Factors Associated With Clinically Significant Patient-Reported Outcomes After Primary Arthroscopic Partial Meniscectomy

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Purpose: The purpose of this study was to establish minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient-acceptable symptom state (PASS) after meniscectomy and factors associated with achieving these goals. **Methods:** A prospectively maintained institutional registry was retrospectively reviewed for all patients undergoing isolated arthroscopic partial meniscectomy from 2014 through 2017. MCID, SCB, and PASS were calculated for the International Knee Documentation Committee (IKDC) and Knee Injury and Osteoarthritis Outcome Score (KOOS) subscores by using the anchor-based methodology and nonparametric receiver operating characteristic curves. Subscores included joint replacement (JR), physical function (PF), symptoms (Sx), pain, activities of daily living (ADL), sport, and quality of life (QOL). **Results:** A total of 269 patients were analyzed in the study, which reported outcomes between 6 and 7 months after surgery. The average age of our population was 48.9 ± 12.4 years. Twenty patients reported no change, 53 reported minimal improvement, and 137 reported substantial change after surgery; whereas 59 patients reported worse outcomes. One hundred seventy-seven patients were satisfied and 92 were not satisfied with the outcome of surgery. Established MCID/SCB/PASS for the IKDC, KOOS JR, KOOS PF, KOOS Sx, KOOS Pain, KOOS ADL, and KOOS QOL were 10.6/25.3/57.9, 10.7/13.2/68.3, -8.2/-11.3/26.2, 8.9/7.1/71.4, 9.7/22.2/76.4, 11.0/16.9/89.0, 12.5/27.5/55.6, and 15.6/34.4/46.9, respectively. Higher preoperative scores were associated with reduced odds of achieving MCID and SCB but greater odds of achieving PASS for nearly all scores ($P < .05$). Workers' compensation status, degenerative tears, medial-sided tears, and root tears were associated with reduced odds of achieving 2 or more clinically meaningful outcomes in 2 or more scores ($P < .05$). **Conclusions:** Clinically meaningful outcomes were established by patient self-assessment. Variables associated with achieving these outcomes include preoperative score (positively correlated with MCID/SCB, negatively correlated with PASS); workers' compensation; degenerative, medial-sided tears; and root tears (remaining negatively correlated with MCID/SCB/PASS). These variables should be accordingly measured for confounding in future outcome reporting.

Meniscus injuries are a common source of knee pain and functional impairment.[1] In the United States, they represent the most common intra-articular knee injury with an annual mean incidence of 66 per 100,000 inhabitants.[2-5] Although meniscus tear symptoms can be treated conservatively, they are often treated surgically and represent 1 of the most common orthopedic procedures.[6] The 3 goals of meniscectomy are as follows: to relieve pain, to facilitate preinjury level of activities of daily living (ADL), and to prevent degenerative arthritis of the knee joint.[7]

Despite the increasing performance and advancements of arthroscopic meniscectomy, the long-term results may not be entirely appreciable. Prior studies have shown inconsistent results regarding outcome reporting after meniscectomy procedures.[8-10] One reason for this is that outcome reporting is incredibly dependent on patient-reported measures, which are often subjective and thus highly variable without any objective clinical finding as support.[11,12] For example, randomized controlled

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clinical trials have had equivocal results when the efficacy of meniscectomy was compared with that of sham surgery or physical therapy, with the conclusion that arthroscopic partial meniscectomy for degenerative tears in knees with osteoarthritis provides no statistically significant lasting benefits compared with sham surgery or physical therapy.[13-19] These studies are primarily limited in sample size, which means that they were not powered to demonstrate clinically meaningful differences. Instead, they were focused on statistically significant evaluation of outcomes, which underpowered the trials.[20-23]

To better determine the clinical efficacy of arthroscopic meniscectomy, clinical significance in patient-reported outcomes (PROs) must be measured. Three standards can be used to measure clinical significance: minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient-acceptable symptomatic state (PASS). MCID, which is the smallest change in outcomes that a patient perceives as clinically important, is fundamental in analyzing the clinical relevance of PROs.[21,24] In addition to MCID, each patient can assess whether his or her outcome meets their individual definition of success with standards such as SCB and PASS.[21,25-29] Within the last few years, integration of MCID, SCB, and PASS for analysis of PROs in orthopedic clinical care has proven to be successful in assessing treatment effectiveness.[25,30-32] Specifically for the knee, MCID has been determined to be a useful measure after anterior cruciate ligament reconstruction.[33] The purpose of this study was to establish MCID, SCB, and PASS after meniscectomy and factors associated with achieving these outcomes. We hypothesize that patients are more likely to achieve clinical improvement (MCID and SCB) with lower preoperative scores and more likely to achieve PASS with higher preoperative scores.

Methods

Study Design

This study was an analysis in which prospectively collected PRO measures (PROMs) from September 2014 to October 2017 were used. After approval was obtained from the institutional review board, an electronic data collection service (Outcome Based Electronic Research Database; Universal Research Solutions, Columbia, MO) was used to review subjective PROMs for all patients undergoing primary, arthroscopic meniscectomy at a single institution. Beginning in 2014, anchor questions were implemented in outcome collection by using the same service. With these outcome measures, we are able to establish threshold measures of clinically significant outcomes. Trained research staff were present on site on the day of surgery to determine the outcome score for each patient. At 6-month follow-up, patients were contacted via e-mail every 5 days for 1 month. The survey expired after this interval so as to not reflect improvement at a different time point. The 6-month follow-up was selected to measure improvement because recent evidence would suggest that improvement occurs in the immediate postoperative period,[10] little to no change occurs after the 6-month period,[34] and patients are generally told that they can expect to experience improvement by 6 months. Extending follow-up beyond this point increases the likelihood of confounding variables and mechanisms related to reinjury.

Patient Selection

All patients who underwent arthroscopic meniscectomy and completed both preoperative and postoperative PROMs were included in this analysis. An initial population of 384 patients was included. The patients in this population were compared with patients who did not complete their 6-month questionnaires to determine any selection bias between compliant and noncompliant groups (Table 1). Each patient's electronic medical record was reviewed for demographics, operative details, and postoperative complications. Intraoperative variables such as cartilage defect, shape of meniscal tear, and location of meniscal tear were collected. All revision procedures were excluded. Patients were excluded if a concomitant ligamentous procedure (anterior cruciate, medial collateral, or posterior cruciate), a concomitant realignment procedure (tibial tubercle osteotomy, distal femoral osteotomy, or high tibial osteotomy), a concomitant meniscal allograft transplantation, or a concomitant cartilage restoration procedure (microfracture, osteochondral allograft, or autologous chondrocyte implantation) was performed. Patients' medical histories were reviewed to exclude any patients with metabolic or autoimmune disease including rheumatoid arthritis. Concomitant chondroplasty was not excluded in the present study because it was believed to

Table 1. Baseline Characteristics and Preoperative Outcome Scores of Compliant Group Versus Noncompliant Group

	Completed Anchors	Incomplete Anchors	*P* Value
N	384	947	
Age (yr)	43.7 ± 14.9	42.8 ± 15.5	.332
Preop IKDC	45.5 ± 18.1	45.0 ± 17.1	.635
Preop KOOS JR	57.4 ± 12.9	58.8 ± 15.8	.124
Preop KOOS PF	41.2 ± 12.0	40.1 ± 14.9	.198
Preop KOOS Sx	58.5 ± 18.6	59.8 ± 19.3	.261
Preop KOOS Pain	56.6 ± 17.2	58.6 ± 19.3	.078
Preop KOOS Daily	65.4 ± 20.4	67.4 ± 21.5	.119
Preop KOOS Sport	33.1 ± 23.6	35.3 ± 25.6	.147
Preop KOOS QOL	26.6 ± 18.4	28.8 ± 19.9	.062

NOTE. Scores and subscores are expressed as mean ± SD.

IKDC, International Knee Documentation Committee Score; JR, joint replacement; KOOS, Knee Injury and Osteoarthritis Outcome Score; PF, physical function; Preop, preoperative; QOL, Quality of life; Sx, Symptoms.

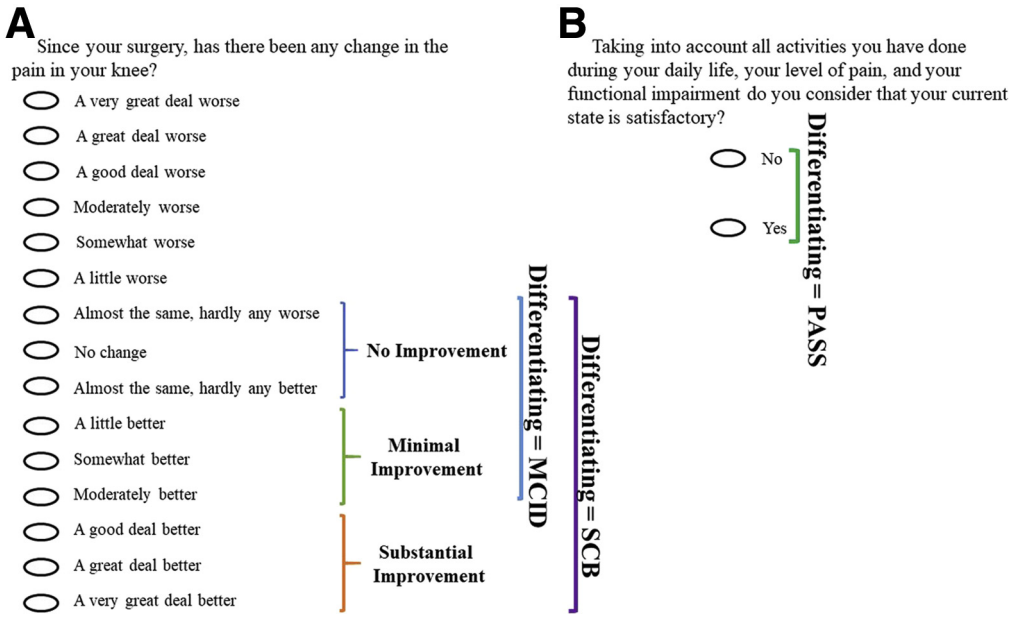

Fig 1. Anchor questions used to calculate (A) minimal clinically important difference, substantial clinical benefit, and (B) patient acceptable symptomatic state. (MCID, minimal clinically important difference; PASS, patient-acceptable symptomatic state; SCB, substantial clinical benefit.)

minimally affect outcomes.[34] All included patients had operations performed by surgeons at a single institution.

Outcome Measures

The following PROMs were used in this analysis: International Knee Documentation Committee Score (IKDC) and Knee injury and Osteoarthritis Outcome Score (KOOS). The following subsets for the KOOS score were included in analysis: KOOS Joint Replacement (JR), KOOS Physical Function (PF), KOOS Symptoms (Sx), KOOS Pain, KOOS ADL, KOOS Sport, and KOOS Quality of Life (QOL). Of note, the KOOS PF was scored in an inverted scale per the initial publication by Perruccio et al.[35]

Anchor Questions

In addition to the questions used to determine the outcome scores, patients were asked 2 anchor questions.[27] One question was aimed at assessing satisfaction: "Taking into account all activities you have done during your daily life, your level of pain, and your functional impairment, do you consider that your current state is satisfactory?" Responses were a binary "yes" or "no." An anchor question to assess pain was also administered: "Since your surgery, has there been any change in the pain in your knee?" Responses were based on a 15-point global scale that was scored from −7 to +7. Patients who responded to the question with "Almost the same, hardly any worse," "No change," or "Almost the same, hardly any better" corresponded to a score of −1 to +1 and represent the no change group. Those who responded "A little better," "Somewhat better," and "Moderately better" corresponded to a score of +2 to +4 and represent the minimal improvement group. Patients who responded "A good deal better," "A great deal better," and "A very great deal better" corresponded to a score of +5 to +7 and represent the substantial improvement group. Differences between the no change (−1 to +1) and minimal change (+2 to +4) groups were used to calculate MCID by using receiver operating characteristic/area under curve (ROC/AUC) analysis, whereas differences between the no change (−1 to +1) and substantial change (+5 to +7) groups were used to calculate the SCB. The SCB was calculated only as a difference between preoperative and postoperative scores for ease of comparison with the MCID. Differences in postoperative scores at 6 months after surgery between satisfied and unsatisfied patients were used to calculate the PASS (Fig 1). The ROC/AUC analysis with the Youden index determined the threshold value of PROMs (determined by maximizing sensitivity and specificity) that could best predict the difference between achieving a clinically significant outcome versus not achieving one. The distribution method was also used to calculate the MCID because it has also been previously established as a reliable way to calculate this value in the absence of anchor questions.[36]

Statistical Analysis

RStudio software version 1.0.143 (R Foundation for Statistical Computing, Vienna, Austria) was used for analysis. A nonparametric ROC/AUC analysis was used to evaluate the threshold measure of MCID, SCB, and PASS that would differentiate patients based on the previously described anchor-based methodology. The degree of association was acceptable if the AUC was greater than 0.7, and it was excellent if the AUC was

Table 2. Demographic Variables of Included Patients Undergoing Primary Arthroscopic Meniscectomy

Sample Size	269
Age (yr)	48.9 ± 12.4
Body mass index	30.0 ± 6.5
Workers' compensation	Yes: 41 No: 228
Symptom duration (mo)	10.3 ± 11.9
Tear origin	
Degenerative	120
Traumatic	149
Arthritis present on arthroscopy	Yes: 184; No: 85
Laterality	Medial: 180; Lateral: 89
Tear pattern	
Bucket handle	9
Discoid	3
Vertical/longitudinal	6
Oblique	21
Degenerative	28
Transverse (radial)	39
Horizontal	10
Root	13
Flap	57
Complex	64
Unknown	19

greater than 0.8.[25,33,37-39] The Youden index was used to identify the optimal cutoff that maximizes sensitivity and specificity for each outcome score. Based on these threshold scores, all patient-reported scores were reviewed to determine which patients achieved MCID, SCB, and PASS. In the event of poor prediction of MCID by the anchor questionnaire, as determined by the AUC value, the distribution-based method was used. In this method, MCID was established by using ½ of the standard deviation for each reported score.[33] This MCID was then validated by using nonparametric ROC/AUC analysis to ensure the threshold value's accurate prediction of at least minimal improvement.[40] Multivariate stepwise regression was performed to identify which preoperative and intraoperative variables collected were associated with achieving MCID, SCB, and PASS. Odds ratios were calculated for each variable with respect to achieving MCID, SCB, and PASS; and significance was defined as $P < .05$.

Results

Patient Demographics

After exclusion criteria were applied, 269 patients who had complete PRO compliance and anchor compliance remained within our study. The average age of our population was 48.9 ± 12.4 years, and mean body mass index (BMI) was 30.0 ± 6.5. Mean symptom duration was 10.3 ± 11.9 months (Table 2). Twenty (7.4%) patients reported no change after surgery, and 53 (19.7%) patients reported minimal improvement after surgery. One hundred thirty (50.9%) patients reported substantial change after surgery, and the remainder (n = 59, 21.9%) reported worse outcomes after surgery. In total, 92 (34.2%) patients reported that they were not satisfied with surgery, and 177 (66.9%) patients reported satisfaction with surgery.

Table 3. Minimal Clinically Important Difference at 6 Months After Meniscectomy

	MCID (Anchor)	Specificity (%)	Sensitivity (%)	AUC (%)	MCID (Distribution)
IKDC	2.2	47.8	80.0	58.9	10.6
KOOS JR	12.6	84.6	39.1	57.7	10.7
KOOS PF	-18.1	90.9	31.6	57.4	-8.2
KOOS Sx	7.1	65.2	56.8	51.0	8.9
KOOS Pain	1.4	40.9	75.0	53.5	9.7
KOOS ADL	3.7	45.5	79.1	60.8	11.0
KOOS Sport	12.5	58.3	58.1	57.5	12.5
KOOS QOL	3.1	39.1	79.1	55.4	15.6

ADL, activities of daily living; AUC, Area under curve; IKDC, International Knee Documentation Committee Score; JR, joint replacement; KOOS, Knee Injury and Osteoarthritis Outcome Score; MCID, minimal clinically important difference; PF, physical function; QOL, quality of life; Sx, Symptoms.

Establishing Threshold Values

Using the ROC/AUC analysis, we obtained threshold values for MCID (Table 3). None of the AUCs met acceptable criteria from anchor-based calculation, so the distribution method was used for this calculation. The AUC after distribution method was determined to be 100% for each score, respectively. The established MCID based off our population was 10.6 for IKDC, 10.7 for (KOOS) JR, −8.2 for PF, 8.9 for Sx, 9.7 for Pain, 11.0 for ADL, 12.5 for Sport, and 15.6 for QOL.

In establishing SCB by ROC/AUC analysis of anchors, all values had acceptable AUCs and thus had sufficient predictive potential to establish SCB. Threshold values were as follows: IKDC = 25.3, KOOS JR = 13.2, KOOS PF = −11.3, KOOS Sx = 7.1, KOOS Pain = 22.2, KOOS ADL = 16.9, KOOS Sport = 27.5, and KOOS QOL = 34.4 (Table 4).

When PASS was established by ROC/AUC analysis of anchors, all values demonstrated that each predictive model of PASS was excellent (AUC >80%). The postoperative score that corresponded to this value for IKDC was above 57.9; KOOS JR was above 68.3, KOOS PF was below 26.2, KOOS Sx was 71.4, KOOS Pain was 76.4, KOOOS ADL was 89.0, KOOS Sport was 55.6, and KOOS QOL was 46.9 (Table 4).

Multivariate Regression

Multivariate regression was performed to determine which variables were associated with achieving clinically significant outcomes with respect to each score (See Appendix). Variables recurring in association with clinically significant outcomes are reported in Table 5. Greater respective preoperative scores were associated with reduced odds of achieving MCID and SCB for IKDC (MCID only), KOOS JR, KOOS PF, KOOS Sx,

Table 4. Substantial Clinical Benefit and Patient Acceptable Symptomatic State After Arthroscopic Partial Meniscectomy

	SCB (Anchor)	Specificity (%)	Sensitivity (%)	AUC (%)
IKDC	25.3	91.3	58.9	78.7
KOOS JR	13.2	84.6	69.9	72.6
KOOS PF	−11.3	72.7	80.9	78.1
KOOS Sx	7.1	65.2	77.9	71.0
KOOS Pain	22.2	77.3	60.7	74.2
KOOS Daily	16.9	72.7	71.0	74.2
KOOS Sport	27.5	79.2	62.3	72.1
KOOS QOL	34.4	82.6	61.8	79.5
	PASS (Anchor)	**Specificity (%)**	**Sensitivity (%)**	**AUC (%)**
IKDC	57.9	76.3	86.2	87.9
KOOS JR	68.3	83.7	77.2	86.2
KOOS PF	26.2	95.9	68.3	86.4
KOOS Sx	71.4	81.4	81.7	86.6
KOOS Pain	76.4	89.9	75.2	88.9
KOOS Daily	89.0	87.9	69.3	85.7
KOOS Sport	55.6	82.8	77.1	87.5
KOOS QOL	46.9	78.8	86.9	91.3

AUC, area under curve; IKDC, International Knee Documentation Committee Score; JR, joint replacement; KOOS, Knee Injury and Osteoarthritis Outcome Score; PASS, patient-acceptable symptom state; PF, physical function; QOL, quality of life; SCB, substantial clinical benefit; Sx, symptoms.

KOOS Pain (MCID only), KOOS ADL, KOOS Sport, and KOOS QOL. Greater preoperative scores were associated with greater odds of achieving PASS for all 8 outcome scores ($P < .05$). Workers' compensation was associated with reduced odds of achieving all clinically significant outcomes with respect to IKDC, KOOS JR, KOOS PF (MCID and SCB only), KOOS Sx, KOOS Pain, and KOOS ADL (SCB and PASS only). Traumatic tears had greater odds of achieving all clinically significant outcomes for IKDC, KOOS JR (SCB and PASS only), KOOS PF, KOOS Sx (MCID and SCB only), KOOS ADL (SCB and PASS only), KOOS Sport, and KOOS QOL (MCID and PASS only). Root tears were associated with reduced odds of achieving all clinically significant outcomes for KOOS—including Sx, ADL (MCID and SCB only), and Sport (MCID and SCB only). Greater body mass index was associated with reduced odds of achieving all clinically significant outcomes for KOOS Sport and KOOS QOL. Medial-sided tears were associated with reduced odds of achieving clinically significant outcomes for KOOS PF (SCB and PASS) (Table 5).

Discussion

The present study includes an evaluation of these outcomes by means of a robust anchor and distribution-based methodology in a large population of patients undergoing primary arthroscopic partial meniscectomy without concomitant procedures. Preoperative outcome scores, workers' compensation, traumatic tears, root tears, medial-sided tears, and greater BMI were recurring variables of association in achieving these clinically significant outcomes. The distribution-based MCID was used because relatively few patients reported minimal improvement, which affected the predictive power of this variable. However, all thresholds reported for SCB were acceptable, and all thresholds reported for PASS were excellent. These scores provide valuable insight to base clinical improvement in clinical practice, reporting outcomes in research, or determining sample size by power analysis. In the current health care climate, establishing clinically significant outcomes increases the standard for improvement in patient outcomes.

The MCID, SCB, and PASS threshold values are inherently specific to the population for which the analysis was performed. The ability to generalize these values hinges on the assumption that the population for which MCID, SCB, and PASS was calculated is similar to other populations. There is a tradeoff between the number of procedures to which we may apply these value and accuracy of these values as we increase the homogeneity of the calculated population. The present study is homogeneous with respect to the inclusion/exclusion criteria of procedures (only arthroscopic partial meniscectomy). Of note, there still exists variability within the patient population with respect to medical history, functional activity, and occupation. The distribution-based methodology lacks the added benefit of incorporating the patient's assessment of improvement[37,38]; however, this has still been demonstrated as a reliable calculation of MCID.[36-38] With respect to SCB and PASS, no distribution-based method exists; thus, the anchor-based methodology is essential in establishing these critical values.[25,41] Because these outcomes have not been established for meniscectomy, our values are only comparable to MCID IKDC for ACL reconstruction (10.4),[33] MCID KOOS subscores for total knee arthroplasty (10),[38] and suggested minimally important change by the KOOS organization (10).[42] Generalized minimal detectable change for KOOS subscores (range, 5-12) and IKDC (11.5) have been determined in the setting of any knee injury; however, these values have yet to be clinically substantiated.[43]

Clinically significant outcomes establish a greater threshold to demonstrate improvement than previously reported statistical significance.[21] The present study also corroborates a recurring trend that higher preoperative scores are generally associated with reduced odds of achieving MCID and SCB but greater odds of achieving PASS.[29,33,44] This is fairly intuitive because patients who have more symptoms before surgery have more room to improve. Conversely, those with higher preoperative scores are also closer to achieving the postoperative measure of PASS. The fact that more patients with

Table 5. Multivariate Logistic Regression of Factors Influencing Patient Achievement of Clinically Significant Outcomes

	MCID		SCB		PASS	
	P Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)
IKDC						
Pre-op IKDC	.073	0.983 (0.968, 1.001)	**<.001**	**0.961 (0.942, 0.981)**	**<.001**	**1.071 (1.045, 1.097)**
Workers' compensation	**.013**	**0.341 (0.146, 0.796)**	**.034**	**0.386 (0.162, 0.923)**	**.011**	**0.302 (0.120, 0.765)**
Traumatic tear	**.006**	**8.174 (1.845, 36.206)**	**.014**	**12.264 (1.664, 90.390)**	**.042**	**2.042 (1.027, 4.062)**
KOOS JR						
Preop KOOS JR	**.036**	**0.964 (0.931, 0.998)**	**.014**	**0.964 (0.931, 0.998)**	**<.001**	**1.079 (1.037, 1.123)**
Workers' compensation	**.018**	**0.197 (0.051, 0.757)**	**.003**	**0.197 (0.051, 0.757)**	**.035**	0.184 (0.038, 0.885)
Traumatic tear	.072	2.001 (0.941, 4.257)	**<.001**	**7.393 (2.908, 18.798)**	**.001**	**3.778 (1.678, 8.505)**
KOOS PF						
Preop KOOS PF	**.040**	**1.050 (1.002, 1.100)**	**.013**	**1.062 (1.0125, 1.113)**	**.002**	**0.918 (0.869, 0.969)**
Workers' compensation	**.020**	**0.070 (0.007, 0.663)**	**.048**	**0.007 (0.006, 0.972)**	.993	
Traumatic tear	**.031**	**2.819 (1.098, 7.239)**	**<.001**	**5.166 (1.991, 13.405)**	**<.001**	**8.351 (2.913, 23.938)**
Tear pattern						
Medial	N/A		**.007**	**0.164 (0.044, 0.607)**	**.010**	**0.154 (0.037, 0.635)**
KOOS Sx						
Preop KOOS Sx	**<.001**	**0.950 (0.932, 0.969)**	**<.001**	**0.941 (0.923, 0.959)**	**<.001**	**1.033 (1.016, 1.052)**
Workers' compensation	**.020**	**0.355 (0.149, 0.847)**	**.003**	**0.267 (0.111, 0.638)**	**.004**	**0.312 (0.143, 0.684)**
Traumatic	**.018**	**9.063 (1.463, 56.127)**	**.008**	**2.368 (1.258, 4.458)**	N/A	
Tear pattern						
Root tear	**.008**	**0.127 (0.027, 0.589)**	**.008**	**0.101 (0.018, 0.555)**	**.032**	**0.197 (0.044, 0.870)**
KOOS Pain						
Preop KOOS Pain	**.020**	**0.976 (0.957, 0.996)**	N/A		**<.001**	**1.048 (1.026, 1.070)**
Workers' compensation	**.039**	**0.413 (0.178, 0.957)**	**.006**	**0.249 (0.093, 0.666)**	**.011**	**0.323 (0.135, 0.775)**
KOOS ADL						
Preop KOOS ADL	**<.001**	**0.964 (0.947, 0.981)**	**<.001**	**0954 (0.937, 0.971)**	**<.001**	**1.056 (1.035, 1.077)**
Workers' compensation	N/A		**.015**	**0.325 (0.131, 0.805)**	**.003**	**0.233 (0.091, 0.601)**
Traumatic	.066	1.741 (0.965, 3.139)	**<.001**	**3.778 (1.984, 7.193)**	**.013**	**2.285 (1.187, 4.398)**
Tear pattern						
Root tear	**.004**	**1.040 (0.022, 0.481)**	**.021**	**1.557 (0.032, 0.756)**	.159	0.279 (0.047, 1.648)
KOOS Sport						
Preop KOOS Sport	**.001**	**0.976 (0.962, 0.990)**	**<.001**	**0.971 (0.958, 0.985)**	**<.001**	**1.039 (1.024, 1.054)**
BMI	**.003**	**0.927 (0.882, 0.975)**	**.041**	**0.953 (0.911, 0.998)**	**.023**	**0.947 (0.904, 0.993)**
Traumatic	**.001**	**2.098 (3.391, 129.794)**	**.040**	**1.822 (1.028, 3.229)**	**.013**	**2.243 (1.183, 4.253)**
Tear pattern						
Root	**.009**	**0.132 (0.029, 0.608)**	**.021**	**0.123 (0.021, 0.731)**	.067	0.222 (0.044, 1.114)
KOOS QOL						
Preop KOOS QOL	**.023**	**0.981 (0.965, 0.997)**	**.001**	**0.972 (0.955, 0.989)**	**<.001**	**1.060 (1.039, 1.082)**
BMI	**.027**	**0.948 (0.904, 0.994**	**.007**	**0.933 (0.887, 0.981)**	**.002**	**0.918 (0.869, 0.969)**
Traumatic	**.034**	**5.096 (1.136, 22.855)**	N/A		**.014**	**7.144 (1.491, 34.232)**

NOTE. Boldface indicates significant association of variable with achieving clinically significant outcomes ($P < .05$)

ADL, activities of daily living; BMI, body mass index; CI, confidence interval; Hx, history; IKDC, International Knee Documentation Committee Score; JR, joint replacement; KOOS, Knee Injury and Osteoarthritis Outcome Score; MCID, minimal clinically important difference; N/A, not applicable; OR, odds ratio; PASS, patient-acceptable symptomatic state; PF, physical function; Preop, preoperative; QOL, quality of life; SCB, substantial clinical benefit; Sx, symptoms.

symptoms have greater propensity to improve is significant in 2 ways. This is an important point to make to patients in the preoperative setting because more debilitated patients are more likely to experience minimal improvement (MCID) and substantial clinical benefit (SCB) and should be counseled accordingly. Second, this emphasizes the importance of reporting both the change in PROMs and preoperative PROMs within comparative studies because patient improvement may be confounded by a population with more preoperative symptoms population.

We found that specific characteristics of the meniscal tear were associated with differences in improvement. Traumatic tears frequently resulted in higher achievement of at least 2 clinically significant outcomes with respect to 7 of 8 scores, even after a multivariate analysis was used to account for other variables. A recent prospective trial identified a statistical difference between KOOS scores for patients with traumatic and degenerative tears, although this was not reported to be clinically meaningful by using the standard minimally important change of 10.[8] Similarly, results of previous randomized controlled trials have suggested that arthroscopic partial meniscectomy for degenerative tears is equivalent to sham surgery and physical therapy.[17,18,45] Although these trials were largely limited by heterogeneous populations and limited sample size, these findings suggest that underlying osteoarthritis is a

significant contributor to patient symptoms, which meniscectomy does not address.

Meniscal root tears are also controversial pathology for which inferior outcomes and increased progression toward osteoarthritis have been reported, despite excision.[46-48] Meniscal root tears have recently been recognized as a source for progression of osteoarthritis by disrupting the circumferential fibers and severely reducing the conversion of axial stress from the body.[49-53] The results of the present study corroborate this finding because this pathology was associated with failure to achieve 2 or more clinically significant outcomes for KOOS Sx, KOOS ADL, and KOOS Sport subscores. Recent clinical evidence and cost analyses suggest meniscal repair may be preferred, even in elderly patients, to manage symptoms and delay progression of osteoarthritis, which may warrant further investigation.[46-48,54] Lastly, in the present study we did not find the presence of chondral defects to be associated with failure to achieve outcomes when controlling for other variables, in contrast to the results of the recent Chondral Lesions and Meniscus Procedures clinical trial.[55] This finding is limited in that these defects were not routinely measured or classified by the Outerbridge classification.

Limitations

The present study is predominantly limited in the retrospective nature of its analysis. Although outcomes were collected prospectively, the design of this study limited accurate measurement of some variables such as chondral defect size. Additionally, lack of patient compliance contributed to selection bias. This was partially controlled for by comparing preoperative characteristics to ensure that baseline scores were equivalent between compliant and noncompliant patients. However, there may be some difference in degrees of improvement in patients who chose to complete outcome surveys. Furthermore, in the present study we elected to include chondroplasty in the selection criteria. This decision was based on recent evidence from the Chondral Lesions and Meniscus Procedures clinical trial suggesting that chondroplasty has no equivalent effect on outcome scores when compared with observation.[34,56] Although this decision incorporated bias that was found within this trial, the evidence on which it is based is corroborated by the fact that both chondroplasty and chondral lesions had minimal influence on the clinically significant outcomes. The present study is also limited by the selection criteria used. The present study did not exclude patients with regard to age, tear pattern, or arthritis, which may account for heterogeneity within the patient population. The present study did not include evaluattion of preoperative imaging to determine the effect of malalignment and chondral lesion size on postoperative outcomes. Pharmaceutical intervention was also not controlled within the present study. The time during which the intervention was effective was also not evaluated but may help provide further evidence on efficacy.

Conclusions

Clinically meaningful outcomes were established by patient self-assessment. Variables associated with achieving these outcomes include preoperative score (positively correlated with MCID/SCB, negatively correlated with PASS); workers' compensation; degenerative, medial-sided tears; and root tears (remaining negatively correlated with MCID/SCB/PASS). These variables should be accordingly measured for confounding in future outcome reporting.

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Appendix. Unabridged Multivariate Logistic Regression of Factors Influencing Patient Achievement of Clinically Significant Outcomes

	MCID		SCB		PASS	
	P Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)
IKDC						
Preop IKDC	.073	0.983 (0.968, 1.001)	**<.001**	**0.961 (0.942, 0.981)**	**<.001**	**1.071 (1.045, 1.097)**
Workers' xompensation	**.013**	**0.341 (0.146, 0.796)**	**.034**	**0.386 (0.162, 0.923)**	**.011**	**0.302 (0.120, 0.765)**
Hx of thyroid disease	.091	0.354 (0.106, 1.181)	N/A		N/A	
No smoking Hx	N/A		**.015**	**9.251 (1.550, 55.220)**	N/A	
BMI	N/A		**.021**	**0.944 (0.899, 0.991)**	.077	0.955 (0.908, 1.005)
Symptom duration	N/A		.126	0.976 (0.946, 1.007)	**.004**	**0.958 (0.931, 0.986)**
Degenerative tear	.083	3.656 (0.843, 15.851)	.099	5.263 (0.730, 37.920)	N/A	
Traumatic tear	**.006**	**8.174 (1.845, 36.206)**	**.014**	**12.264 (1.664, 90.390)**	**.042**	**2.042 (1.027, 4.062)**
Tear pattern						
Bucket handle	N/A		.131	4.585 (0.635, 33.104)	N/A	
Vertical/longitudinal	.992		N/A		N/A	
Oblique	**.018**	**6.771 (1.397, 32.818)**	N/A		**.028**	**5.208 (1.200, 22.607)**
Horizontal	.990		N/A		N/A	
Complex	N/A		.140	1.646 (0.849, 3.191)	N/A	
Root	.067	0.279 (0.071, 1.094)	.082	0.189 (0.029, 1.235)	**.054**	**0.149 (0.022, 1.036)**
KOOS JR						
Preop KOOS JR	**.036**	**0.964 (0.931, 0.998)**	**.014**	**0.964 (0.931, 0.998)**	**<.001**	**1.079 (1.037, 1.123)**
Age	**.031**	**0.960 (0.924, 0.996)**	**.045**	**0.960 (0.924, 0.996)**	**.038**	**0.963 (0.929, 0.998)**
Workers' compensation	**.018**	**0.197 (0.051, 0.757)**	**.003**	**0.197 (0.051, 0.757)**	**.035**	0.184 (0.038, 0.885)
No smoking Hx	.164	2.158 (0.730, 6.380)	.900	2.158 (0.730, 6.380)	.056	3.431 (0.969, 12.154)
Hx of HTN	N/A		.151	0.440 (0.144, 1.340)	N/A	
Hx of thyroid disease	N/A		N/A		**.036**	**4.397 (1.104, 17.516)**
Symptom duration	.055	0.965 (0.931, 1.000)	N/A		**.012**	**0.946 (0.906, 0.988)**
Traumatic tear	.072	2.001 (0.941, 4.257)	**<.001**	**7.393 (2.908, 18.798)**	**.001**	**3.778 (1.678, 8.505)**
Tear pattern						
Discoid meniscus	.994		.991		N/A	
Medial	N/A		**.009**	**0.206 (0.064, 0.670)**	N/A	
Transverse/radial	N/A		N/A		.134	0.432 (0.144, 1.296)
Vertical/longitudinal	N/A		.108	0.088 (0.004, 1.711)	N/A	
KOOS PF						
Preop KOOS PF	**.040**	**1.050 (1.002, 1.100)**	**.013**	**1.062 (1.0125, 1.113)**	**.002**	**0.918 (0.869, 0.969)**
Workers' compensation	**.020**	**0.070 (0.007, 0.663)**	**.048**	**0.007 (0.006, 0.972)**	.993	
No smoking Hx	N/A		.926	1.068 (0.270, 4.216)	.328	2.129 (0.468, 9.688)
Hx of HTN	.089	0.363 (0.113, 1.165)	.097	0.375 (0.117, 1.194)	N/A	
Chondral defect	.087	2.500 (0.876, 7.137)	N/A		N/A	
Traumatic tear	**.031**	**2.819 (1.098, 7.239)**	**<.001**	**5.166 (1.991, 13.405)**	**<.001**	**8.351 (2.913, 23.938)**
Tear pattern						
Medial	N/A		**.007**	**0.164 (0.044, 0.607)**	**.010**	**0.154 (0.037, 0.635)**
Oblique	.101	8.162 (0.664, 100.261)	N/A		N/A	
Transverse/radial	.172	3.154 (0.608, 16.371)	N/A		N/A	
Vertical/longitudinal	N/A		.992		N/A	
Flap	N/A		.152	2.186 (0.750, 6.377)	.110	2.543 (0.811, 7.979)
Complex	N/A		.148	2.282 (0.745, 6.989)	N/A	
KOOS Sx						
Preop KOOS Sx	**<.001**	**0.950 (0.932, 0.969)**	**<.001**	**0.941 (0.923, 0.959)**	**<.001**	**1.033 (1.016, 1.052)**
Workers' compensation	**.020**	**0.355 (0.149, 0.847)**	**.003**	**0.267 (0.111, 0.638)**	**.004**	**0.312 (0.143, 0.684)**
HTN	.106	1.944 (0.867, 4.358)	N/A		N/A	
BMI	.084	0.960 (0.917, 1.005)	N/A		**.029**	**0.950 (0.907, 0.995)**
Symptom duration	**.016**	**0.986 (0.943, 0.994)**	.060	0.973 (0.946, 1.001)	**.036**	**0.974 (0.951, 0.998)**
Degenerative	**.033**	**7.109 (1.171, 43.156)**	N/A		N/A	
Traumatic	**.018**	**9.063 (1.463, 56.127)**	**.008**	**2.368 (1.258, 4.458)**	N/A	
Tear pattern						
Lateral	.061	0.538 (0.281, 1.029)	N/A		.094	0.590 (0.318, 1.096)
Root tear	**.008**	**0.127 (0.027, 0.589)**	**.008**	**0.101 (0.018, 0.555)**	**.032**	**0.197 (0.044, 0.870)**
Complex	.152	1.690 (0.824, 3.465)	N/A		N/A	
KOOS Pain						
Preop KOOS Pain	**.020**	**0.976 (0.957, 0.996)**	N/A		**<.001**	**1.048 (1.026, 1.070)**
Age	**.042**	**1.026 (1.000, 1.052)**	N/A		N/A	
Workers' compensation	**.039**	**0.413 (0.178, 0.957)**	**.006**	**0.249 (0.093, 0.666)**	**.011**	**0.323 (0.135, 0.775)**

(continued)

Appendix. Continued

	MCID		SCB		PASS	
	P Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)
Hx of HTN	N/A		N/A		**.040**	**0.456 (0.216, 0.963)**
BMI	N/A		N/A		.051	0.953 (0.908, 1.000)
Symptom duration	**.007**	**0.966 (0.942, 0.991)**	N/A		**.002**	**0.955 (0.928, 0.984)**
Degenerative	N/A		N/A		**.054**	**0.547 (0.296, 1.012)**
Traumatic	.063	1.843 (0.968, 3.510)	**<.001**	**12.352 (2.816, 54.178)**	N/A	
Chondroplasty	.071	0.511 (0.246, 1.059)	N/A		.096	1.986 (0.886, 4.449)
Tear pattern						
Medial	N/A		N/A		.095	1.828 (0.901, 3.708)
Discoid meniscus	N/A		N/A		.988	
Transverse/radial	N/A		N/A		**.045**	**2.358 (1.020, 5.451)**
Root	N/A		N/A		.108	0.258 (0.049, 1.344)
Vertical/longitudinal	.987		N/A		N/A	
Oblique	.104	2.772 (0.811, 9.476)	.101	5.830 (0.709, 47.947)	N/A	
Horizontal	N/A		.985		N/A	
KOOS ADL						
Preop KOOS ADL	**<.001**	**0.964 (0.947, 0.981)**	**<.001**	**0954 (0.937, 0.971)**	**<.001**	**1.056 (1.035, 1.077)**
Workers' compensation	N/A		**.015**	**0.325 (0.131, 0.805)**	**.003**	**0.233 (0.091, 0.601)**
No Smoking Hx	.321	1.568 (0.644, 3.813)	.830	0.902 (0.352, 2.311)	.053	2.709 (0.987, 7.437)
Chondral defect	**.011**	**2.442 (1.227, 4.862)**	N/A		N/A	
Hx of HTN	N/A		**.044**	**0.454 (0.211, 0.979)**	.062	0.484 (0.225, 1.037)
BMI	N/A		N/A		.140	0.963 (0.917, 1.012)
Traumatic	.066	1.741 (0.965, 3.139)	**<.001**	**3.778 (1.984, 7.193)**	**.013**	**2.285 (1.187, 4.398)**
Symptom duration	N/A		N/A		**.009**	**0.960 (0.932, 0.990)**
Chondroplasty	**.012**	**0.360 (0.161, 0.801)**	.095	0.498 (0.220, 1.128)	N/A	
Tear pattern						
Vertical/longitudinal	.967		.987		N/A	
Oblique	N/A		**.006**	**4.982 (1.581, 15.706)**	N/A	
Root	**.004**	**1.040 (0.022, 0.481)**	**.021**	**1.557 (0.032, 0.756)**	.159	0.279 (0.047, 1.648)
KOOS Sport						
Preop KOOS Sport	**.001**	**0.976 (0.962, 0.990)**	**<.001**	**0.971 (0.958, 0.985)**	**<.001**	**1.039 (1.024, 1.054)**
Age	.071	1.026 (0.998, 1.055)	N/A		N/A	
Workers' compensation	.116	0.472 (0.185, 1.204)	N/A		.075	0.451 (0.188, 1.083)
Diabetes	.984		N/A		N/A	
Hx of thyroid disease	.150	0.395 (0.112, 1.397)	N/A		N/A	
BMI	**.003**	**0.927 (0.882, 0.975)**	**.041**	**0.953 (0.911, 0.998)**	**.023**	**0.947 (0.904, 0.993)**
Symptom duration	**.021**	**0.969 (0.944, 0.995)**	.085	0.974 (0.944, 1.004)	**.015**	**0.968 (0.943, 0.994)**
Degenerative	**.003**	**1.561 (2.588, 94.122)**	N/A		N/A	
Traumatic	**.001**	**2.098 (3.391, 129.794)**	**.040**	**1.822 (1.028, 3.229)**	**.013**	**2.243 (1.183, 4.253)**
Tear pattern						
Medial	**.025**	**0.281 (0.093, 0.853)**	N/A		N/A	
Lateral	**.019**	**0.353 (0.150, 0.841)**	N/A		N/A	
Bucket handle	.260	5.399 (0.373, 78.240)	N/A		N/A	
Oblique	.181	2.467 (0.657, 9.270)	N/A		**.029**	**3.746 (1.148, 12.227)**
Root	**.009**	**0.132 (0.029, 0.608)**	**.021**	**0.123 (0.021, 0.731)**	.067	0.222 (0.044, 1.114)
Complex	.156	1.710 (0.815, 3.587)	.154	1.592 (0.840, 3.017)	N/A	
KOOS QOL						
Preop KOOS QOL	**.023**	**0.981 (0.965, 0.997)**	**.001**	**0.972 (0.955, 0.989)**	**<.001**	**1.060 (1.039, 1.082)**
Age	.142	1.019 (0.994, 1.046)	.151	0.982 (0.957, 1.007)	N/A	
Workers compensation	.062	0.461 (0.205, 1.040	.060	0.443 (0.190, 1.036)	**<.001**	**0.160 (0.060, 0.422)**
Diabetes	.994		N/A		N/A	
BMI	**.027**	**0.948 (0.904, 0.994**	**.007**	**0.933 (0.887, 0.981)**	**.002**	**0.918 (0.869, 0.969)**
Symptom duration	N/A		**.007**	**0.955 (0.924, 0.988)**	.079	0.976 (0.949, 1.003)
Chondral defect	N/A		N/A		.068	1.962 (0.952, 4.042)
Degenerative	.052	4.419 (0.987, 19.793	N/A		.068	4.223 (0.899, 19.830)
Traumatic	**.034**	**5.096 (1.136, 22.855)**	N/A		**.014**	**7.144 (1.491, 34.232)**
Tear pattern						
Lateral	N/A		N/A		**.048**	**0.495 (0.247, 0.994)**
Vertical/longitudinal	.992		N/A		N/A	
Oblique	N/A		N/A		.054	4.140 (0.976, 17.555)
Transverse/radial	.050	2.578 (0.999, 6.647)	N/A		N/A	
Flap	N/A		**.025**	**2.216 (1.105, 4.445)**	N/A	

(continued)

Appendix. Continued

	MCID		SCB		PASS	
	P Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)
Root	N/A		N/A		**.021**	**0.154 (0.031, 0.758)**
Complex	N/A		**.046**	**1.936 (1.012, 3.701)**	N/A	

NOTE. Boldface indicates significant association of variable with achieving clinically significant outcomes ($P < .05$).

ADL, activities of daily living; BMI, body mass index; CI, confidence interval; HTN, hypertension; Hx, history; IKDC, International Knee Documentation Committee Score; JR, joint replacement; KOOS, Knee Injury and Osteoarthritis Outcome Score; MCID, minimal clinically important difference; N/A, not applicable; OR, odds ratio; PASS, patient-acceptable symptomatic state; PF, physical function; QOL, quality of life; SCB, substantial clinical benefit; Sx, symptoms.