*P* Value
Revision surgery	—	—	—	.895
Yes vs no	−0.985	4.14	−9.13 to 7.16	.812
No tear was repaired vs no	1.06	2.82	−4.48 to 6.6	.707
Labral tear (yes vs no)	−3.76	4.33	−5.53 to 3.02	.385
Pincer deformity	—	—	—	.824
Yes, without contrecoup	−0.717	2.15	−4.95 to 3.52	.739
Yes, with contrecoup	−1.6	2.59	−6.69 to 3.5	.538
Chondrolabral separation (yes vs no)	−1.25	2.17	−5.53 to 3.02	.565
Cartilage lesion				
Grade (III or IV vs none, I, or II)	−0.298	2.93	−6.06 to 5.46	.919
Location (cartilage lesion vs none)	1.73	2.7	−3.58 to 7.04	.522
Cam lesion (yes vs no)	5.4	3.61	−1.7 to 12.5	.136

[a]Note that none of the arthroscopic findings variables showed a statistically significant association with the response variable in the context of the reference model. This means that there is no evidence that any arthroscopic findings variable adds information above what is available in the reference model for understanding or predicting HOOS-PF. See the Discussion section for a note on power as a limitation of this result.

TABLE A6
VR-12 PCS: Testing Arthroscopic Findings Variables
in Context of Multivariate Reference Model[a]

Term	Coefficient	SE	95% CI on Coefficient	*P* Value
Revision surgery	—	—	—	.696
Yes vs no	−0.767	2.11	−4.92 to 3.38	.716
No tear was repaired vs no	−1.1	1.38	−3.82 to 1.62	.427
Labral tear (yes vs no)	−1.92	2.28	−3.34 to 1.45	.401
Pincer deformity	—	—	—	.733
Yes, without contrecoup	0.721	1.13	−1.5 to 2.94	.523
Yes, with contrecoup	0.978	1.35	−1.68 to 3.63	.469
Chondrolabral separation (yes vs no)	−0.943	1.22	−3.34 to 1.45	.439
Cartilage lesion				
Grade (III or IV vs none, I, or II)	−1.93	1.43	−4.74 to 0.874	.177
Location (cartilage lesion vs none)	−0.613	1.3	−3.18 to 1.95	.638
Cam lesion (yes vs no)	3.16	1.88	−0.53 to 6.86	.093

[a]Note that none of the arthroscopic findings variables showed a statistically significant association with the response variable in the context of the reference model. This means that there is no evidence that any arthroscopic findings variable adds information above what is available in the reference model for understanding or predicting VR-12 PCS. See the Discussion section for a note on power as a limitation of this result.