Original Article

Surgical Decision Making for Arthroscopic Partial Meniscectomy in Patients Aged Over 40 Years

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Purpose: To identify clinical variables that affect a surgeon's decision to recommend arthroscopic partial meniscectomy (APM). **Methods:** Members of 2 orthopaedic specialty societies were invited to participate in an online survey by e-mail. The survey consisted of surgeon demographics and case scenarios to evaluate clinical decision making for APM. Posterior probabilities were calculated to determine the effect of clinical factors on the likelihood of recommending APM. **Results:** Of the respondents with valid e-mail addresses, 733 (19.3%) returned a completed survey, but only 533 (14.1%) met the eligibility criteria (treated or referred an APM candidate within the past year). Respondents were aged 46.7 ± 9.4 and had performed a mean of 115 APMs in the previous year. Posterior probabilities for a combination of 6 clinical indicators identified 3 factors that most influenced a surgeon's decision to recommend APM: radiographic findings, McMurray test, and failure of nonoperative management. **Conclusions:** Significant variation exists among practicing orthopaedic surgeons with regard to decision making for APM. The 3 clinical factors that most influenced a surgeon's decision to recommend APM were normal radiographic findings, failed nonoperative treatment, and the presence of positive physical examination findings (i.e., positive McMurray test, joint line tenderness, and effusion). **Level of Evidence:** Level III, decision analysis.

Meniscus tears are one of the most common knee injuries, and arthroscopic partial meniscectomy (APM) rates are correspondingly high. In 1998 it was estimated that 1.5 million knee arthroscopies were performed in the United States, of which 850,000 were meniscal procedures.[1] Since that time, the frequency of APM has likely increased, although no firm figures are available.

Despite the frequency with which APM is performed, there are no clear guidelines regarding the indications for APM, particularly in the 40- to 60-year-old patient, who may have degenerative changes in the knee. A recent trial of 90 patients aged 45 to 64 years with degenerative meniscal injuries randomized to APM versus physical therapy (PT) showed no advantage for APM with regard to improved pain or function.[2] This is similar to the finding of 2 randomized trials of knee arthroscopy for moderate to severe osteoarthritis, which did not exclude patients with meniscal pathology except for large tears.[3,4]

Given the lack of consensus on indications for APM in patients with varying degrees of pre-existing de-

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generative changes, surgical decision making in the treatment of meniscus tears in middle-aged patients remains unclear.[5] The results of this survey will provide insight into the clinical management of meniscal injuries in patients aged over 40 years with possible early-stage knee osteoarthritis, particularly with regard to the factors associated with the decision to perform APM.

The purpose of this study was to identify the clinical factors that orthopaedic surgeons use to make the decision to perform APM rather than to recommend nonoperative treatment in the management of meniscus tears for patients aged over 40 years. Our hypothesis, developed in cooperation with a panel of expert clinicians and researchers, was that APM would be more often recommended in patients with an acute injury, an active lifestyle, no evidence of osteoarthritis on radiography, a longer duration of symptoms, positive physical examination findings, and failed nonoperative treatment.

METHODS

The survey was developed through discussions with an expert panel of 3 orthopaedic surgeons, 3 clinical epidemiologists (1 of whom is also a surgeon), and 1 biostatistician. We reviewed the survey for content, clarity, diction, ease of use, and selected appropriate magnetic resonance imaging (MRI) and radiographic studies for case scenarios. The surveys were sent to a pilot group of orthopaedic surgeons for field testing. Revisions to the survey were made after we incorporated their suggestions. To minimize respondent burden and increase data completeness, the survey was designed to be completed in less than 10 minutes.

The survey was placed on an established commercial survey administration Web site (www.surveymonkey.com) (SurveyMonkey, Palo Alto, CA). Every active member of the American Orthopaedic Society for Sports Medicine (AOSSM) and Arthroscopy Association of North America (AANA) was e-mailed an invitation to participate, which included the link to the online survey. Another link was included in the e-mail, which allowed the recipient to decline participation and be removed from our mailing list. Only practicing attending surgeons who referred or treated patients with meniscus tears within the previous year were asked to participate. A reminder e-mail was sent to nonrespondents 3 months after the original mailing.

Survey

The first section of the survey contained questions regarding surgeon demographics including surgical subspecialty training, years in practice, APM volume in the previous year, practice location and type, and membership in orthopaedic professional societies. These questions were asked in random order for each respondent to minimize presentation bias.

Case scenarios were presented for 12 fictitious patients aged 40 to 60 years. These represented 6 pairs of scenarios (Table 1). Six clinical factors previously associated with success of APM were presented in each of the scenarios: physical activity/lifestyle,[6] history of acute injury,[7] duration of symptoms,[8,9] nonoperative treatment,[4,10] physical examination findings,[11] and radiographic evidence of degenerative changes in the knee.[5,12] Age, pain with squatting, and MRI evidence were held constant for all 12 scenarios. Two MRI studies (coronal and sagittal) and 2 radiographic images (anteroposterior and lateral) were included for each case scenario (Fig 1). Each of the 6 pairs represented scenarios in which 1 of the 6 clinical factors was changed. For example, for pair 1, scenarios 1A and 1B only differed on whether an acute injury was reported by the patient.

The variable modification was intended to make the decision to recommend APM more or less clear. For each pair, the changed variable was expected to decrease the likelihood of recommending APM. In the first 3 pairs, the "A" scenarios (1A, 2A, and 3A) represented cases where the expert panel believed the likelihood of recommending surgery would be high and the changed variable in the paired "B" scenarios (1B, 2B, and 3B) would make the decision less clear. In the latter 3 pairs, the "A" scenarios (4A, 5A, and 6A) represented cases where the panel believed the decision to recommend APM would be unclear and the changed variable in the paired "B" scenarios (4B, 5B, and 6B) would make the decision more clear to decide against recommending surgery.

For each scenario, surgeons were asked to choose from the following: definitely recommend APM, probably recommend APM, probably not recommend APM, and definitely not recommend APM. The 12 case scenarios were presented in random order, and respondents were blinded to the pairing so that they would remain unaware that their surgical decision making was being evaluated with regard to these specific variables.

TABLE 1. *Description of Scenarios*

	Acute Injury		Lifestyle		OA on Radiography		Duration of Symptoms		Physical Examination		Nonoperative Treatment	
	Scenario 1A	Scenario 1B	Scenario 2A	Scenario 2B	Scenario 3A	Scenario 3B	Scenario 4A	Scenario 4B	Scenario 5A	Scenario 5B	Scenario 6A	Scenario 6B
Patient history												
Age (yr)	40	42	44	45	43	44	48	49	52	54	57	56
Lifestyle	Sedentary	Sedentary	Active	Sedentary	Active	Active	Sedentary	Sedentary	Active	Active	Sedentary	Sedentary
Injury history												
Acute injury	Injury	None	Injury	Injury	None	None	None	None	None	None	None	None
Duration of symptoms	<6 wk	<6 wk	6-12 wk	6-12 wk	3-6 mo	3-6 mo	3-6 mo	<6 wk	6-12 wk	6-12 wk	3-6 mo	3-6 mo
Nonoperative treatment												
PT	No	No	No	No	Yes	Yes	Yes	Yes	No	No	Yes	No
Intra-articular injection	No	No	No	No	No	No	No	No	No	No	Yes	No
NSAIDs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No
Physical examination												
Joint line tenderness	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
McMurray test	+	+	+	+	+	+	–	–	+	–	–	–
Effusion	Present	Present	None	None	Present	Present	Present	Present	Present	None	Present	Present
Pain with squatting	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Imaging												
OA on radiography	None	None	None	None	None	Moderate	Mild	Mild	Moderate	Moderate	Moderate	Moderate
Tear on MRI	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Abbreviations: NSAIDs, nonsteroidal anti-inflammatory drugs; OA, osteoarthritis.

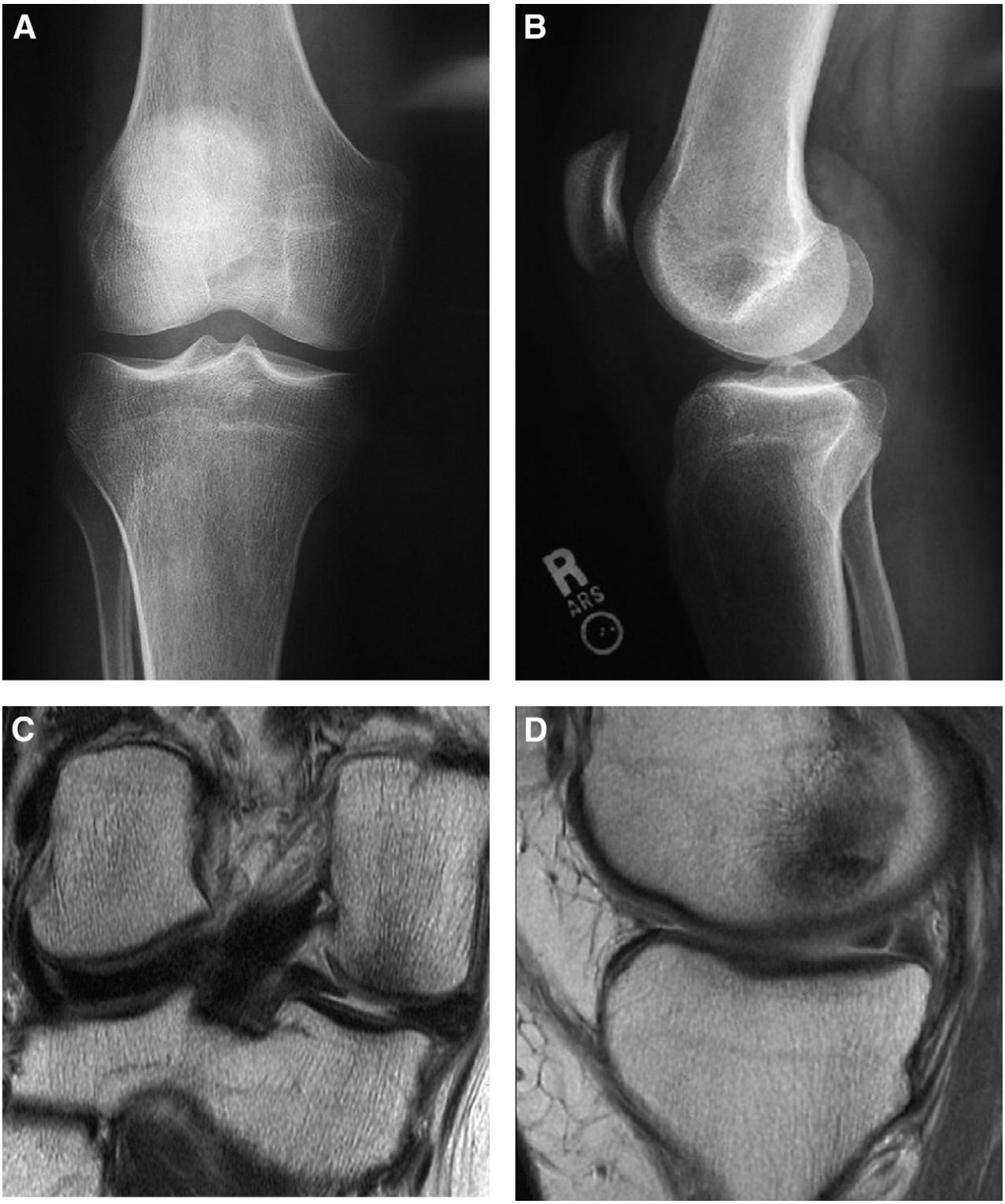

Figure 1. Sample magnetic resonance and radiographic images used in clinical scenario 1. (A) Anteroposterior radiographic view, (B) lateral radiographic view, (C) coronal magnetic resonance image, and (D) sagittal magnetic resonance image.

Statistical Analysis

Descriptive analysis consisted of means, standard deviations, and minimum/maximum values for continuous variables and frequency and percentages for discrete variables. Inferential analysis consisted of Fisher exact tests or χ^2 tests for discrete comparisons and *t* tests for continuous comparisons. For comparisons across surgical volume categories, a χ^2 test for trend was used.

To facilitate presentation and interpretation of the data, response options from the survey were consolidated before the initiation of analysis. For questions relating to surgical indications, the responses "agree" and "strongly agree" were combined into "agree." Similarly, the responses "disagree" and "strongly disagree" were combined into "disagree."

Variables from the clinical scenarios were evaluated for their influence on changing a surgeon's decision (proportion of respondents who changed their surgical choice regardless of direction), the likelihood that the change was in the direction anticipated by the authors (change ratio [CR]), and the likelihood that a patient with a given set of characteristics would be recommended surgery (posterior probability).

Change Ratio

For the case scenarios, a CR was calculated for each clinical variable. This CR was used to quantify the ability of each clinical variable to influence a surgeon to change his or her recommendation in the direction expected: from APM to conservative treatment. Surgeons who did not change their recommendation between scenarios were ignored in this ratio, because for those surgeons, the specific factor was not influential in their decision. Therefore the CR represents the ratio of surgeons moving toward nonoperative therapy to surgeons moving toward surgery based on the 1 variable that was modified: $CR = p(\Delta_{no\ apm})/p(\Delta_{apm})$.

Posterior Probabilities

The clinical scenario data were pooled to create unadjusted surgical probabilities for each of the clinical factors considered likely to contribute to the decision to operate. Although they represent different clinical findings, joint line tenderness and effusion were not differentiated in the clinical scenarios, so these factors became "joint line tenderness and effusion" (yes/no). No difference in the probability of recommending surgery was found for history of PT, nonsteroidal anti-inflammatory drugs, or PT and nonsteroidal anti-inflammatory drugs, so these were combined into 1 category, representing "history of nonoperative treatment." In addition, probabilities were nearly identical for history of acute injury, so that factor was dropped from the posterior probability analysis. Therefore 5 factors were included in these calculations: radiographic findings, McMurray sign, joint line tenderness/effusion, history of conservative therapy, and history of acute injury.

For each of these factors, the unadjusted probability of recommending surgery was calculated. For example, some scenarios reported normal radiographic findings. For each of these scenarios, the proportion of patients for which the surgeons would recommend surgery represented the unadjusted probability (e.g., 50.8% of patients with a normal radiograph were recommended for APM). The posterior probability of recommending APM (PP_{APM}) was then calculated by use of the methods defined by Neutra,[13] which had been used to identify the likelihood of a patient having appendicitis given a profile of signs and symptoms. "Posterior probability" is the conditional probability of the event or outcome of interest after incorporation of available evidence. An explanation of the formula for PP_{APM} is provided in the Appendix.

The resulting PP represents the probability of recommending APM given the combination of factors in a patient's case history and is reported as a percentage. If surgeons uniformly agreed to operate in a given hypothetical patient scenario, the PP_{APM} would be 100%. Conversely, if surgeons uniformly agreed not to operate in a given hypothetical patient scenario, the PP_{APM} would be 0%. The combination of factors evaluated resulted in 144 unique combinations (144 distinct PP_{APM} values).

RESULTS

Invitations were sent to 1,982 members of AOSSM and 2,262 members of AANA. Invalid e-mail addresses (350) and refusals to participate (102) reduced this number. Surveys were completed by 733 surgeons (19.3% of those with valid e-mail addresses who did not opt out), but 200 (27.3%) did not meet the inclusion criteria. Eleven surgeons who referred patients for APM but did not perform any APMs within the prior 12 months were included. We received eligible surveys from 533 surgeons (14.1% of all valid e-mail addresses), of whom 463 completed all questions. The remaining 70 surgeons did not complete all clinical scenarios but were included for completed scenarios.

TABLE 2. *Surgeon Demographics by Surgical Volume*

	Self-Reported Annual APM Volume		
	Low (≤60 Cases/yr)	Medium (61-120 Cases/yr)	High (>120 Cases/yr)
No. of surgeons	182	156	194
APM cases/yr			
Mean	34.8 ± 17.8	93.5 ± 14.1	208.0 ± 79.4
Minimum-maximum	0-60	63-120	125-700
Fellowship training			
None	39 (21.40%)	29 (18.60%)	40 (20.60%)
Sports medicine	113 (62.10%)	112 (71.80%)	141 (72.70%)
Arthroplasty	21 (11.50%)	7 (4.50%)	6 (3.10%)
Knee surgery	7 (3.80%)	9 (5.80%)	9 (4.60%)
Shoulder and elbow	3 (1.60%)	2 (1.30%)	2 (1.00%)
Trauma	5 (2.70%)	4 (2.60%)	1 (0.50%)
Other	15 (8.20%)	7 (4.50%)	12 (6.20%)
Practice setting			
Academic	43 (23.60%)	31 (19.90%)	19 (9.80%)
Academic affiliate	33 (18.10%)	38 (24.40%)	54 (27.80%)
Private practice	102 (56.00%)	84 (53.80%)	119 (61.30%)
Military	4 (2.20%)	3 (1.90%)	2 (1.00%)
Specialty society membership			
AAOS	166 (91.20%)	48 (94.90%)	182 (93.80%)
AOSSM	111 (61.00%)	105 (67.30%)	133 (68.60%)
AANA	115 (63.20%)	109 (69.90%)	148 (76.30%)
AAHKS	17 (9.30%)	8 (5.10%)	7 (3.60%)
Knee Society	10 (5.50%)	1 (0.60%)	5 (2.60%)
Nearest referral center >50 mi from surgeon's practice	32 (17.60%)	25 (16.10%)	25 (12.90%)

Abbreviations: AAHKS, American Association of Hip and Knee Surgeons; AAOS, American Academy of Orthopaedic Surgeons.

The response rates for the individual questions ranged from 70% to 100%. The mean time for completion of the survey was 11 minutes.

The mean age was 46.7 ± 9.4 years (range, 30 to 76 years). Respondents estimated having performed a mean of 115.2 ± 89.2 APMs (range, 0 to 700 APMs) in the previous year. Surgeons were stratified into 3 categories based on their self-reported surgical volume for APM: (1) low volume (≤60 cases/yr), (2) moderate volume (61 to 120 cases/yr), or (3) high volume (>120 cases/yr). These strata were chosen to group the surgeons into roughly equal tertiles (Table 2). Higher-volume surgeons were more likely to be sports medicine trained and be in private practice than lower-volume surgeons. No significant associations were found between fellowship training or years in practice and likelihood of recommending APM.

For the case scenarios, the likelihood of recommending surgery ranged from a high of 89.1% for scenario 1A (history of acute injury) to a low of 24.7% for scenario 5B (negative physical examination) (Table 3). Clinical agreement (>80%) was achieved for 3 case scenarios: 1A (with history of acute injury), 1B (without history of acute injury), and 3A (no osteoarthritis on radiography).

As expected, the likelihood of recommending APM was higher for "A" scenarios and the change of each clinical variable in the "B" scenarios reduced the likelihood of recommending surgery (Table 3). The net effect of changing a single clinical variable ranged from 3.3% for duration of symptoms to as high as 32.5% for positive physical examination. Two clinical variables caused a large number of surgeons to change their decision and moved the change in the expected direction, resulting in a high CR: positive physical examination (CR, 9.8) and failed nonoperative treatment (CR, 10.5). All CRs achieved statistical significance with the exception of duration of symptoms.

For nearly all case scenarios, there was a trend toward a higher likelihood of recommending APM by volume category, but this was only statistically significant for duration of symptoms (both scenarios) and positive physical examination findings (Fig 2). The highest-volume group was always more likely to recommend APM than the lowest-volume group.

TABLE 3. *Effect of Change for Each Pair on Likelihood of Recommending APM*

	Acute Injury		Lifestyle		Osteoarthritis on Radiography		Duration of Symptoms		Positive Physical Examination		Failed Nonoperative Treatment	
	Scenario 1A: Yes	Scenario 1B: No	Scenario 2A: Active	Scenario 2B: Sedentary	Scenario 3A: None	Scenario 3B: Moderate	Scenario 4A: 3-6 mo	Scenario 4B: <6 wk	Scenario 5A: Yes	Scenario 5B: No	Scenario 6A: Yes	Scenario 6B: No
% Recommend APM	89.1%	80.7%	72.0%	59.7%	86.7%	78.1%	57.5%	54.2%	57.2%	24.7%	64.8%	39.0%
% Difference (A – B)	8.4%		12.3%		8.6%		3.3%		32.5%		25.8%	
% Change either direction	14.7%		25.1%		21.0%		26.1%		39.2%		30.9%	
Change in expected direction (n)	55		90		67		68		167		136	
Change in other direction (n)	15		28		31		53		17		13	
CR	3.2		3.7		2.2		1.3		9.8		10.5	
P value (Fisher exact test)	.001		< .001		.013		.367		<.001		<.001	

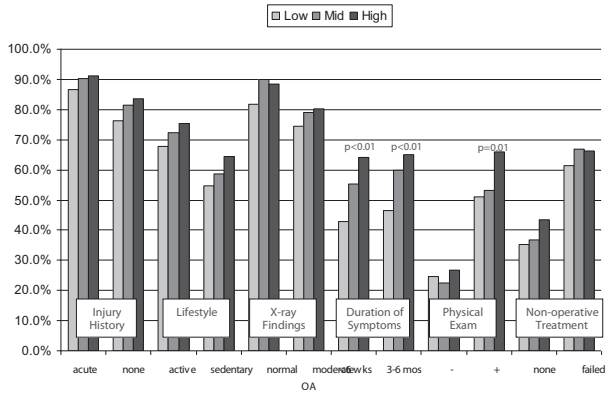

FIGURE 2. Relation between surgical volume and responses to case scenarios. (OA, osteoarthritis.)

Posterior probabilities, which provide an estimate of the combined effect of various clinical characteristics on surgical decision making, identified 1 combination of variables that resulted in an extremely high PP_{APM} (>95%) and another combination of variables that resulted in an extremely low PP_{APM} (<10%) (Table 4). The highest PP_{APM} was seen for patients with short duration of symptoms (<6 weeks), positive McMurray test, normal radiograph, previous nonoperative treatment, history of acute injury, and positive joint line tenderness and effusion (PP_{APM}, 96.6%). Conversely, the lowest PP_{APM} was found for patients with the opposite profile: longer duration of symptoms (>6 weeks), negative McMurray test, evidence of osteoarthritis on radiography, no history of conservative treatment, no acute injury, and negative joint line tenderness and effusion (PP_{APM}, 6.4%).

DISCUSSION

Despite the high volume of APMs performed in the United States, surgical decision making for meniscus tears is not straightforward, particularly in the presence of degenerative changes in the knee.[4] The definition of "clinical agreement" among orthopaedic surgeons has previously been proposed in the literature using more or less arbitrary criteria but usually ranges from 60% to 95%.[14-17] For the purposes of this study, the definition of clinical agreement as proposed by Dunn et al.[17] (80%) was used.

To our knowledge, no prior study has evaluated the clinical variables that surgeons consider to be important when making the decision to perform APM. Among the 3 clinical scenarios thought to be the most likely candidates for APM, 2 achieved clinical agree-

Table 4. *Posterior Probability of Recommending APM Based on 6 Clinical Variables*

Posterior Probability	Duration of Symptoms	McMurray Test	Radiography	Conservative Therapy	Acute Injury	JLT/Effusion
Highest probabilities						
96.6%	<6 wk	+	Normal	PT or NSAIDs	Yes	Yes
95.2%	<6 wk	+	Normal	Cortisone	Yes	Yes
94.7%	3-6 mo	+	Normal	PT or NSAIDs	Yes	Yes
Coin-flip probabilities						
51.1%	6-12 wk	–	Normal	Cortisone	No	Yes
49.9%	<6 wk	–	Normal	None	No	Yes
49.5%	3-6 mo	–	Abnormal	PT or NSAIDs	Yes	No
49.0%	6-12 wk	+	Abnormal	None	Yes	Yes
Lowest probabilities						
11.4%	6-12 wk	–	Abnormal	None	No	Yes
9.9%	3-6 mo	–	Abnormal	None	No	No
6.4%	6-12 wk	–	Abnormal	None	No	No

Abbreviations: JLT, joint line tenderness; NSAIDs, nonsteroidal anti-inflammatory drugs; OA, osteoarthritis.

ment of greater than 80% among the survey respondents: recommending APM with an acute injury present (89.1% clinical agreement) and recommending APM if radiographic findings are normal (86.7%). Lack of an acute injury history also resulted in clinical agreement (80.7%).

For the clinical scenarios thought to be the least likely candidates for APM, respondents were more aggressive than predicted by the pilot survey results. These 3 case scenarios, which we anticipated to have a stronger indication for nonoperative treatment, had the lowest likelihood of recommending APM but did not meet the criteria for clinical agreement: 24.7% recommended APM with a negative physical examination; 39.0% recommended APM with no history of nonoperative treatment; and over half, 54.2%, recommended APM for a patient with duration of symptoms of less than 6 weeks. In total, 9 of the 12 cases failed to achieve clinical agreement, suggesting that wide disagreement exists among practicing orthopaedists who perform APM in patients aged over 40 years.

The posterior probability analysis identified the combination of clinical factors that were more or less likely to result in a surgeon's decision to recommend APM. Failure of nonoperative treatment again was an important predictor of the likelihood of recommending APM. However, a positive McMurray test was found to be substantially more predictive than positive joint line tenderness or effusion. A third factor found to be important in the decision to operate, though not found to be as important in CR analysis, is the presence of degenerative radiographic findings.

The proportion of surgeons recommending APM for each clinical scenario was systematically higher for higher-volume surgeons. These associations are consistent with the "enthusiasm hypothesis,"[18] which has also been shown for shoulder surgery.[17] This hypothesis proposes that surgeons who believe strongly in a procedure will be more likely to recommend it for their patients.

Limitations of this study include the fact that an online survey creates an artificial setting in which to evaluate clinical factors. To be able to draw meaningful conclusions and to minimize confounding factors, the case scenarios were purposely created such that the most appropriate surgical intervention, if deemed necessary, would be APM rather than meniscal repair. To discourage meniscus repair as an attractive option, every case scenario presented a patient aged over 40 years with imaging studies indicating a tear that was not appropriate for repair.[19] In addition, the presence of locking or mechanical symptoms in the knee was not included as a variable in the case scenarios because it was believed that there would be nearly uniform agreement that patients with such symptoms would require surgery.[20]

In this survey we studied only a limited number of variables. There may be other important factors that were not evaluated. To identify the most relevant and important variables, we relied on the recommendations of an expert panel. By doing so, the respondent time burden was reduced and may have increased the number of surveys completed. However, ultimately, this represented the clinical opinions of a select group of experts, which may not necessarily represent the community of orthopaedic surgeons at large.

Self-selection bias is also possible because the 733 responses received represents a 19.3% response rate.

It is unknown what proportion of all recipients would be ineligible, so a more accurate response rate cannot be calculated. It is also unknown how nonrespondents differed from respondents. Although the response rate may introduce bias into the findings of this study, we adhered to 3 of the 4 steps of Dillman, which is considered the standard for survey implementation.[21] We did not adhere to the final step (follow-up contact by phone or traditional mail), because of the large number of contacts required (3,059).

Another limitation of the study is the presence of selection bias because all physicians surveyed were members of AOSSM and AANA. Approximately 8% of the members of the American Academy of Orthopaedic Surgeons are members of AOSSM and 9% are members of AANA, and 96% of practicing orthopaedic surgeons in the United States are members of the American Academy of Orthopaedic Surgeons. Thus this represents a survey of the clinical opinions of a select group of orthopaedic surgeons and does not necessarily represent the most appropriate clinical decision for recommendation of APM in these hypothetical patients.

CONCLUSIONS

Significant variation exists among practicing orthopaedic surgeons with regard to decision making for APM. The 3 clinical factors that most influenced a surgeon's decision to recommend APM were normal radiographic findings, failed nonoperative treatment, and the presence of positive physical examination findings (i.e., positive McMurray test, joint line tenderness, and effusion).

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APPENDIX

Posterior probability is calculated by use of the formulas listed in this section, with an example at the end.

By way of introduction, the notation | represents "given" so that $P_{(APM|X\text{-}RAY)}$ is equivalent to "the probability of recommending APM given the radiographic finding." More precisely, this could be written as $P_{(APM|NORMAL\ X\text{-}RAY)}$, or "the probability of recommending APM given a normal radiographic finding." Each of these unadjusted probabilities was calculated by use of the clinical scenarios. These values can be found in Appendix Table 1 (available at www.arthroscopyjournal.org).

In its most simple form, the formula for the poste-

rior probability of recommending APM is $PP_{APM} = P_{APM}/(P_{APM} + P_{NO})$, or the probability of recommending APM given all known clinical factor values divided by the sum of that probability and the probability of recommending no surgery given those same known clinical factor values. The formulas for the probability of recommending APM (P_{APM}) and recommending no surgery (P_{NO}) are as follows:

$$P_{APM} = ([P_{(APM|DURATION)} \times P_{(APM|McMURRAY)} \times P_{(APM|X\text{-}RAY)} \times P_{(APM|CONSERVATIVE\ THERAPY)} \times P_{(APM|INJURY)} \times P_{(APM|JLT/EFFUSION)}] \times P_{SURG})$$

$$P_{NO} = ([P_{(NO|DURATION)} \times P_{(NO|McMURRAY)} \times P_{(NO|X\text{-}RAY)} \times P_{(NO|CONSERVATIVE\ THERAPY)} \times P_{(NO|INJURY)} \times P_{(NO|JLT/EFFUSION)}] \times P_{NO\ SURG})$$

The multipliers at the end of each of those formulas is the overall probability of recommending APM (P_{SURG}) or no surgery ($P_{NO\ SURG}$) regardless of any clinical information.

For a given combination of factors, a "category" from Appendix Table 1 should replace the factor name in the formula. For example, $P_{(APM|X\text{-}RAY)}$ would become $P_{(APM|NORMAL\ X\text{-}RAY)}$ if we want to know the posterior probability of a scenario in which patients had a normal radiograph. The corresponding probability for that category would be 0.508, meaning that 50.8% of surgeons in this study recommended APM in situations in which the radiograph was normal.

By way of example, if a patient were found to have a short duration of symptoms, positive McMurray test, normal radiograph, previous PT or nonsteroidal anti-inflammatory drug (NSAID) therapy, history of acute injury, and joint line tenderness (JLT) and effusion, the formula would be as follows:

$$\begin{aligned}
PP_{APM} &= ([P_{(APM|<6\ WEEKS)} \times P_{(APM|McMURRAY+)} \times P_{(APM|NORMAL\ X\text{-}RAY)} \times P_{(APM|PT\ OR\ NSAID)} \times P_{(APM|ACUTE\ INJURY)} \times P_{(APM|JLT/EFFUSION+)}] \times P_{surg})/[([P_{(APM|<6\ WEEKS)} \times P_{(APM|McMURRAY+)} \times P_{(APM|NORMAL\ X\text{-}RAY)} \times P_{(APM|PT\ OR\ NSAID)} \times P_{(APM|ACUTE\ INJURY)} \times P_{(APM|JLT/EFFUSION+)}] \times P_{SURG}) + ([P_{(NO|<6\ WEEKS)} \times P_{(NO|McMURRAY+)} \times P_{(NO|NORMAL\ X\text{-}RAY)} \times P_{(NO|PT\ OR\ NSAID)} \times P_{(NO|ACUTE\ INJURY)} \times P_{(NO|JLT/EFFUSION+)}] \times P_{NO\ SURG})] \\
&= ([0.299 \times 0.686 \times 0.508 \times 0.753 \times 0.293 \times 0.797] \times 0.637)/([[0.299 \times 0.686 \times 0.508 \times 0.753 \times 0.293 \times 0.797] \times 0.637) + ([0.177 \times 0.406 \times 0.255 \times 0.506 \times 0.181 \times 0.676] \times 0.363 \\
&= 0.01167/(0.1167 + 0.00041) \\
&= 0.01167/0.01208 \\
&= 0.9659 \\
&= 96.6\%)]
\end{aligned}$$

The value of 96.6% for recommending APM given this combination of clinical factors is represented in Table 4 as the single highest posterior probability of any of the 144 combinations of clinical factors.

Appendix Table 1. *Unadjusted Probabilities of APM or No APM for Each Clinical Factor Based on Clinical Scenarios*

Clinical Factor	Category	P_{APM}	$P_{NO\ APM}$
Overall probability of surgery		0.637	0.363
Duration of symptoms	Short duration	0.299	0.177
	Mid duration	0.280	0.426
	Long duration	0.421	0.397
Acute injury	Injury	0.293	0.181
	No injury	0.502	0.725
Activity level	Active	0.414	0.415
	Sedentary	0.586	0.585
Conservative therapy	Cortisone + PT + NSAIDs	0.087	0.083
	PT + NSAIDs	0.355	0.281
	NSAIDs only	0.398	0.225
	PT and/or NSAIDs	0.753	0.506
	No conservative therapy	0.160	0.411
Radiography	Normal radiograph	0.508	0.255
	Mild/moderate radiograph	0.492	0.745
McMurray sign	Positive	0.686	0.406
	Negative	0.314	0.594
Joint line tenderness	Positive	0.797	0.676
	Negative	0.203	0.324
Effusion	Positive	0.797	0.676
	Negative	0.203	0.324

Abbreviations: NSAIDs, nonsteroidal anti-inflammatory drugs; OA, osteoarthritis.