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Predictors of Successful Treatment 1 Year After Arthroscopic Partial Meniscectomy

Data from the OME Cohort

Cleveland Clinic Sports Health*

Investigation performed at the Cleveland Clinic, Cleveland, Ohio

Background: Arthroscopic partial meniscectomy (APM) is one of the most common orthopaedic procedures. Understanding factors that predict better patient-reported outcomes is important for guiding patient and clinician decision-making. The purpose of this study was to evaluate predictors of pain and function after APM in a large, multisite, academic health system cohort.

Methods: We prospectively enrolled 665 patients who were ≥40 years of age and who had APM without any concomitant ligament or cartilage-resurfacing procedures. There were 486 subjects (73%) who completed baseline and follow-up questionnaires including demographic variables (age, sex, body mass index [BMI], education level), surgical findings (meniscal tear type, articular cartilage grade), and patient-reported outcomes (Knee injury and Osteoarthritis Outcome Score [KOOS] Pain, Physical Function Short Form [PS], and knee-related Quality of Life [QOL]; and Veterans RAND 12-Item [VR-12] Mental Component Score [MCS] and Physical Component Score [PCS]). We constructed multivariable statistical models to assess predictors of improvement in patient-reported outcomes, as well as a model to assess predictors of a successful improvement of at least 10 points in either KOOS Pain or KOOS-PS.

Results: The mean age was 55 years, 46% of patients were female, and the mean BMI was 30 kg/m^2. There were clinically important and significant improvements ($p < 0.001$) in all patient-reported outcomes from baseline to the 1-year follow-up. The following factors predicted less improvement in at least 1 patient-reported outcome: higher baseline score, higher BMI, older age, less education, current smoking, lower VR-12 MCS, prior ipsilateral surgical procedure, bipolar medial compartment cartilage lesions, and a lateral meniscal tear. Eighty-three percent of subjects had a successful improvement of 10 points in either KOOS Pain or KOOS-PS. The odds of successful improvement were lower in patients with a medial meniscal root tear, a lateral meniscal tear, or higher baseline KOOS Pain score.

Conclusions: Eighty-three percent of patients improved by at least 10 points in pain and function after APM. Patients with a medial meniscal root tear or a lateral meniscal tear had decreased odds of a clinically important improvement in pain or function after APM. Increased BMI, smoking, and worse VR-12 MCS are potentially modifiable risk factors that predict less improvement after APM and warrant further study.

Level of Evidence: Prognostic Level I. See Instructions for Authors for a complete description of levels of evidence.

Nearly 1 million knee arthroscopic procedures are performed in the United States each year, and arthroscopic partial meniscectomy (APM) is the most common[1]. Some randomized trials have shown that APM is no better than sham surgery[2] or conservative treatment that includes physical therapy for treatment of a symptomatic meniscal tear[3-5]. Other

*A list of the Cleveland Clinic Sports Health members for this work is given as a note at the end of the article.

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studies have shown more treatment failures in patients who undergo conservative treatment, with the treatment failures including subjects who cross over to APM from nonoperative treatment arms[4,6-8].

Nevertheless, APM continues to be performed at a high rate, so it is important to understand the patient factors that are associated with a favorable outcome. These factors include younger age, less osteoarthritis, shorter duration of symptoms, and lower body mass index (BMI); however, most studies were retrospective and did not include enough subjects to perform multivariable analysis[9,10]. Understanding the predictors of failure to relieve pain or improve function and of worse outcome is important to provide patients and clinicians with the best evidence available to guide shared decision-making on treatment.

Our study had the aims of evaluating predictors of pain and function 1 year after APM in a large, prospective cohort from multiple facilities in an academic hospital system; of evaluating the predictors of achieving a successful improvement in patient-reported outcomes at 1 year in this patient cohort; and of developing a nomogram based on the model for successful improvement that can be used for shared decision-making prior to APM. We hypothesized that cartilage damage and meniscal root tears would be associated with failure to relieve pain or improve function along with worse outcomes in these patients.

Materials and Methods

Study Design and Setting

Patients undergoing knee arthroscopy at the Cleveland Clinic were prospectively enrolled in the OrthoMiDaS Episode of Care (OME) cohort as part of the standard of care at our institution. The OME is a data collection system developed at the Cleveland Clinic that prospectively captures patient and surgeon data at baseline and patient data at a 1-year follow-up.

Participants

Patients were eligible for inclusion in the analysis cohort if they were ≥40 years of age, underwent APM, and did not undergo concomitant ligament reconstruction, meniscal transplant, or cartilage-resurfacing procedures. Patients were excluded if they had undergone a bilateral surgical procedure.

Description of Treatment

In general, our surgeons followed a treatment approach informed by results of the MeTeOR (Meniscal Tear in Osteoarthritis Research) randomized controlled trial[8]: patients with a symptomatic medial meniscal tear and mechanical symptoms were referred to physical therapy, and patients who did not improve after physical therapy were indicated for surgical treatment. Patients with >50% joint space narrowing (equivalent to Kellgren-Lawrence grade 4) in the symptomatic compartment were not considered

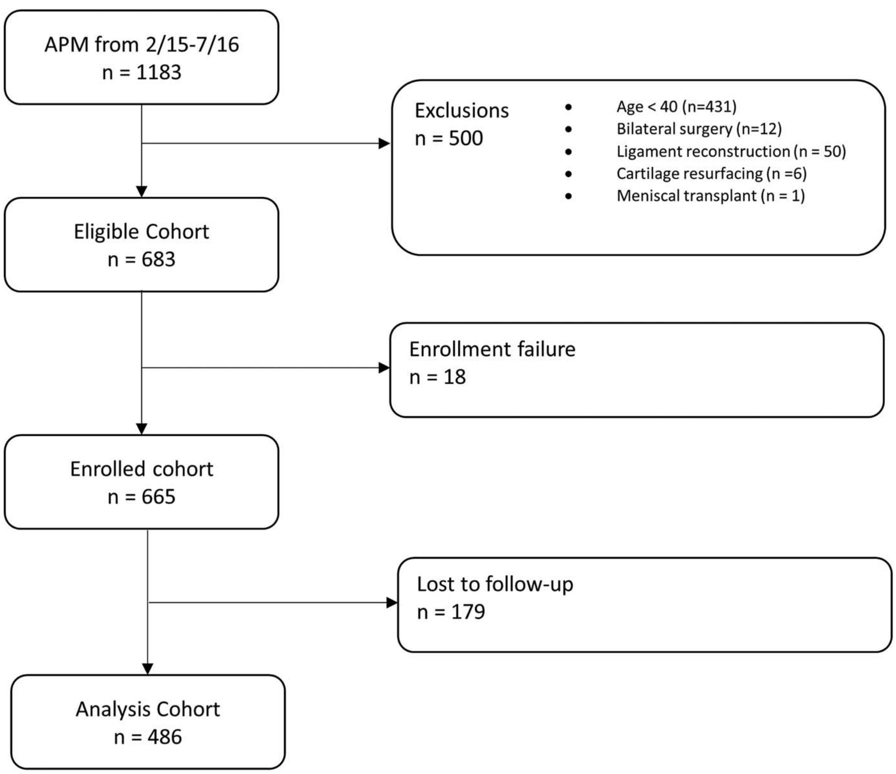

Fig. 1
Enrollment and exclusions flowchart.

TABLE I Baseline Characteristics of the Cohort

Variable	Included (N = 486)	Lost to Follow-up (N = 179)
Age* *(yr)*	55 (49 to 62)	52 (47 to 58.5)
Sex†		
Male	265 (54.5%)	105 (58.7%)
Female	221 (45.5%)	74 (41.3%)
BMI* *(kg/m²)*	30.1 (26 to 34.5)	30.2 (26.6 to 33.8)
Education* *(yr)*	15.5 (12 to 16)	14 (12 to 16)
Smoking status†		
Never	289 (59.5%)	91 (50.8%)
Quit	161 (33.1%)	54 (30.2%)
Current	36 (7.4%)	34 (19.0%)
Root tear†		
No	450 (92.6%)	174 (97.2%)
Yes	36 (7.4%)	5 (2.8%)
Medial meniscal tear type†		
None	66 (13.6%)	37 (20.7%)
Oblique or flap	61 (12.6%)	12 (6.7%)
Longitudinal	12 (2.5%)	3 (1.7%)
Bucket-handle	12 (2.5%)	5 (2.8%)
Radial	40 (8.2%)	23 (12.8%)
Root	32 (6.6%)	3 (1.7%)
Horizontal	11 (2.3%)	2 (1.1%)
Complex	252 (51.9%)	94 (52.5%)
Lateral meniscal tear type†		
None	333 (68.5%)	118 (65.9%)
Oblique or flap	14 (2.9%)	3 (1.7%)
Longitudinal	6 (1.2%)	2 (1.1%)
Bucket-handle	6 (1.2%)	6 (3.4%)
Radial	10 (2.1%)	7 (3.9%)
Root	4 (0.8%)	2 (1.1%)
Horizontal	13 (2.7%)	1 (0.6%)
Complex	100 (20.6%)	40 (22.3%)
Medial cartilage†		
Normal	233 (47.9%)	96 (53.6%)
Bipolar lesions	59 (12.1%)	22 (12.3%)
Unipolar lesion	194 (39.9%)	61 (34.1%)
Lateral cartilage†		
Normal	378 (77.8%)	144 (80.4%)
Bipolar lesions	28 (5.8%)	9 (5.0%)
Unipolar lesion	80 (16.5%)	26 (14.5%)
Patellofemoral cartilage†		
Normal	247 (50.8%)	101 (56.4%)
Bipolar lesions	107 (22.0%)	30 (16.8%)
Unipolar lesion	132 (27.2%)	48 (26.8%)
Synovitis†		
No	411 (84.6%)	157 (87.7%)
Yes	75 (15.4%)	22 (12.3%)

continued

TABLE I (*continued*)

Variable	Included (N = 486)	Lost to Follow-up (N = 179)
Prior ipsilateral surgery†		
No	419 (86.2%)	156 (87.2%)
Yes	67 (13.8%)	23 (12.8%)
Outcomes* *(points)*		
VR-12 MCS	55.8 (46.5 to 62.5)	54.2 (42.7 to 61.7)
KOOS Pain	47.2 (36.1 to 61.1)	41.7 (30.6 to 52.8)
KOOS-PS	42 (35.3 to 54.4)	48.5 (40.3 to 57.9)
KOOS QOL	31.2 (18.8 to 43.8)	25 (12.5 to 37.5)
VR-12 PCS	32.3 (25.5 to 39.2)	27.8 (22.9 to 37.5)

*The values are given as the median, with the interquartile range in parentheses. †The values are given as the number of patients, with the percentage in parentheses.

surgical candidates. Patients with a locked knee or a displaced portion of meniscal tissue would typically undergo a surgical procedure before completing a course of physical therapy. We did not monitor preoperative care as a part of this study. Surgical treatment included arthroscopy with debridement of an unstable meniscus and articular cartilage tissue.

Aftercare and Follow-up

Patients were referred to physical therapy after the surgical procedure, but we did not collect data with regard to the number of therapy visits or adherence to home exercise programs. Patients were administered follow-up questionnaires at 1 year postoperatively.

Variables and Outcomes Measures

Baseline patient questionnaires were administered on tablet computers on the day of the surgical procedure and included demographic characteristics (age, sex, years of education), general health data (height, weight, smoking status), and patient-reported outcome measures (Veterans RAND 12 [VR-12] and Knee injury and Osteoarthritis Outcome Score [KOOS] Pain subscale, Physical Function Short Form [KOOS-PS], and knee-related Quality of Life [KOOS QOL]). The 3 KOOS scores consist of a total of 20 items that are transformed to a 0-to-100 scale, with a KOOS Pain score of 100 representing no pain, a KOOS QOL score of 100 representing normal quality of life, and a KOOS-PS score of 0 representing no impairment (normal function)[11-14]. The VR-12 consists of 12 items that assess health-related quality of life. The VR-12 Physical Component Score (PCS) emphasizes items about physical functioning and pain, and the VR-12 Mental Component Score (MCS) emphasizes items about mental health and social functioning. The population norm for the VR-12 PCS and VR-12 MCS is 50, with higher scores representing better health[15,16].

Surgeon questionnaires were collected on smartphones and included articular cartilage on 6 surfaces (patella, trochlea, medial femoral condyle, medial tibial plateau, lateral femoral condyle, and lateral tibial plateau) graded by a modified Outerbridge classification (grade 0: normal, grade 1: softening, grade 2: fissures and superficial changes, grade 3: fragmentation and deep changes, and grade 4: exposed bone)[11,12], meniscal tear pattern (oblique or flap, horizontal, longitudinal, radial, displaced bucket-handle, root, or complex tear)[13], and grading of synovitis (reactive synovitis present or absent).

Patient follow-up questionnaires including the same patient-reported outcomes were collected at a minimum of 1 year postoperatively. Patients were contacted by a combination of email, telephone call, and mail.

Study data were collected and managed using REDCap electronic data capture tools[4].

TABLE II Baseline and 1-Year Follow-up KOOS Subscale Scores and VR-12 PCS

Outcome Score	Baseline*	1-Year Follow-up*	P Value
KOOS Pain	47.2 (36.1 to 61.1)	80.6 (63.9 to 91.7)	<0.001
KOOS-PS	42.0 (35.3 to 54.4)	27.5 (14.8 to 37.0)†	<0.001
KOOS QOL	31.3 (18.8 to 43.8)	62.5 (43.8 to 81.3)	<0.001
VR-12 PCS	32.3 (25.5 to 39.2)	44.5 (34.9 to 52.8)	<0.001

*The values are given as the median, with the interquartile range in parentheses. †The lower number is indicative of better physical function.

Statistical Analysis

The primary predictors of outcome included articular cartilage status and meniscal tear type. Categories were combined a priori to make predictors more clinically relevant, to preserve degrees of freedom in the analysis, and to avoid including rare predictors. We classified articular cartilage status for the medial, lateral, and patellofemoral compartments according to the following categories. A normal compartment had no grade-

TABLE III Predictors of Change Scores for the Proportional Odds Logistic Regression Model

	VR-12 PCS		KOOS Pain		KOOS-PS		KOOS QOL	
	Coefficient*	P Value	Coefficient*	P Value	Coefficient*	P Value	Coefficient*	P Value
Age	−0.1 ± 0.05	0.06	−0.09 ± 0.1	0.38	−0.19 ± 0.09	0.04†	0.03 ± 0.13	0.79
Female sex	−0.05 ± 0.91	0.95	−1.39 ± 1.78	0.43	−1.53 ± 1.62	0.35	−2.97 ± 2.27	0.19
BMI	−0.3 ± 0.07	<0.01†	−0.42 ± 0.13)	<0.01†	−0.35 ± 0.12	<0.01†	−0.49 ± 0.16	<0.01†
Years of education	0.26 ± 0.16	0.11	0.65 ± 0.32)	0.04†	0.55 ± 0.29	0.06	0.43 ± 0.4	0.29
Smoking status								
Quit	0.25 ± 0.96	0.8	2.58 ± 1.85	0.16	2.38 ± 1.7	0.16	1.75 ± 2.37	0.46
Current	−4.56 ± 1.72	0.01†	−9.21 ± 3.39	0.01†	−5.73 ± 3.09	0.06	−8.93 ± 4.27	0.04†
Baseline VR-12 MCS	0.15 ± 0.04	<0.01†	0.2 ± 0.08	0.01†	0.22 ± 0.07	<0.01†	0.19 ± 0.1	0.07
Medial meniscal tear								
Root	−0.7 ± 2.3	0.76	−7.03 ± 4.46	0.12	−3.25 ± 4.09	0.43	−10.48 ± 5.78	0.07
Other	1.41 ± 1.63	0.39	0.45 ± 3.16	0.89	−0.22 ± 2.93	0.94	−0.24 ± 4.05	0.95
Lateral meniscal tear	−3.08 ± 1.19†	0.01†	−4.08 ± 2.31	0.08	−3.95 ± 2.15	0.07	−4.25 ± 2.99	0.16
Medial cartilage lesion								
Unipolar	−0.22 ± 0.96	0.82	−2.26 ± 1.87	0.23	−1.25 ± 1.73	0.47	−3.07 ± 2.4	0.20
Bipolar	−3.1 ± 1.51	0.04†	−7.29 ± 2.94	0.01†	−7.43 ± 2.7	0.01†	−10.66 ± 3.76	<0.01†
Lateral cartilage lesion								
Unipolar	−0.94 ± 1.26	0.46	−2.04 ± 2.46	0.41	−2.9 ± 2.27	0.20	−4.15 ± 3.15	0.19
Bipolar	1.87 ± 2.01	0.35	−2.23 ± 3.89	0.57	−1.68 ± 3.62	0.64	0.07 ± 4.98	0.99
Patellofemoral cartilage lesion								
Unipolar	1.19 ± 1.03	0.25	3.59 ± 2.02	0.08	0.46 ± 1.85	0.80	2.58 ± 2.57	0.32
Bipolar	0.11 ± 1.21	0.93	1.15 ± 2.35	0.62	−1.52 ± 2.16	0.48	−1.08 ± 3.01	0.72
Synovitis	1.01 ± 1.23	0.41	3.65 ± 2.4	0.13	1.25 ± 2.2	0.57	2.08 ± 3.07	0.50
Prior ipsilateral surgery	−0.53 ± 1.33	0.69	−6.68 ± 2.59	0.01†	−3.15 ± 2.36	0.18	−6.53 ± 3.31	0.05
Baseline score	−0.62 ± 0.05	<0.01†	−0.71 ± 0.05	<0.01†	−0.76 ± 0.05	<0.01†	−0.62 ± 0.07	<0.01†

*The values are given as the coefficient and the standard error. †Significant.

3 or grade-4 lesions on either cartilage surface, a unipolar compartment had a grade-3 or 4 lesion on either the femur or the tibia (medial and lateral compartments) or on the patella (patellofemoral compartment), and a bipolar compartment had grade-3 or 4 cartilage lesions on both cartilage surfaces. We classified meniscal tears as either medial root tears, other medial tears, or lateral tears because we did not have enough cases to analyze each type of tear as a predictor. We classified reactive synovitis as present or absent. Significance was set at $p < 0.05$.

In addition to the meniscus and articular cartilage variables, we also included the following covariates in the models: age, sex, BMI, race, smoking status, history of a surgical procedure in the index knee, years of education, VR-12 MCS, and baseline score (the model for KOOS Pain included baseline KOOS Pain as a covariate, the model for KOOS-PS included baseline KOOS-PS as a covariate, and the response to treatment model included baseline KOOS Pain as a covariate).

We performed multivariable statistical analysis in 3 phases: (1) the mean improvement in patient-reported outcome measures was assessed using the paired Wilcoxon signed-rank test for each patient-reported outcome measure, (2) an analysis of continuous outcomes was performed to determine the predictors of improvement in patient-reported outcomes from baseline to the 1-year follow-up, and (3) an analysis of response to treatment was performed to determine the predictors of a successful improvement in either pain or function at the 1-year follow-up. All covariates described above were specified a priori to be included in the full models for each outcome to enable adequate adjustment for clinically relevant confounders. Variable reduction was only performed if rules with regard to the ratio between the degrees of freedom of the observations and number of events, according to Harrell, were violated[17].

Continuous Outcome Analysis

Multivariable statistical models were built to predict the improvement score in KOOS Pain, KOOS QOL, KOOS-PS, and VR-12. Ordinary linear regression was used to model the change scores. The assumptions of normally distributed residuals and a constant variance were assessed and were verified graphically to ensure

TABLE IV ORs for Successful Treatment, Defined as a 10-Point Improvement in Either KOOS Pain or KOOS-PS

Variable	OR*	P Value
Age	0.98 (0.95 to 1.01)	0.219
Smoking status		
Never	Reference	
Quit	1.45 (0.79 to 2.66)	0.227
Current	0.49 (0.19 to 1.26)	0.140
Baseline VR-12 MCS	1.02 (1 to 1.05)	0.072
Tear status		
Medial tear not involving root	Reference	
Medial root tear	0.27 (0.11 to 0.66)	0.004†
Lateral tear only	0.42 (0.2 to 0.9)	0.025†
Medial and lateral tears	0.32 (0.17 to 0.61)	0.001†
Medial cartilage		
Normal	Reference	
Bipolar lesions	0.54 (0.24 to 1.21)	0.134
Unipolar lesion	0.67 (0.38 to 1.19)	0.172
Prior ipsilateral surgical procedure	0.52 (0.26 to 1.06)	0.072
Baseline score	0.96 (0.94 to 0.97)	<0.001†

*The values are given as the OR, with the 95% CI in parentheses. †Significant.

model adequacy. Variable reduction was not performed for continuous outcomes because Harrell's rule of thumb for ordinary regression suggests 10 observations per model degree of freedom, which was satisfied a priori[17].

Response to Treatment Analysis

Successful response to treatment was defined as an improvement of 10 points in either KOOS Pain or KOOS-PS. A multivariable logistic regression model was constructed to determine predictors of successful treatment. Clinically driven candidate variables were selected to be tested for removal in the event of overfitting by the full model to ensure that clinically important and significant variables were kept while reasonably satisfying degree of freedom to event ratios. The Akaike information criterion (AIC) was used to compare the full model and the reduced model. Candidate variables were removed if a decrease in the AIC was observed.

Regression Analytics

We used QQ (quantile-quantile) plots to assess the assumption of residual normality and compared fitted plots with plots of the residuals to assess the assumption of a constant variance. We calculated bootstrap-validated R^2 values for each model.

Results

Study Population

From February 2015 until July 2016, 665 patients were enrolled, and 486 patients (73%) completed questionnaires at the 1-year follow-up. Additional details of enrollment and exclusions are shown in Figure 1.

The mean age was 55 years, 45.5% of patients were female, and the mean BMI was 30 kg/m^2. Seventy percent of patients had medial meniscal tears (7% were root tears), 14% had lateral meniscal tears, and 16% had both medial and lateral meniscal tears. Twenty-eight percent of patients had normal articular cartilage in all 3 compartments. Table I shows additional baseline characteristics.

Overall Improvement

The median VR-12 PCS improved from 32.3 points preoperatively to 44.5 points postoperatively, the median KOOS Pain subscore improved from 47.2 points preoperatively to 80.6 points postoperatively, the median KOOS QOL improved from 31.3 points preoperatively to 62.5 points postoperatively, and the median KOOS-PS improved from 42.0 points preoperatively to 27.5 points postoperatively. These were all clinically important and significant improvements ($p < 0.001$) (Table II).

Multivariable Regression

Multivariable modeling shows that baseline score was the strongest predictor of improvement in the 1-year follow-up scores for all outcome measures (VR-12 PCS, KOOS Pain, KOOS-PS, and KOOS QOL), with a lower baseline score predicting a larger improvement. For demographic factors, subjects with lower BMI had more improvement for all outcomes, subjects with younger age had more improvement in KOOS-PS but not in other outcomes, and subjects with more education had more improvement in KOOS Pain but not in other outcomes. Patient sex was not a significant predictor of improvement. Current smoking, a modifiable risk factor, predicted less improvement for all outcomes except KOOS-PS. Higher VR-12 MCS at baseline predicted more improvement for all outcome measures except KOOS QOL. For intra-articular findings, bipolar grade-3 or 4 medial compartment cartilage lesions predicted less improvement for all outcome measures, a lateral meniscal tear predicted less improvement for VR-12 PCS but not for other outcomes, and a prior surgical procedure on the index knee predicted less improvement for KOOS Pain but not for other outcomes. Lateral articular cartilage status, patellofemoral articular cartilage status, synovitis, and a medial meniscal tear were not significant predictors of improvement. The coefficients and p values for all outcomes and predictors are shown in Table III. The bootstrap-validated R^2 values were 0.25 for VR-12 PCS, 0.26 for KOOS Pain, 0.31 for KOOS-PS, and 0.16 for KOOS QOL.

Multivariable Modeling of Predictors of 10-Point Improvement in KOOS Pain or KOOS-PS

Subjects with a 10-point improvement in KOOS Pain or KOOS-PS were considered to have a successful treatment. Eighty-three percent of patients in the cohort had a successful outcome based on these criteria. The odds of successful treatment were lower in patients with a medial meniscal root tear, a

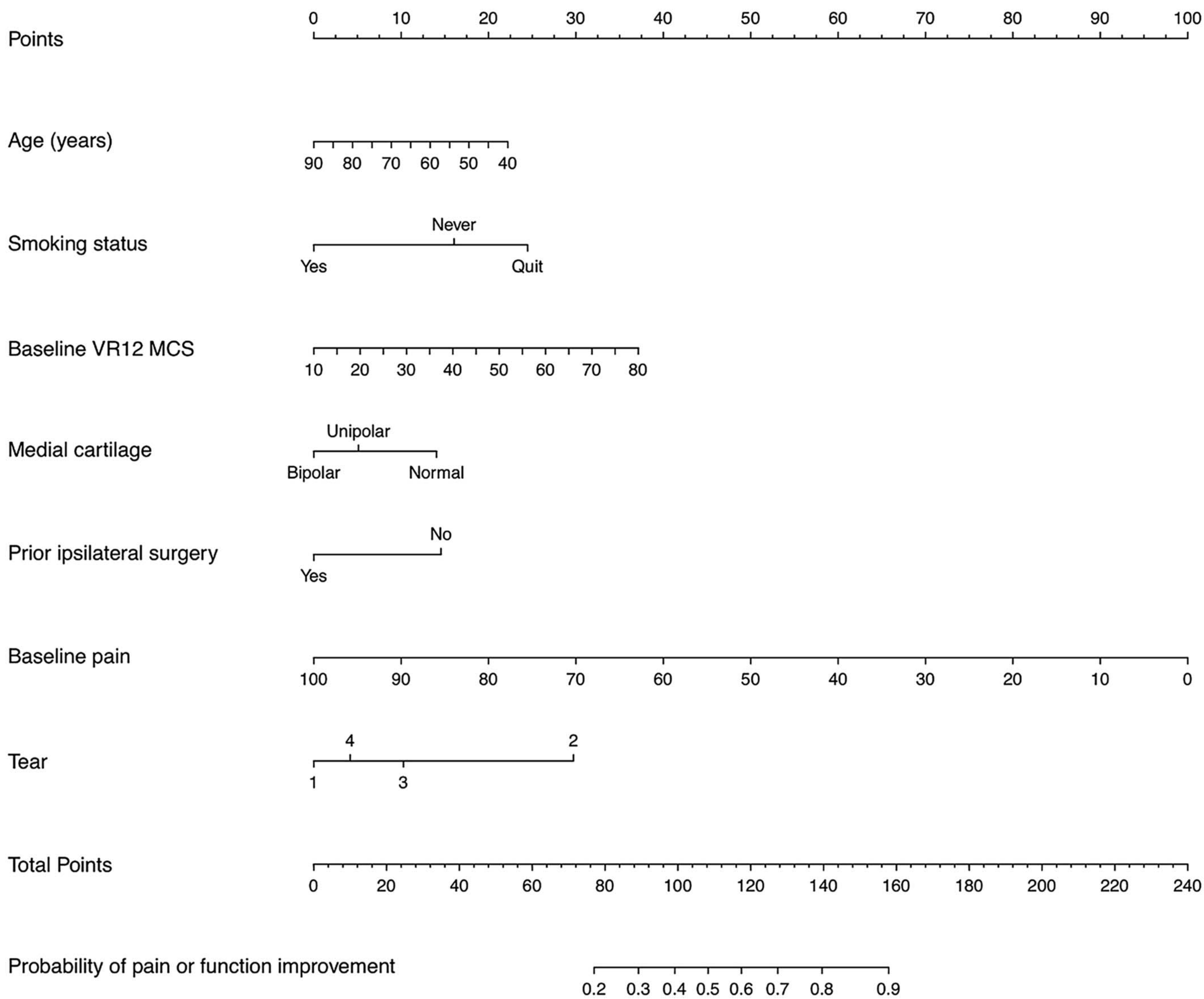

Fig. 2

Nomogram for the probability of successful treatment, defined as improvement by at least 10 points in either KOOS Pain or KOOS-PS.

lateral meniscal tear, or a higher baseline KOOS Pain score. Table IV shows odds ratios (ORs), 95% confidence intervals (CIs), and p values for variables included in the model. Figure 2 is a nomogram that demonstrates the relative importance of each variable in determining the probability of successful treatment and allows the reader to calculate the probability of successful treatment for individual patients.

Discussion

We demonstrated, in a prospective cohort study of 486 patients undergoing APM, after adjusting for potential confounding factors, that patients with an isolated medial meniscal tear without damage to the medial meniscal root or to the lateral meniscus had greater odds of clinically important improvement at the 1-year follow-up compared with other patients. We also showed that additional factors including age, smoking status, VR-12 MCS, medial compartment articular cartilage status, and a prior surgical procedure were important for predicting successful improvement even though the individual variables were not significant in the model. To our knowledge, this represents the largest cohort to date of APM cases with prospectively collected data and multivariable analysis of successful improvement. These findings are quite useful in counseling patients who are considering APM, especially those with a lateral meniscal tear or a medial meniscal root tear, and can potentially be used in a computerized clinical prediction tool during surgical decision-making.

Our finding of an overall improvement in patient-reported outcomes after APM is consistent with data from randomized trials of APM compared with nonoperative treatment. In a systematic review of 6 randomized trials (in which data from 5 trials were analyzed) comparing APM with nonoperative treatment, van de Graaf et al.[18] showed that both the operative and nonoperative groups had clinically important and significant improvement in physical function and pain according to various patient-reported outcome measures at 6 months and no significant change from 6 months to 1 year.

Kamimura et al. evaluated 130 knees in 123 subjects using multivariable analysis, and a radial tear of the midsegment and a flap tear were both predictors of successful outcome; other tear types, including horizontal, complex, root, and minor tears, were not[10]. These findings support our finding that subjects without a medial meniscal root tear have a better chance of a successful outcome. Several authors have reported their outcomes after medial meniscal root repair, which aims to address this problem[19-22].

We also performed a multivariable analysis of predictors of change, and the following factors predicted a significant improvement in at least 1 outcome measure: lower BMI, younger age, more education, currently not smoking, higher VR-12 MCS, absence of bipolar cartilage lesions in the medial compartment, absence of a lateral meniscal tear, and a prior surgical procedure in the knee of interest. Of particular interest are the potentially modifiable risk factors that we identified, which include BMI, VR-12 MCS (if related to a treatable neuropsychiatric condition), and smoking status. The impact of interventions to address these modifiable factors warrants further study.

In a secondary analysis of the ChAMP (Chondral Lesions and Meniscus Procedures) randomized controlled trial, obesity was identified as a risk factor for worse outcomes, which is consistent with our finding that higher BMI was associated with worse outcomes for all patient-reported outcomes[1]. Another secondary analysis of the ChAMP trial identified unstable chondral lesions requiring debridement as a risk factor for worse outcomes. Although we demonstrated that bipolar medial compartment cartilage lesions predicted worse outcomes, we did not measure whether articular cartilage lesions were stable or unstable[23].

A systematic review of outcomes after APM in 4,250 patients and 32 studies, including both prospective and retrospective data, concluded that the following factors were associated with worse outcomes: presence of radiographic knee osteoarthritis on preoperative radiographs, symptom duration longer than 1 year, and resecting >50% of meniscal tissue or leaving a damaged meniscal rim. Eijgenraam et al. also concluded that acute or chronic onset of symptoms, sex, tear type, and activity level were not associated with worse outcomes; they found conflicting evidence with regard to age, chondral damage, BMI, and leg alignment[9]. These findings support our findings of worse medial compartment osteoarthritis being associated with worse outcomes, but demonstrate that the heterogeneity between various studies makes a comparison of results problematic.

In a systematic review that evaluated 20 articles for the annual risk of undergoing total knee arthroplasty after APM, Winter et al. calculated the annual rate to be approximately 2% overall, but the rate increased to 3.9% in patients >50 years of age and 4.1% in patients with worse osteoarthritis at the time of the surgical procedure. Although we did not measure total knee arthroplasty as an outcome in our cohort, these findings are consistent with our evidence that patients with more chondral damage had worse outcomes[24].

Liebensteiner et al. showed in a multivariable analysis of 216 subjects after APM that more cartilage degeneration, but not age, was associated with worse outcomes on the Short Form-36 (SF-36)[25].

A limitation of our study was that we did not collect certain baseline factors hypothesized to have an effect on outcome. These included the amount of meniscal resection, the presence of osteoarthritic changes on radiographs, and increased duration of symptoms. In the MeTeOR study, the amount of meniscal resection was not predictive of outcome[8]. The presence of osteoarthritic changes on radiographs has been shown to be insensitive to actual articular cartilage chondromalacia, so we believe that our arthroscopic assessment on each of the 6 surfaces is more important[13]. Another limitation was that we collected follow-up data at a single time point at 1 year postoperatively. However, 1 year after APM is a clinically relevant time point for patients undergoing APM to determine the initial response to the surgical procedure, and the long-term survival of this initial improvement warrants further study[8].

In conclusion, 83% of patients improved by at least 10 points in pain and function after APM. Patients with a medial meniscal root tear or a lateral meniscal tear had decreased odds of a clinically important improvement in pain or function after APM. Increased BMI, smoking, and worse VR-12 MCS are potentially modifiable risk factors that predict less improvement after APM and warrant further study. ■

Note: The Cleveland Clinic Sports Health authors for this work include Morgan H. Jones, MD, MPH, Lutul D. Farrow, MD, Anthony Miniaci, MD, FRCSC, Richard D. Parker, MD, James T. Rosneck, MD, Paul M. Saluan, MD, Kim L. Stearns, MD, Greg J. Strnad, MS, James S. Williams, MD, Alexander Zajichek, MS, and Kurt P. Spindler, MD.

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