

Predictors of Pain and Function Before Knee Arthroscopy

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Background: Patient-reported outcome measures are commonly used to measure knee pain and functional impairment. When structural abnormality is identified on examination and imaging, arthroscopic partial meniscectomy and chondroplasty are commonly indicated for treatment in the setting of pain and decreased function.

Purpose: To evaluate the relationship between patient characteristics, mental health, intraoperative findings, and patient-reported outcome measures at the time of knee arthroscopy.

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

Methods: Between February 2015 and October 2016, patients aged 40 years and older who were undergoing routine knee arthroscopy for meniscal and cartilage abnormality, without reconstructive or restorative procedures, were prospectively enrolled in this study. Routine demographic information was collected, and the Knee Injury and Osteoarthritis Outcome Score (KOOS) Pain, Quality of Life (QoL), and Physical Function Short Form (PS) subscales and the mental and physical component subscales of the Veterans RAND 12-Item Health Survey (VR-12 MCS and VR-12 PCS) were administered preoperatively on the day of surgery. Intraoperative findings were collected in a standardized format. Patient demographics, intraoperative findings, and the VR-12 MCS were used as predictor values, and a multivariate analysis was conducted to assess for relationships with the KOOS and VR-12 as dependent variables.

Results: Of 661 eligible patients, baseline patient-reported outcomes and surgical data were used for 638 patients (97%). Lower scores on both subscales of the VR-12 were predicted by female sex, positive smoking history, fewer years of education, and higher body mass index (BMI). All KOOS subscales were negatively affected by lower VR-12 MCS scores, female sex, lower education level, and higher BMI in a statistically meaningful way. Positive smoking history was associated with worse scores on the KOOS-PS. Abnormal synovial status was associated with worse KOOS-Pain.

Conclusion: The demographic factors of sex, smoking status, BMI, and education level had an overwhelming impact on preoperative KOOS and VR-12 scores. Of interest, mental health as assessed by the VR-12 MCS was also a consistent predictor of KOOS scores. The only intraoperative finding with a significant association was abnormal synovial status and its effect on KOOS-Pain scores.

Keywords: knee pain; knee function; patient-reported outcome measures; knee arthroscopy

Outpatient knee arthroscopy is one of the most commonly performed orthopaedic procedures in the United States. Its incidence has increased at rates surpassing the corresponding population growth, with nearly 1 million procedures reported in 2006.¹⁸ Preoperative patient-reported outcome measures can influence postoperative outcomes after knee reconstruction and arthroplasty.^{4,21,29} To study patient outcomes, a comprehensive understanding of factors that influence common patient-reported outcome measures is warranted. Given the aggregate cost associated with knee arthroscopy nationwide, it is important to identify factors that influence preoperative measures to better understand postoperative outcomes.

Because of the widespread application of knee arthroscopy for the treatment of meniscal tears and chondral injuries in the middle-aged population, its use has come under scrutiny, with some studies casting doubt over the efficacy of arthroscopy compared with nonsurgical treatment modalities.^{14,17,27} Multiple studies have also brought into question the cause of perceived knee symptoms for patients whose pain and level of function are commonly attributed to structural abnormality found on imaging or at the time of surgery. Although some authors have demonstrated that knee abnormality or synovial biomarkers²⁴ can be associated with patients' pain and function, other authors have found demographic factors to be more predictive.^{3,5,6,10,12,20,26,30,31} Aside from physical attributes and abnormalities, the mental health of patients with common musculoskeletal conditions can be an important predictor of pain and functional outcomes.^{1,7,13,34}

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A recent study by Tornbjerg et al³⁰ in a European population examined the relationship between intraoperative findings at the time of knee arthroscopy and preoperative scores on 3 subscales of the Knee injury and Osteoarthritis Outcome Score (KOOS): Pain (KOOS-Pain), Function in Sport and Recreation (KOOS-Sport/Rec), and Function in Activities of Daily Living (KOOS-ADL). No strong associations between structural abnormality and outcomes were identified. The current cross-sectional study encompasses a larger American cohort and additionally examines the effect of preoperative mental health on overall pain and function. Our hypothesis was that although structural abnormality might not relate to patient-reported outcome measures, patient demographics as well as mental health would have a significant impact on baseline knee pain and function.

METHODS

This study was approved by a local institutional review board. Patients age 40 years and older undergoing unilateral knee arthroscopy for partial meniscectomy and/or chondroplasty at our institution were prospectively enrolled between February 2015 and October 2016. Patients were excluded if they had a prior surgery on the ipsilateral or contralateral knee other than a knee arthroscopy for partial meniscectomy and/or chondroplasty, if they had an intraoperative diagnosis of an anterior cruciate ligament injury, or if they were undergoing concomitant procedures including ligamentous repair or reconstruction, osteotomy, removal of hardware, irrigation and debridement, microfracture, autologous chondrocyte implantation, or osteochondral autograft or allograft transfer.

On the day of surgery, patients were asked preoperatively to complete a Veterans RAND 12-Item Health Survey (VR-12), which assesses general health and has both a Physical Component Score (VR-12 PCS) and a Mental Component Score (VR-12 MCS). Patients were also asked to complete several portions of the KOOS, including the

KOOS-Pain, Physical Function Short Form (KOOS-PS), and Quality of Life (KOOS-QoL) subscales to assess knee health.^{11,33} Demographic information, including sex, age, body mass index (BMI), education, and smoking status, was also collected. Data were entered by the patient on an electronic tablet. All information was collected and managed on a secure online Research Electronic Data Capture (REDCap) database managed by our institution.¹⁶

At the conclusion of each surgery, a secure email was sent to the primary surgeon with an electronic link to a data entry system. This system, using branching logic, efficiently collects detailed intraoperative findings; it is designed to be completed promptly after surgery on a smartphone or similar device and stores that information in a secure REDCap database.

Groupings were made of similar intraoperative predictor values to decrease the number of independent variables and decrease the chance that meaningful associations would be subject to type II error. Cartilage and meniscal lesions were grouped into distinct categories based on the similarity of the lesions. Cartilage groupings included grade 0 or 1 lesions, grade 2 focal lesions, grade 2 diffuse lesions, grade 3 or 4 focal lesions, and grade 3 or 4 diffuse lesions. Meniscal lesions were categorized as normal, oblique or flap tears, longitudinal or bucket-handle tears, radial tears, root tears, or horizontal or complex tears. Ipsilateral and contralateral knee range of motion in 5° increments and the presence of a flexion contracture were also noted but were not used in the statistical analysis, as most participating surgeons did not measure these parameters with a goniometer and it was believed that the data might not be consistently accurate.

With the KOOS and VR-12 scores used as outcome variables, univariate and multivariate analyses were conducted with patient demographic data and intraoperative findings as predictor variables. The VR-12 MCS doubled as a predictor variable in analysis of the remaining outcome scores to determine the effect of a patient's mental health on his or her perceived overall and knee-specific function,

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Ethical approval for this study was obtained from Cleveland Clinic Institutional Review Board.

pain, and quality of life. For the univariate analysis, the categorical predictors and outcome variables were compared by use of the Welch 2-sample *t* test or 1-way analysis of variance, whereas Pearson correlations were used to measure and test associations between numerical predictors and the outcome variables.

To control for confounders, multivariate analysis was conducted. Outcome variables were modeled by ordinary least squares regression. Predictor variables were selected in a backward-stepwise manner according to *P* values with a retention threshold of .05. Remaining predictors were added and removed from each model individually to ensure that no important variables were omitted. All analyses were performed with R software (R version 3.3.2), and all testing was 2-sided and considered significant at the 5% level.

RESULTS

A total of 661 patients were identified at our institution according to the inclusion and exclusion criteria. No data for the KOOS and VR-12 scores were available for 13 patients. Ultimately, 648 patients were available for investigation, more than 98% of the initial eligible cohort. In 10 of these patients, the surgeon noted a prior partial excision of the medial or lateral meniscus when describing the meniscal status. These groups were deemed too small to independently analyze by meniscal tear status and type, and from the surgeon-collected data available it was unclear which of the remaining meniscal groups these patients should be categorized under. A decision was made to exclude these patients from analysis, leaving almost 97% (*n* = 638) of the initially eligible cohort.

The patient data used in the final analysis were contributed by 18 surgeons. Only 4 data points were missing in the entirety of the remaining data: 3 KOOS subscale scores and 1 medial meniscal tear type. Data from these patients were used except for observations directly related to the missing values. Numerical predictors are summarized in Table 1, and categorical predictors are summarized in Table 2. Univariate and multivariate analyses were completed for all outcome variables, and the results are summarized in Table 3.

Either a flexion contracture or a difference in knee extension of 5° or more with normal flexion (equal to the nonoperative knee and ≥120°) was noted in 28 patients. Knee flexion less than 120° or any difference in knee flexion of 5° or more with normal extension (no flexion contracture and equal to the nonoperative knee) was noted in 74 patients. Abnormalities in both flexion and extension were noted in 10 patients.

Considering VR-12 MCS as an outcome variable, the multivariate model displayed a low *R*² of 0.0647, meaning that only 6.5% of the variance in VR-12 MCS was explained by the model. The same variables that were associated on the univariate model were all significant on the multivariate model (female sex, *P* = .049; positive smoking status, *P* < .001; fewer years of education, *P* = .02; and higher BMI, *P* < .001), whereas no new variables

TABLE 1
Numerical Variables at Time of Surgery^a

Numerical Variable	Mean ± SD	Q1	Median	Q3
Age, y	55.1 ± 8.6	48.6	54.6	60.8
Education ^b	14.7 ± 2.7	12	14.5	16
Body mass index, kg/m ²	31.3 ± 7.2	26	30.2	34.8
Compartments with diffuse cartilage injury, 0-3	0.87 ± 0.89	0.0	1.0	2.0
VR-12 MCS	55.4 ± 11.5	45.8	55.8	62.3
VR-12 PCS	32.2 ± 10.2	24.8	31.1	39.2
KOOS-Pain	47.4 ± 18.5	36.1	47.2	61.1
KOOS-QoL	29.6 ± 18.1	18.8	31.2	43.8
KOOS-PS	46 ± 16.8	45.6	56	64.7

^a*N* = 638 patients. Q1 and Q3 reflect the first (25%) and third (75%) quartiles, respectively. KOOS, Knee injury and Osteoarthritis Outcome Score; MCS, Mental Component Score; PCS, Physical Component Score; PS, Physical Function Short Form; QoL, Quality of Life; VR-12, Veterans RAND 12-Item Health Survey.

^bYears completed starting at first grade.

TABLE 2
Categorical Variables at Time of Surgery^a

Categorical Variable and Groupings	Result
Sex	
Male	52%
Female	47%
Smoking	
Yes (current and former)	58%
No	42%
Prior arthroscopy	
None	87%
Ipsilateral	4%
Contralateral	8%
Bilateral	1%
Ipsilateral effusion	
Yes (any)	18%
No	82%
Meniscal status	
Normal	18% M, 71% L
Partial tear	26% M, 11% L
Complete tear	55% M, 19% L
Main meniscal tear type	
None	18% M, 71% L
Oblique or flap	8% M, 3% L
Longitudinal or bucket handle	5% M, 3% L
Radial	9% M, 3% L
Root	5% M, 1% L
Horizontal or complex	55% M, 19% L
Cartilage injury	
Grade 0 or 1	35% PF, 33% M, 72% L
Grade 2 focal	11% PF, 7% M, 5% L
Grade 2 diffuse	10% PF, 10% M, 6% L
Grade 3 or 4 focal	21% PF, 20% M, 10% L
Grade 3 or 4 diffuse	24% PF, 31% M, 7% L
Synovium	
Normal	91%
Abnormal	9%

^aL, lateral compartment; M, medial compartment; PF, patellofemoral compartment.

TABLE 3
Results of Univariate and Multivariate Analyses^a

Outcome Variable	Significant Predictors After Univariate Analysis		Significant Predictors After Multivariate Analysis		<i>R</i> ²
	Predictor	<i>P</i>	Predictor	<i>P</i>	
VR-12 MCS	Female sex	.019	Female sex	.049	0.0647
	Positive smoking history	<.001	Positive smoking history	<.001	
	Fewer years of education	<.001	Fewer years of education	.02	
	Higher BMI	<.001	Higher BMI	<.001	
VR-12 PCS	Female sex	<.001	Female sex	<.001	0.178
	Positive smoking history	<.001	Positive smoking history	.002	
	Lower VR-12 MCS	.002	Fewer years of education	<.001	
	Fewer years of education	<.001	Higher BMI	<.001	
	Higher BMI	<.001			
	Patellofemoral cartilage lesion type	.031			
	Lateral compartment cartilage lesion type	.029			
KOOS-Pain	Female sex	<.001	Female sex	.003	0.224
	Positive smoking history	<.001	Lower VR-12 MCS	<.001	
	Lower VR-12 MCS	<.001	Fewer years of education	<.001	
	Fewer years of education	<.001	Higher BMI	<.001	
	Higher BMI	<.001	Abnormal synovium	.032	
	Patellofemoral cartilage lesion type	.015			
	Medial compartment cartilage lesion type	.029			
	Abnormal synovium	.039			
KOOS-PS	Female sex	.001	Female sex	.034	0.237
	Positive smoking history	<.001	Positive smoking history	.003	
	Lower VR-12 MCS	<.001	Lower VR-12 MCS	<.001	
	Fewer years of education	<.001	Fewer years of education	<.001	
	Higher BMI	<.001	Higher BMI	<.001	
KOOS-QoL	Female sex	<.001	Female sex	.008	0.175
	Positive smoking history	.001	Lower VR-12 MCS	<.001	
	Lower VR-12 MCS	<.001	Fewer years of education	.001	
	Fewer years of education	<.001	Higher BMI	<.001	
	Higher BMI	<.001			

^aBMI, body mass index; KOOS, Knee injury and Osteoarthritis Outcome Score; MCS, Mental Component Score; PCS, Physical Component Score; PS, Physical Function Short Form; QoL, Quality of Life; VR-12, Veterans RAND 12-Item Health Survey.

emerged. Figure 1 demonstrates the independent effect of each predictor on the VR-12 MCS outcome.

When the VR-12 PCS was analyzed as an outcome variable on multivariate analysis, the *R*² was 0.178. Female sex (*P* < .001), positive smoking status (*P* = .002), fewer years of education (*P* < .001), and higher BMI (*P* < .001) demonstrated statistically significant relationships with the outcome variable. Although significant on the univariate analysis, patellofemoral and lateral cartilage characteristics as well as the VR-12 MCS and number of diffuse cartilage grades no longer demonstrated an association. Figure 2 demonstrates the independent effect of each predictor on VR-12 PCS.

Multivariate analysis of the KOOS-Pain subscale demonstrated an *R*² value of 0.224. VR-12 MCS (*P* < .001), female sex (*P* = .003), lower education level (*P* < .001), higher BMI (*P* < .001), and abnormal synovial status (*P* = .032) maintained a significant relationship with the KOOS-Pain outcome variable when controlling for other

variables, whereas the remainder of the associations found on the univariate analysis were lost. Figure 3 demonstrates the independent effect of each predictor on KOOS-Pain.

Multivariate analysis of the KOOS-PS subscale demonstrated an *R*² value of 0.237. Significant relationships between KOOS-PS and VR-12 MCS (*P* < .001), female sex (*P* = .034), positive smoking status (*P* = .003), lower education level (*P* < .001), and higher BMI (*P* < .001) were confirmed. Figure 4 demonstrates the independent effect of each predictor on KOOS-PS.

Relationships between the KOOS-QoL and independent predictors on multivariate analysis revealed a significant relationship between lower scores and VR-12 MCS (*P* < .001), female sex (*P* = .008), years of education (*P* = .001), and BMI (*P* < .001), with an *R*² of 0.175. Figure 5 demonstrates the independent effect of each predictor on KOOS-QoL.

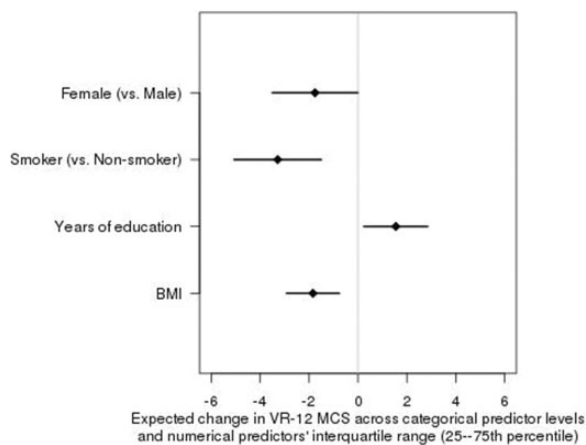


Figure 1. Effect of each predictor on Veterans RAND 12-Item Health Survey Mental Component Score (VR-12 MCS), with the other predictors held constant. BMI, body mass index.

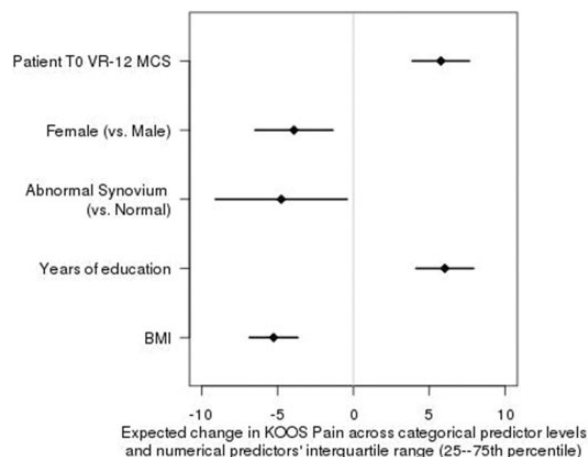


Figure 3. Effect of each predictor on Knee injury and Osteoarthritis Outcome Score (KOOS) Pain, with the other predictors held constant. BMI, body mass index; VR-12 MCS, Veterans RAND 12-Item Health Survey Mental Component Score.

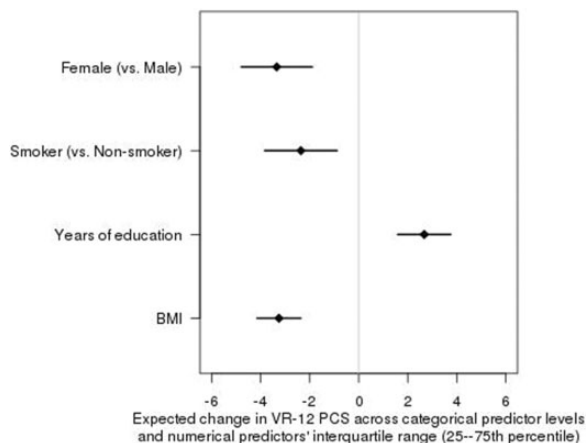


Figure 2. Effect of each predictor on Veterans RAND 12-Item Health Survey Physical Component Score (VR-12 PCS), with the other predictors held constant. BMI, body mass index.

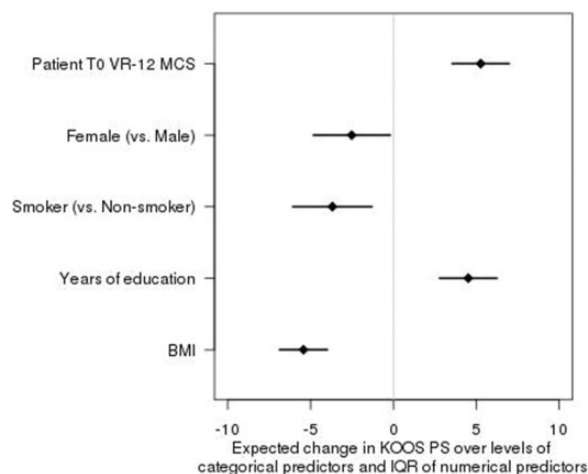


Figure 4. Effect of each predictor on Knee injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), with the other predictors held constant. BMI, body mass index; IQR, interquartile range; VR-12 MCS, Veterans RAND 12-Item Health Survey Mental Component Score.

DISCUSSION

For all patient-reported outcome measures assessed, there was an overwhelming association with patient factors not related to abnormality in the operative knee, including sex, education level, BMI, and smoking status. When the VR-12 MCS was used as a predictor variable, a statistically significant association was uncovered with all KOOS subscales. Although it was not found to influence the VR-12 PCS, this result would be expected given the orthogonal nature of the 2 distinct subsections of the VR-12. The only intraoperative finding that predicted preoperative pain or function was the influence of an abnormal synovial status (anything other than “normal” noted by the surgeon) on the KOOS-Pain score.

In the multivariate models, all outcomes except VR-12 MCS had R^2 values in the 0.18 to 0.24 range, meaning that about 20% of the variance in each model can be explained

by the predictor variables. The VR-12 MCS model explains only 6.5% of the variance, indicating that much of the variance is explained by variables not captured in our data set.

In 2017, Tornbjerg et al³⁰ examined a cohort of 443 Danish patients who were 18 years or older with meniscal abnormality and compared intraoperative findings with KOOS-Pain, KOOS-Sport/Rec, and KOOS-ADL scores just prior to surgery. Age, sex, and body mass were the most consistent predictors of outcomes in their model, although their associations were weak, with R^2 values between 0.10 and 0.12. The only structural abnormality with any association was the presence of synovitis and its effect on the

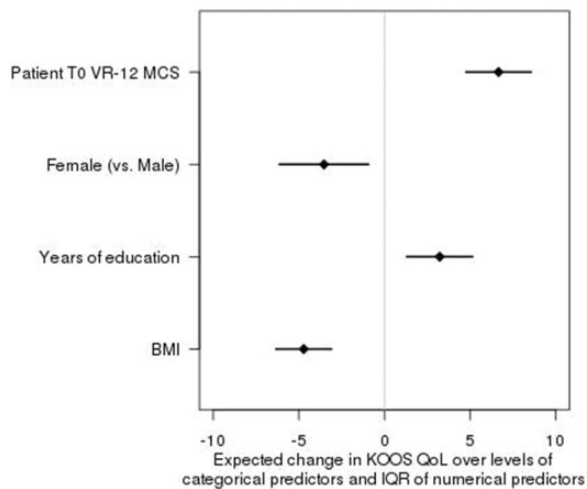


Figure 5. Effect of each predictor on Knee injury and Osteoarthritis Outcome Score Quality of Life (KOOS-QoL), with the other predictors held constant. BMI, body mass index; IQR, interquartile range; VR-12 MCS, Veterans RAND 12-Item Health Survey Mental Component Score.

KOOS-Sports/Rec subscale, although the R^2 was only 0.03. Our study showed similar findings regarding the effects of abnormal synovium on patient-reported outcome measures.

Our findings differ from the Tornbjerg et al³⁰ study in that age was not a significant predictor in our cohort. Our minimum age for inclusion was 40 years, which might explain the difference in findings, although overall average ages were similar between the 2 cohorts (49.7 ± 12.8 vs 55.1 ± 8.6 years for the current study). Our study addressed smoking status, which was found to be a significant predictor in 3 of the 5 measured outcome variables. When mental health was assessed with the VR-12 MCS, this was also found to have a significant association with all KOOS subscales.

Other studies have examined the effects of demographics and abnormality on pain and function. Sex-based differences in preoperative pain and function have been identified in patients undergoing total knee arthroplasty. Although this likely includes a more advanced disease process of the cartilage in comparison with our cohort of arthroscopy patients, our results confirm these findings.²⁵ In a 2017 study by Baldwin et al,² an analysis of KOOS scores in healthy individuals revealed that women and participants with higher BMIs tended to have lower KOOS scores. In another cohort study of patients with Kellgren-Lawrence grade 2 or higher knee osteoarthritis, having fewer than 12 years of education was found to predict lower Western Ontario and McMaster Universities Index of Osteoarthritis (WOMAC) scores.⁸ Lower education levels predicted lower KOOS scores in our study. Finally, in a cohort of Finnish forestry workers,²³ a higher BMI and current or former smoking status were associated with reports of knee pain at the onset of the study. The demographic predictors of pain and poor function identified in our cohort confirm these past findings.

Scanzello et al²⁶ compared preoperative 12-Item Short Form Health Survey, Lysholm, and visual analog scale (VAS) pain scores with intraoperative diagnoses of synovitis in 28 patients undergoing knee arthroscopy. Inflammatory findings were confirmed by pathological analysis and were found, in addition to BMI, to be associated with worse Lysholm scores. Our study, which involved a much larger cohort but no histological analysis, confirms the conclusion that symptoms and synovitis are associated, although different predictive and outcome measures were used. Unlike the findings of Boks et al,⁶ the presence of knee effusion within our cohort was not found to be associated with more severe symptoms.

A patient's mental health has been shown to be an important predictor of symptoms and outcomes of musculoskeletal disease.^{13,15} In their observations in an outpatient spine surgery clinic, Abtahi et al¹ found that psychological distress, as measured by the Distress and Risk Assessment Method (DRAM) questionnaire, was significantly associated with the results of a patient satisfaction survey. Wylie et al³⁴ examined a cohort of 169 patients with full-thickness rotator cuff tears. The strongest predictor of VAS pain, VAS function, Simple Shoulder Test (SST), and American Shoulder and Elbow Surgeons (ASES) scores was the 36-Item Short Form Health Survey Mental Component Summary (SF-36 MCS), a validated measure of mental health. Our study found a similar association in a population of patients undergoing knee arthroscopy for nonreconstructive indications.

Whereas our study examined only preoperative patient-reported outcomes, Liebensteiner et al¹⁹ searched for factors related to improvement in SF-36 scores after arthroscopic knee surgery. Those investigators found that the degree of cartilage degeneration was significantly associated with the degree of improvement after surgery (patients with milder arthritic changes tended to improve more than patients with severe changes). These findings suggest that although preoperative factors may not be associated with intra-articular abnormality, changes in postoperative outcome measures could be more closely correlated with structural findings and subsequent treatment.

The current study has several limitations. Our study cohort did not represent the general population, as it was a self-selected group of patients presenting with knee pain who consented to undergo arthroscopic surgery. No asymptomatic control group was included, and the results should not be interpreted as indicating that meniscal tears or cartilage abnormality does not cause pain or limit function. Although our predictor variables may be important in predicting pain and function before surgery in this group, similar findings have been identified in populations not seeking treatment for knee pain.² Our study involved the collection of detailed intraoperative data by multiple surgeons. Among our specific group, no published data are available regarding inter- or intraobserver reliability of the surgeon-generated data, although several studies have shown that the arthroscopic grading of meniscal⁹ and cartilage²² lesions is reliable and reproducible among multiple surgeons operating at different medical centers.

As a cross-sectional investigation, this study examined only the effects of findings noted by the patient and the surgeon on the day of surgery. No conclusions can be drawn regarding changes in outcomes after surgery and what factors, if any, may modify these results. Previous studies have identified associations between baseline characteristics and outcomes after knee arthroscopy.²⁸ Further research with postoperative outcome data on this cohort would certainly be helpful to identify whether the same predictors of preoperative pain and function have the same overwhelming effect on outcomes after surgery. Many surgeons would find it beneficial to understand what modifiable factors could be identified to predict outcomes after intervention. Although the KOOS is a widely used outcome measure for knee injuries, other measures may have different characteristics that make them more or less appropriate for certain abnormalities.³² Finally, our database does not include any information regarding radiographic or magnetic resonance imaging findings, although these are commonly obtained before the time of knee arthroscopy. Our hope is that the detailed documentation of intraoperative findings would more accurately describe the extent of the disease process.

CONCLUSION

In a large cohort of North American patients undergoing knee arthroscopy for nonreconstructive purposes, KOOS and VR-12 measures of baseline health were correlated with the patient demographic characteristics of sex, BMI, education level, and smoking status, as well as mental health as measured by the VR-12 MCS. Intraoperative findings did not consistently predict preoperative pain or function, as abnormal synovial status was associated only with worse KOOS-Pain scores. Surgeons should understand that patients' preoperative pain and function levels may be more closely related to patient demographics and mental health than actual abnormality.

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