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Background: The opioid epidemic in the United States has placed increased pressure on physicians to engage in responsible opioid prescribing practices. However, surgeons currently have little information to guide their postoperative prescription decision-making. The purpose of this study was to assess opioid consumption after knee arthroscopy and identify preoperative factors that may predict higher opioid usage.

Methods: A prospective observational study of 221 patients was conducted in patients undergoing outpatient knee arthroscopy for meniscal repair, partial meniscectomy, debridement, chondroplasty, or loose body removal. Participants recorded their daily opioid consumption in a postoperative pain diary. Total opioid consumption was calculated from counts of remaining pills at the 2-week and 6-week postoperative office visits. Variables, including age, sex, body mass index, smoking status, alcohol consumption, preoperative pain severity and duration, preoperative opioid usage, Patient-Reported Outcomes Measurement Information System (PROMIS) scores, and the Connor-Davidson Resilience Scale, were evaluated for an association with opioid consumption.

Results: Total opioid consumption ranged from 0 to 188 pills, with a median of 7 pills (hydrocodone 5-mg equivalents). Forty-six percent of patients took ≤5 pills, 59% took ≤10 pills, and 81% took ≤20 pills. Fifty-six percent of patients had discontinued opioid usage by the third postoperative day. Eighty-eight percent of patients had surplus opioid medication at the time of the final follow-up. Patients undergoing meniscal repair, smokers, and those taking preoperative opioids were significantly more likely to take ≥20 pills ($p < 0.05$).

Conclusions: The median number of pills taken after knee arthroscopy is 7, with the majority of patients consuming ≤20 pills. Meniscal repair, smoking, and preoperative opioid usage were associated with higher postoperative opioid consumption.

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

Prescription opioid use in the United States quadrupled from 1999 to 2015[1]. Paralleling this trend has been a nearly identical rise in opioid-related morbidity and mortality[2,3]. In 2015, opioids were responsible for over 33,000 drug overdose deaths, with half of these due to prescription opioids1. Alarmingly, the United States now accounts for 80% of total opioid consumption and 99% of hydrocodone use despite comprising only 5% of the world's population[4].

Emphasis on quality-of-care metrics such as pain control and patient satisfaction may create an incentive for physicians to overprescribe[5]. Furthermore, with the rescheduling of hydrocodone as a Schedule-II controlled substance in 2014, larger prescriptions may be written to avoid return patient trips to the office to refill prescriptions. The result is potentially a surplus of prescription opioid medication available for diversion and abuse. More than half of non-medical opioid users obtain their drugs from a friend or family member and prescription opioid medication may serve as a gateway drug for the majority of heroin users[6,7]. Therefore, reducing the availability of prescription opioids on a population level could combat this trend of rising narcotic abuse[2].

Orthopaedic surgeons play an important role in this effort as the third highest prescribers of opioids in the United States[8]. Knee arthroscopy is one of the most commonly performed

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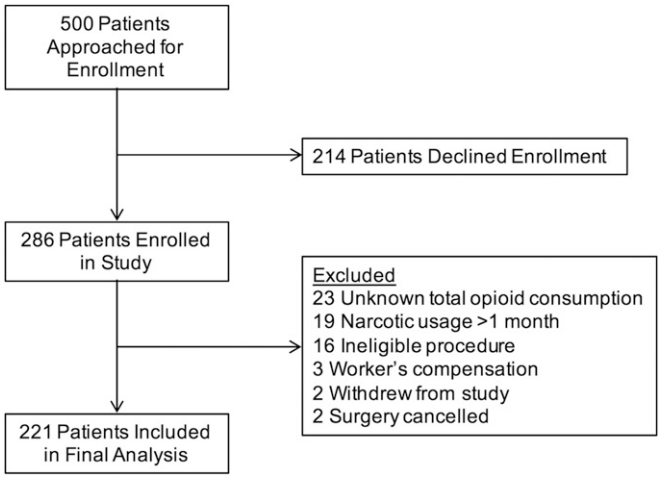

Fig. 1

Flow diagram of study enrollment.

surgical procedures and thus an ideal target for curtailing excessive postoperative opioid prescriptions. However, surgeons currently have little objective data to guide their postoperative prescribing practices and are frequently forced to make an educated guess with regard to opioid consumption.

The purpose of this prospective study was to assess the pattern of total opioid consumption after knee arthroscopy and to identify preoperative factors predictive of higher opioid consumption. Such information could guide the appropriate prescribing of opioid medications after knee arthroscopy.

Materials and Methods

Following institutional review board approval, a prospective observational study was conducted for patients undergoing outpatient knee arthroscopy at a single academic medical center between May 2016 and June 2017. Procedures eligible for inclusion were meniscal repair (both all-inside and inside-out repairs), partial meniscectomy, loose body removal, debridement, and chondroplasty. Exclusion criteria were age of <12 years (these patients are ineligible for a surgical procedure at our outpatient surgery center), a revision surgical procedure, preoperative opioid consumption of >1 month, or Workers' Compensation cases. The last 3 criteria were chosen because these are patients known to require higher doses of opioid medication after a surgical procedure and we believed that this could skew results[9].

Five hundred patients were approached for study enrollment, of whom 286 patients consented to participation. Sixty-five patients did not meet inclusion criteria, including 23 patients who had missing data preventing determination of total opioid consumption, 16 patients who underwent a procedure ineligible for the study, and 2 patients who had their surgical procedures cancelled after initial enrollment (Fig. 1). All patients for whom the total number of opioid pills consumed was ascertainable from the collected data were included in the final analysis, regardless of other missing data. The final data analysis involved 221 patients, including 11 minors (14 to 17 years of age).

Patients completed a preoperative questionnaire at the time of enrollment with regard to smoking status, alcohol consumption, psychiatric medication usage, preoperative pain severity and duration, preoperative opioid and non-opioid

TABLE I Preoperative Patient Characteristics

Characteristic	Value
Age* *(yr)*	46.2 (14 to 76)
Sex†	
Male	114 (51.6%)
Female	107 (48.4%)
Weight* *(kg)*	87.8 (49.9 to 181.9)
BMI* *(kg/m²)*	29.0 (17.2 to 70.0)
Smoking status†	
Nonsmokers	212 (95.9%)
Smokers	8 (3.6%)
Not reported	1 (0.5%)
Alcohol use†	
Never	39 (17.6%)
<1 time/mo	44 (19.9%)
<1 time/wk	36 (16.3%)
1 to 3 times/wk	72 (32.6%)
>3 to 6 times/wk	21 (9.5%)
Daily	9 (4.1%)
Psychiatric medication†	
No	173 (78.3%)
Yes	39 (17.6%)
Not reported	9 (4.1%)
VAS knee pain severity* (0 to 100) *(points)*	39.5 (0 to 100)
Knee pain duration†	
1 wk to 1 mo	24 (10.9%)
>1 to 3 mo	59 (26.7%)
>3 to 6 mo	42 (19.0%)
>6 to 24 mo	63 (28.5%)
>24 mo	29 (13.1%)
Not reported	4 (1.8%)
Preoperative opioid usage† (<1 mo)	
No	215 (97.3%)
Yes	6 (2.7%)
Connor-Davidson Resilience Scale score*† *(points)*	33.1 (13 to 40)
PROMIS scores*	
Anxiety	47.4 (32.9 to 71.6)
Depression	43.6 (34.0 to 68.7)
Pain interference	60.1 (38.6 to 75.3)
Physical function	41.1 (20.0 to 73.0)

*The values are given as the mean, with the range in parentheses. †The values are given as the number of patients, with the percentage in parentheses. ‡In this score, 0 is the least resilient and 40 is the most resilient.

analgesic use, and the Connor-Davidson Resilience Scale[10,11], which assesses one's ability to cope with stress. The Connor-Davidson Resilience Scale remained valid and was included for all patients who responded to at least 9 of the 10 questions.

No modifications were made to surgeons' intraoperative and postoperative procedures or protocols in this observational study. Specifically, local anesthetic injections at case conclusion, postoperative weight-bearing restrictions, and analgesic prescriptions were left to the discretion of the attending surgeon. Additionally, patients were permitted to use any over-the-counter non-opioid analgesics as necessary. All procedures were performed under general anesthesia by 1 of 5 fellowship-trained orthopaedic sports medicine surgeons with participation of a fellow or resident. Surgical procedures were performed at a single orthopaedic-only outpatient center with a consistent team of anesthesiologists and nurses. Although the perioperative pain management instructions were not specifically controlled for this investigation, the interpatient variability was minimal.

Following the surgical procedure, patients completed a daily pain diary documenting their mean pain level on a visual analog scale (VAS) scored on a continuum from 0 to 100 points and pain medication consumption, both opioid and non-opioid analgesics. Data were logged each day for the first 7 days and on the day of the first postoperative office visit, typically 10 to 14 days after the procedure. At both the 2-week and 6-week postoperative office visits, patients completed a questionnaire with regard to the number of opioid pills remaining in their last bottle, whether they were still taking opioid pain medication, and overall satisfaction with the postoperative pain control regimen on a VAS of 0 to 100 points. Patients were asked to bring their opioid pill bottles to the office for counts to be verified by research staff. All opioid pills were converted to an equivalent number of hydrocodone 5-mg pills for ease of analysis and interpretation[12].

The medical record was reviewed for demographic information, preoperative Patient-Reported Outcomes Measurement Information System (PROMIS) scores (anxiety, depression, pain interference, and physical function), type and quantity of opioid and non-opioid pills prescribed, number and quantity of refills provided, and the use of a postoperative regional anesthetic block.

Statistical Analysis

Data were analyzed with descriptive statistics to determine the frequency for categorical variables and the mean, standard deviation, median, and quartiles for continuous variables, as appropriate for their distribution. The association between procedure type, site of local anesthetic injection, or initial prescription size and outcome variables was analyzed using the Kruskal-Wallis test.

Logistic regression analysis was then performed to identify predictors of low opioid consumption (<20 pills) compared with high opioid consumption (≥20 pills). Univariate logistic regression analysis was first conducted to determine predictive variables (defined as those with $p < 0.1$) of total opioid consumption for inclusion in stepwise regression. Patients with missing data for predictive variables were excluded from regression analyses in a list-wise deletion fashion. Predictive variables were checked for multicollinearity using Pearson or Spearman correlation coefficients, as appropriate for their distribution. Those with values of >0.7 were analyzed in separate stepwise regressions and model fit statistics were utilized to determine which variable to include in the final model. Variables from the stepwise analysis with $p < 0.05$ were included in the final logistic regression model.

Results

Table I outlines the distribution of baseline variables including smoking status, psychiatric medication usage, preoperative pain severity and duration, and preoperative opioid consumption (<1 month). Table II shows the distribution of surgical variables including primary surgical procedure, initial

TABLE II Distribution of Surgical Variables*

Variable	No. of Patients
Primary surgical procedure	
Partial meniscectomy	170 (76.9%)
Meniscal repair	13 (5.9%)
All-inside	11
Inside-out	2
Chondroplasty	19 (8.6%)
Loose body removal	14 (6.3%)
Debridement	5 (2.3%)
Initial opioid prescription	
Hydrocodone	214 (96.8%)
Oxycodone	2 (0.9%)
Tramadol	2 (0.9%)
Codeine	3 (1.4%)
Initial prescription size	
20 pills	68 (30.8%)
30 pills	5 (2.3%)
40 pills	98 (44.3%)
50 pills	41 (18.6%)
60 pills	9 (4.1%)
NSAID prescription	
Yes	132 (59.7%)
No	89 (40.3%)
Local anesthetic use	
Portals only	98 (44.3%)
Intra-articular	123 (55.7%)
Regional anesthesia block	
None	218 (98.6%)
Single shot block	1 (0.5%)
Continuous catheter	2 (0.9%)

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

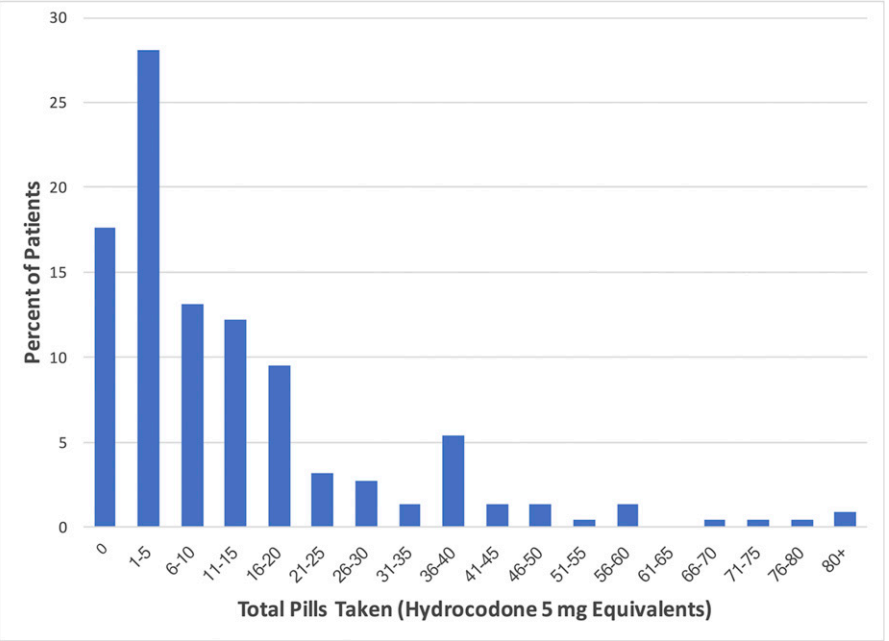

Fig. 2

Distribution of total postoperative opioid consumption at the time of the final follow-up (converted to hydrocodone 5-mg equivalents).

opioid prescription size, and prescription for a nonsteroidal anti-inflammatory drug (NSAID).

Total opioid consumption ranged from 0 to 188 pills, with a median of 7 pills (hydrocodone 5-mg equivalents) (Fig. 2 and Table III). Forty-six percent of patients took ≤5 pills, 59% of patients took ≤10 pills, and 81% of patients took ≤20 pills. The single patient who took 188 pills represented an outlier (the next highest value was only 90 pills), and was excluded from the remainder of the analysis to prevent bias of results.

Of 221 patients, 191 (86.4%) completed the postoperative pain diary recording their daily opioid and non-opioid analgesic use. Of these 191 patients, 56% had discontinued opioid use by postoperative day 3 and 76%, by postoperative day 5 (Fig. 3). Seventy-three patients recorded taking a prescribed anti-inflammatory medication and 82 patients took an over-the-counter analgesic. Total opioid consumption was no different in those who took a prescribed anti-inflammatory or any over-the-counter analgesic compared with those who did not ($p = 0.36$). Patient satisfaction with their pain management regimen was high, with a range from 0 to 100 points and median of 97 points.

One hundred and eighty patients (81.4%) brought their pills to the office for research staff to count and the remainder had a self-reported pill count. Ninety-eight patients had both self-reported and staff counts, of which 83 (84.7%) reported identical counts, 10 differed by 1 to 10 pills, and 5 differed by 11 to 20 pills. At the time of the final follow-up, 194 patients (87.8%) had surplus opioid medication. Twenty-seven patients (12.2%) completed their initial prescription, but only 13 patients (5.9%) obtained a refill. Comparing patients who received an initial opioid prescription for 20 pills, 30 to 40 pills, and ≥50 pills, the percentage of patients obtaining refills decreased from 10.3% to 4.9% to 2.0% with each increased initial prescription size, but final patient satisfaction did not differ between the groups ($p = 0.23$). Sixteen percent of patients were still taking opioids at the 2-week postoperative visit, and 6.2% of patients were still taking opioids at the

TABLE III Distribution of Total Opioid Consumption (Hydrocodone 5-mg Equivalents)

No. of Pills Taken	Percentage	Cumulative Percentage
0	17.6	17.6
1 to 5	28.1	45.7
6 to 10	13.1	58.8
11 to 15	12.2	71.0
16 to 20	9.5	80.5
21 to 25	3.2	83.7
26 to 30	2.7	86.4
31 to 35	1.4	87.8
36 to 40	5.4	93.2
41 to 45	1.4	94.6
46 to 50	1.4	95.9
51 to 55	0.5	96.4
56 to 60	1.4	97.7
61 to 65	0.0	97.7
66 to 70	0.5	98.2
71 to 75	0.5	98.6
76 to 80	0.5	99.1
>80	0.9	100.0

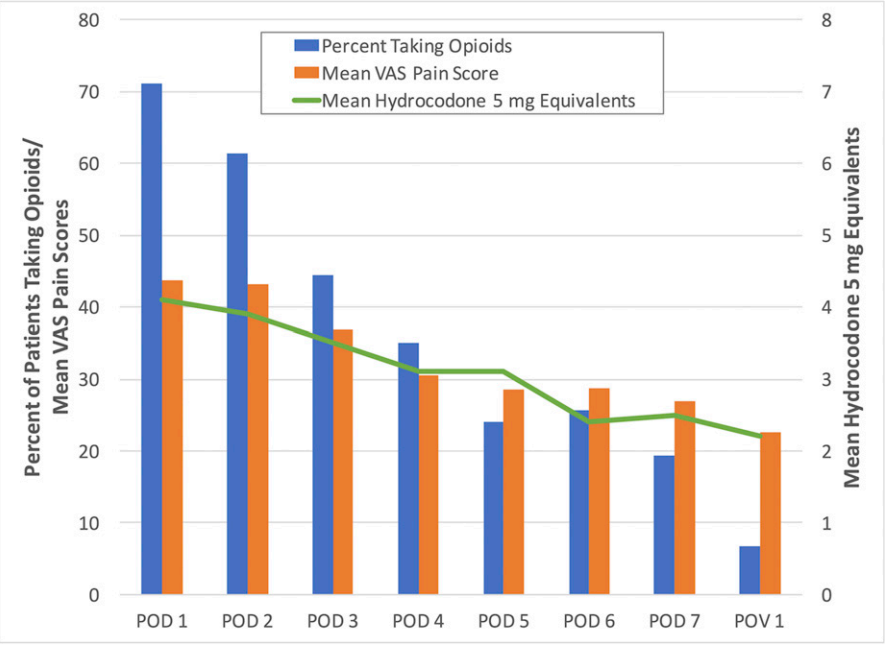

Fig. 3

Percent of patients taking opioids, mean VAS pain score, and mean opioid consumption for each postoperative day (POD). POV = postoperative visit.

6-week postoperative office visit. Patients undergoing meniscal repair took significantly more pills than those undergoing other procedures ($p = 0.006$) (Fig. 4).

Predictors of higher opioid consumption (≥20 pills) included meniscal repair compared with other procedures (odds ratio [OR], 7.9 [95% confidence interval (CI), 1.8 to 35.7]), smoking (OR, 11.9 [95% CI, 2.0 to 71.7]), and preoperative opioid use (OR, 7.7 [95% CI, 1.2 to 50.0]). However, the interpretation of these values is somewhat limited by small sample sizes, with 13 meniscal repairs, 8 smokers, and 6 preoperative opioid users. Despite the number of predictive variables analyzed, R^2 for the final logistic regression

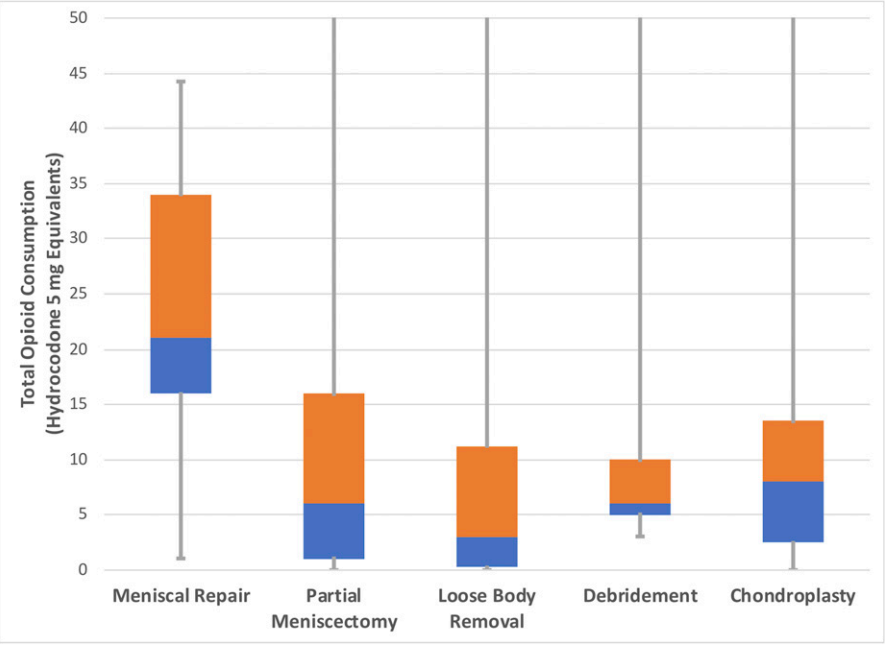

Fig. 4

Box-and-whisker plot showing the minimum, lower quartile, median (junction of the blue and orange boxes), upper quartile, and maximum total opioid consumption for each surgical procedure.

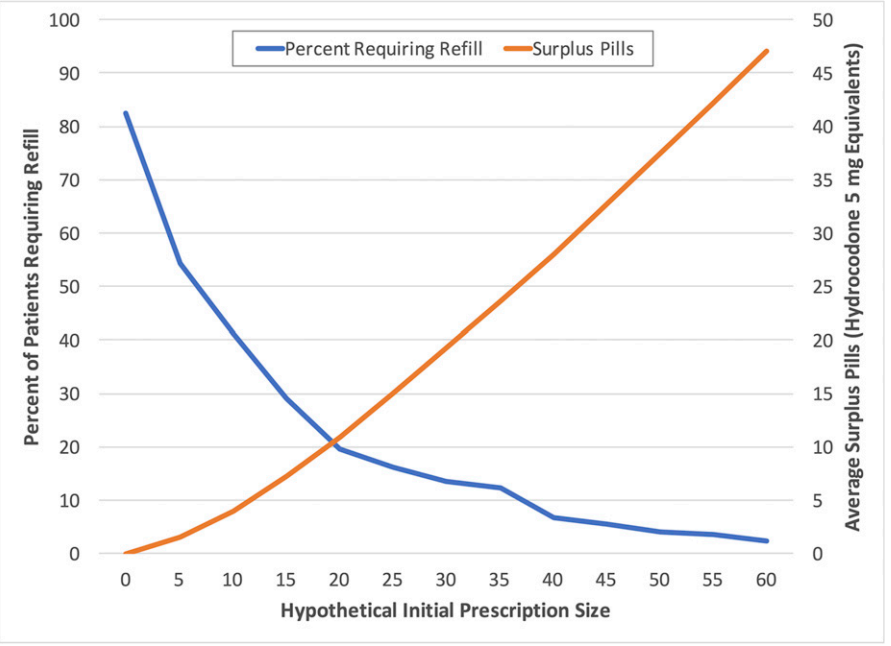

Fig. 5

Percentage of patients who would require a refill and the mean surplus pills per patient for a range of hypothetical initial prescription sizes.

model was only 0.21. No association was seen between age, sex, weight, body mass index (BMI), alcohol consumption, psychiatric medication usage, preoperative pain severity or duration, PROMIS scores, Connor-Davidson Resilience Scale score, site of local anesthetic injection, postoperative NSAID prescription, or over-the-counter analgesic use and total opioid consumption in the logistic regression analysis.

From the data, we calculated the percentage of patients who would have a required an opioid refill and the mean number of surplus pills per patient if a range of hypothetical initial prescription sizes had been given to all patients (Fig. 5). For example, if all patients were given an initial prescription of 30 pills, approximately 15% would require a refill, but the mean patient would have 20 surplus pills.

Discussion

After knee arthroscopy, nearly 50% of patients took ≤5 pills and approximately 80% took ≤20 pills. More than half of the patients had discontinued opioid use by the third postoperative day. Patient satisfaction was not associated with initial prescription size. Not surprisingly, smaller prescription sizes resulted in fewer surplus pills potentially available for diversion but at the expense of necessitating a greater number of refills for the prescribing surgeon. We did not standardize physicians' responses to refill requests because this was an observational study. Considering that Figure 5 may overestimate actual refill rates because not all patients who complete their prescription will obtain a refill, we conclude that routine prescriptions in excess of 30 pills are unnecessary and a smaller amount such as 15 or 20 pills is likely appropriate except for meniscal repair procedures.

Patients undergoing meniscal repair, smokers, and those taking opioids preoperatively, even for <1 month, are more likely to take ≥20 pills after the surgical procedure. We suspect that the higher opioid requirement for meniscal repair is due to suture placement through the well-innervated capsular tissue. Only 2 of the repairs were performed with an inside-out technique, so we do not believe that the additional incision or soft-tissue dissection played a major role in the increased opioid usage. Physiological changes that may develop from smoking and preoperative opioid use may increase the need for opioid use after a surgical procedure. Both animal and functional imaging studies have suggested an interaction between nicotine and the endogenous opioid system with nicotine stimulating mu-receptor neurotransmission[13]. Our logistic regression model only explains 21% of the variance, suggesting that the prediction of patients likely to require higher amounts of opioids remains incompletely understood. This is similar to the findings of Grant et al.[14], whose multivariate regression model only explained half of the variance in opioid consumption in adolescents undergoing spine surgery. It remains unclear what factors affect pain tolerance, but the present study serves as a first step in understanding this important clinical issue by establishing rough guidelines for typical usage and highlighting the need for further investigation into factors associated with opioid use in these patients.

The results of the present study add to an increasing body of literature on postoperative opioid consumption in orthopaedic surgery. A recently published investigation of patients undergoing operative fixation of distal radial fractures found a mean opioid consumption of 14.6 oxycodone 5-mg tablets for a mean duration of 4.8 days after the surgical procedure[15]. In that study, younger patients, those without insurance, and

patients with public aid consumed higher levels of opioids after the surgical procedure. In our study, 56% of patients discontinued opioid consumption by postoperative day 3 and 81% discontinued by postoperative day 7. Our current study and that by O'Neil et al. suggest that the majority of patients undergoing a procedure with a predictable level of pain (mild to moderate) will likely not require opioid medication beyond 1 week after the surgical procedure. Kim et al.[16] and Rodgers et al.[17] reported a mean consumption of 8 to 10 pills in patients undergoing an upper-extremity surgical procedure, with patients undergoing soft-tissue procedures requiring significantly fewer opioid pills than those undergoing bone or joint procedures ($p < 0.05$). Half of their patients required opioid medication for only 2 days after the surgical procedure. Investigations in the orthopaedic trauma literature have highlighted the importance of socioeconomic status in predicting postoperative opioid consumption, with unemployed, lower-income, and less-educated patients more likely to believe that they were underprescribed pain medication and seek additional opioid medication beyond that prescribed by their surgeon[18,19].

We did not observe an association between psychiatric mediation usage, PROMIS scores, or Connor-Davidson Resilience Scale scores and opioid consumption. In contrast, Helmerhorst et al. found that patients who scored higher on catastrophic thinking, anxiety, and depression questionnaires were significantly more likely to take opioid medication 1 to 2 months after the surgical procedure for orthopaedic trauma regardless of injury severity, fracture location, or treating surgeon[20]. Some of this may reflect differences in the experience of trauma surgery compared with elective knee surgery as well as the overall demographic characteristics of these patient populations. Moreover, this association of mental health and coping mechanisms with opioid usage remains a difficult factor to measure or quantify.

There were several limitations of this study. First, patients were not blinded to their participation or the study aims and may have reduced their opioid consumption in an effort to appear tough to the treating surgeon. We attempted to mitigate this effect by excluding surgeons from data collection or pill counting. Although >80% of the patients had a recorded pill count by a research staff member, the self-reported pill counts of the remaining patients may be prone to bias. However, an analysis of a sample of patients with both counts suggests discrepancies between the 2 counts were minimal. Additionally, we did not limit over-the-counter medications that may have influenced opioid consumption. However, we observed no difference in opioid consumption in those who documented use of these medications in their pain diary. Our requirement that total postoperative opioid consumption be ascertainable may have excluded patients who obtained multiple refills or several different opioid prescriptions, as these patients' opioid consumption was more difficult to track and there was no opioid-monitoring program in our state at the time of the study. The selection bias involving patients who agreed to study participation may have influenced our results if these patients differed systematically from those who declined enrollment. Additionally, our suburban study location resulted in few underinsured or low-socioeconomic-status patients being enrolled, which is a group known to require higher levels of opioids after orthopaedic procedures[18,19]. Some surgical variability may have occurred within our procedure groupings for which we were unable to account. There may also have been other variables predictive of opioid consumption that we did not measure or control, such as perioperative pain management counseling and osteoarthritis grade at the time of arthroscopy. We did not include a radiographic or arthroscopic osteoarthritis grade as a statistical variable in our analysis because there were not enough patients with each grade of cartilage degeneration to provide a meaningful analysis of its effect on opioid consumption. Finally, we did not enroll patients who had been taking preoperative opioids longer than 1 month. Consequently, we are unable to comment on postoperative opioid consumption in patients with chronic pain, who may be the most challenging to treat.

In treating patients postoperatively, surgeons must strike a balance between meeting patient expectations for pain control and responsible prescribing practices for the good of society. Establishing a standard pain protocol for specific surgical procedures can set expectations for patients and can assist in identifying patients whose medication requirements fall outside the expected range[4]. The findings of this study can help to set such a protocol for knee arthroscopy that meets patient expectations and minimizes surplus opioid medication.

In conclusion, the median number of hydrocodone 5-mg equivalent pills taken after knee arthroscopy is 7, with the majority of patients consuming ≤20 pills. Meniscal repair, smoking, and preoperative opioid usage were associated with higher postoperative opioid consumption. ■

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