Prospective, Observational Study of Opioid Use After Hip Arthroscopy for Femoroacetabular Impingement Syndrome

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Purpose: To provide estimates of postoperative opioid use after hip arthroscopy for femoroacetabular impingement (FAI) syndrome and to identify risk factors for increased postoperative opioid use. **Methods:** All patients aged at least 18 years who were undergoing hip arthroscopy for FAI syndrome performed by 1 of 2 hip-preservation surgeons between November 2015 and August 2016 were eligible for inclusion in this study. Target minimum enrollment was set at 30 patients per surgeon based on an a priori sample size calculation. Enrolled patients completed the International Hip Outcome Tool, visual analog pain scale, Pain Catastrophizing Scale, abbreviated Patient Health Questionnaire, and questions regarding demographic characteristics and opioid and anti-inflammatory use. Opioid consumption was assessed through pill counting at 2- and 6-week postoperative appointments. Of 80 patients enrolled, 67 had complete 2- and 6-week opioid use data. Patient and operative factors were correlated with outcomes in multivariate models. **Results:** Opioid use in the 2 weeks before surgery was significantly associated with higher postoperative opioid use at 2 weeks postoperatively (253.8 additional oral morphine equivalents [OMEs]; 95% confidence interval [CI], 171.2-336.5 additional OMEs; $P < .0001$; n = 73) and 6 weeks postoperatively (385.3 additional OMEs; 95% CI, 241.6-529.0 additional OMEs; $P < .0001$; n = 67). By 6 weeks postoperatively, 41 of 52 patients (79%) without opioid use in the 2 weeks before surgery used 30 or fewer 5-mg oxycodone pills compared with only 2 of 15 patients (13%) with preoperative use (odds ratio, 24.9; 95% CI, 4.2-148.5; $P < .0001$). **Conclusions:** Among patients undergoing hip arthroscopy for FAI syndrome, any opioid use in the 2 weeks preceding surgery was the strongest predictor of opioid use after hip arthroscopy. The impact of preoperative opioid use far exceeded the impact of other baseline patient and operative factors. Assessment of preoperative opioid use could be an important factor in guiding postoperative opioid prescribing. **Level of Evidence:** Level II, prospective observational study.

The United States is in an epidemic of opioid misuse and abuse,[1-4] and orthopaedic surgeons are the third highest prescribers of opioids.[5] Previous studies have reported that patients undergoing routine surgical procedures are overprescribed pain medication after surgery and are left with a substantial amount of opioid pain medication.[6-8] Overprescribing of opioids is likely multifactorial in nature but may stem from inadequate research into tailoring pain medication prescriptions to individual patient needs after specific surgical procedures. To publicly address the opioid misuse and abuse epidemic, the American Academy of Orthopaedic Surgeons and Institute of Medicine have advocated for instituting evidence-based opioid prescription guidelines for specific clinical situations that take into account patient factors that may affect potential abuse.[3,9-11]

Patients aged 20 to 39 years report the highest rate of illicit drug use and are the same age group that most commonly undergoes hip arthroscopy.[12,13] Postoperative pain after hip arthroscopy has been shown to be modulated by several operative factors such as infusion pressures and extent of bony and soft-tissue debridement.[14,15] In other areas of orthopaedics, biopsychosocial factors such as chronic pain, pain

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catastrophizing, psychiatric disease, and sex are related to the development of persistent postoperative pain and opioid use.[16-18] Furthermore, chronic pain medication use before orthopaedic surgical procedures, including hip, knee, and ankle arthroplasty, is associated with increased pain sensitivity (hyperalgesia), persistent postoperative pain, and increased opioid demand.[19-21] Despite increased research into opioid requirements within the operating room[22] and recent advances in local and regional anesthesia aimed at reducing perioperative pain,[15,23,24] patients undergoing hip arthroscopy often still require powerful analgesia in the postoperative period while recovering at home.[7,25,26]

In light of the opioid misuse and abuse crisis, orthopaedic surgeons are in need of evidence-based postoperative opioid prescription protocols and risk factor identification mechanisms to predict increased use so that opioid prescriptions can be titrated to individual patient needs.[5,10] Hip arthroscopy currently has no evidence to guide postoperative opioid prescriptions. The purposes of this study were to provide estimates of postoperative opioid use after hip arthroscopy for femoroacetabular impingement (FAI) syndrome and to identify risk factors for increased postoperative use. This study hypothesized that postoperative opioid use may be driven by biopsychosocial factors such as patient characteristics, psychiatric scores, and prior opioid use.

Methods

Study Design

This prospective, observational study underwent institutional review board approval and evaluated opioid use after arthroscopic treatment of FAI syndrome. The study was conducted between November 2015 and July 2016; patients were enrolled from the clinics of 2 established hip-preservation surgeons (S.O., R.M.) with standardized operative and postoperative treatment protocols at a high-volume, academic, tertiary care center. Target enrollment was set at 30 patients per surgeon based on an a priori sample size calculation described further in the "Study Size" subsection. The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cohort studies, which provides guidance for strengthening observational studies.[27]

Usual Practice

Patients with FAI syndrome were considered surgical candidates if they had minimal evidence of pre-existing osteoarthritis and if conservative management consisting of at least 6 months of treatment, including physical therapy, corticosteroid injection, rest, and anti-inflammatory medication, had failed. Patients were not routinely prescribed opioid analgesia by their surgeon as part of conservative treatment, although some patients received opioid prescriptions from outside providers. Surgical treatment was dictated by intraoperative findings and included labral repair, acetabular rim trimming, femoral osteochondroplasty, and/or microfracture (Table 1).

Consistent with usual practice regarding perioperative and postoperative anesthesia, anesthesiologists dictated acute pain medication administration surrounding surgery, including the use of perioperative nerve blocks. All patients received general anesthesia with analgesia provided by intravenous (IV) fentanyl. Patients stayed in the hospital for a 23-hour observational period, during which they could receive oral and/or IV analgesia. All patients received prescriptions for 5-mg oxycodone orally unless they had pre-existing opioid preferences. The prescription amount was decided on a case-by-case basis. All patients received prescriptions for 500-mg naproxen for heterotopic ossification prophylaxis. Other standardized discharge medications are listed in Appendix Table 1 (available at www.arthroscopyjournal.org, "Postoperative medications" section). One surgeon prescribed the use of a continuous passive motion (CPM) device (Kinetec

Table 1. Baseline, Operative, and Postoperative Factors in Entire Sample (n = 73)

Baseline Characteristics	Data
Age, yr	36.5 (11.3)
Female sex	55 of 73 (75.3%)
White race	63 of 73 (86.3%)
BMI	27.1 (5.6)
ASA	1.8 (0.5)
Opioid use in 2 wk before surgery	16 of 73 (21.9%)
Anti-inflammatory use in 2 wk before surgery	37 of 73 (50.6%)
Preoperative pain (out of 10)	5.4 (2.3)
iHOT-12 (out of 100)	30.7 (18.5)
PHQ (out of 24)	5.8 (5.5)
PCS (out of 52)	16.3 (14.7)
Prior ipsilateral hip surgery	5 of 73 (6.8%)
Nerve block	22 of 73 (30.1%)
Procedure duration, h	2.2 (0.5)
Acetabular rim trimming	61 of 73 (100%)
Labral repair	72 of 73 (99%)
Femoral osteochondroplasty	68 of 73 (93%)
Additional procedure	5 of 73 (6.8%)
Acetabular microfracture	3 of 73 (4%)
Hamstring repair	1 of 73 (1%)
Trochanteric bursectomy	1 of 73 (1%)
CPM, compressive icing, and hip brace (vs active ROM and ice packs)*	38 of 73 (52%)

NOTE. Data are presented as average (standard deviation) or proportion (percentage).

ASA, American Society of Anesthesiologists; BMI, body mass index; CPM, continuous passive motion; iHOT-12, International Hip Outcome Tool; PCS, Pain Catastrophizing Scale; PHQ, Patient Health Questionnaire; ROM, range of motion.

*Surgeon-dependent factors.

Spectra, Jackson, WI), hip brace, and compressive ice device, whereas the other surgeon prescribed gentle active range of motion (ROM) and the use of ice packs. All patients were encouraged to start formal physical therapy in the first week after hip arthroscopy. Operative and postoperative protocols along with medication instructions are displayed in Appendix Table 1 (available at www.arthroscopyjournal.org, "Surgical and postoperative technique" section).

Variables

The primary study outcome was opioid pain medication use measured by pill counting at the 2- and 6-week postoperative time points. To reduce the impact of opioid use outliers, postoperative opioid use was also analyzed in a binary fashion for intake exceeding 225 oral morphine equivalents (OMEs), or the equivalent of thirty 5-mg oxycodone pills. Secondary outcomes included intraoperative opioid use, postoperative in-hospital opioid use, opioids remaining at 6 weeks postoperatively, prescribed opioids up to the 6-week and 90-day postoperative time points, and the binary outcome of additionally prescribed opioids between 6 weeks and 90 days postoperatively.

Because opioid use may be dependent on a number of patient and operative factors, multiple input variables were measured: age, sex, race, body mass index (BMI), American Society of Anesthesiologists score, and prior ipsilateral hip surgery. Patients were asked to report daily dosages, routes of administration, and types of opioid and anti-inflammatory medications they consumed in the 2 weeks before surgery (preoperative opioid and preoperative anti-inflammatory use). Patients were considered to have "preoperative opioid use" or "preoperative anti-inflammatory use" if they reported using opioids or anti-inflammatory medications in the 2 weeks before surgery. Participants also completed a series of patient-reported outcome measures including the International Hip Outcome Tool (iHOT-12, hip functional measure),[28] visual analog scale (VAS) for pain,[29] Pain Catastrophizing Scale (PCS),[30] and Patient Health Questionnaire 8 (PHQ-8).[31] The PCS rated respondents' psychological state through a 13-question assessment, with a total PCS score of 30 representing a clinically relevant level of catastrophizing. For the PHQ-8, scores of 5, 10, 15, and 20 represented mild depression, moderate depression, moderately severe depression, and severe depression, respectively.[31] Operative and postoperative characteristics included procedure time, placement of nerve block, operative interventions, and prescribed opioid and rehabilitation.

Measurements

Intra-procedure and post-procedure in-hospital opioid use was tabulated from the electronic medical record. Patients recorded their daily opioid use and pain in a booklet that was provided to them to take home. Patients were reminded by study staff multiple times throughout the first 2 weeks to be filling out the booklet on a daily basis. At the 2- and 6-week postoperative visits, opioid use was measured through pill counting, performed primarily by clinicians in the office setting. However, if patients were unable to come to the clinic, they were allowed to count pills and report their count to the research staff (25 of 140 pill counts, 18%). Total OMEs prescribed and remaining at various time points were also recorded. Because patients were not all prescribed the same dosage and type of medication, all opiate dosages were converted to OMEs for comparison using standard conversion factors[32] (Appendix Table 2, available at www.arthroscopyjournal.org).

Postoperative pain and functional measurements included the VAS pain score, which was remeasured at the 2- and 6-week visits, and the iHOT-12 score, which was remeasured at the 6-week visit. To align with recommendations on evaluating pain and functional outcomes in orthopaedics, a minimal clinically important difference (MCID) of a 10% reduction in preoperative to postoperative pain was selected for evaluation based on previous reports on mild to moderate hip osteoarthritis.[33,34] Because the iHOT-12 had no reported MCID, the iHOT-33 MCID of 6.1[35] was scaled to the iHOT-12, yielding an MCID of 2.2 on the 12-point scale.

Study Size

Because the surgeons involved in the study used different postoperative rehabilitation protocols and rehabilitation could potentially affect outcomes, the sample size was determined to detect a difference in proportions of patients meeting the MCID for pain reduction at 2 weeks postoperatively. Before study initiation, each surgeon reviewed a consecutive sample of his patients to determine the rate of patients achieving the threshold for the MCID for pain reduction. In this analysis, 9 of 10 (90%) of one surgeon's patients met this threshold compared with 6 of 11 (55%) of the other surgeon's patients. By use of a standard, publicly available sample size calculator for differences in proportions comparing 2 independent samples (www.stat.ubc.ca/ rollin/stats/ssize/b2.html), 30 or more patients per group would be needed to detect a significant difference in the 2-week pain outcome with a power of 0.80 and an of .05.

Statistical Analysis

Averages and standard deviations or proportions and percentages were calculated for baseline characteristics and outcomes. Univariate tests of significance were carried out between all preoperative variables and all study outcomes using JMP Pro (version 13.0.0; SAS

Institute, Cary, NC). Univariate statistical tests included Student *t* tests and Pearson correlation for continuous study outcomes (OME use outcomes) and ^{2} analysis for binary study outcomes, including intake of the OME of more than thirty 5-mg oxycodone pills orally by the 2- and 6-week postoperative visits. Preoperative covariates with univariate $P < .1$ were incorporated into multivariate main effects linear (continuous outcomes) or logistic (binary outcomes) regression models and reported as adjusted estimates, odds ratios, or odds ratios per unit change in predictor. Predictors in multivariate models with $P < .05$ were reported as significant. Ninety-five percent confidence intervals were displayed for all factors in multivariate models.

A Kaplan-Meier curve was constructed to display the time-dependent proportion of patients achieving their first day without opioid use and meeting the MCID for pain threshold after surgery up to 2 weeks postoperatively. Cox proportional hazards models were calculated in the same manner as multivariate regression models.

Results

A total of 80 patients were enrolled in this study. To enroll 80 patients, we approached 103 patients who were screened and potentially eligible for participation in the study; however, 23 declined to participate (Fig 1). Of the 80 patients who consented to the study, 7 (9%) were withdrawn for the following reasons: 3 patients (4%, 2 from the CPM surgeon and 1 from the non-CPM surgeon) did not return for in-office appointments, 2 patients (3%, both from the CPM surgeon) did not bring their opioid prescriptions to any follow-up visits, and 2 patients (3%, both from the CPM surgeon) used opioid medication from outside providers. For 73 of 80 patients (91%, 38 from the CPM surgeon and 35 from the non-CPM surgeon), at least 1 study outcome was available for analysis. For 67 of 80 patients (84%, 35 from the CPM surgeon and 32 from the non-CPM surgeon), complete data were available for the primary outcomes of 2- and 6-week opioid use. The home booklet was completed by 64 of 80 patients (80%, 32 from the CPM surgeon and 32 from the non-CPM surgeon). Of the 80 patients, 6 (8%, 3 from the CPM surgeon and 3 from the non-CPM surgeon) did not provide any study data at the 6-week visit but were included in the 2-week analyses. For all outcomes, enrollment exceeded the per-surgeon targeted threshold (minimum of 30 patients per surgeon).

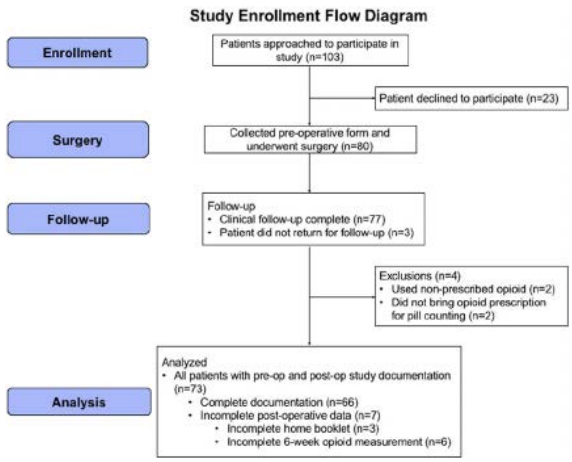

Fig 1. Study enrollment flow diagram. (post-op, postoperative; pre-op, preoperative.)

Baseline patient characteristics are displayed in Table 1. On average, patients reported a VAS pain score of 5.4 of 10, an iHOT-12 score of 30.7, a depression score (on the PHQ-8) of 5.8, and a catastrophizing score (on the PCS) of 16.3. Five patients underwent prior ipsilateral hip surgery, and 5 required an operative intervention during their index procedure in addition to labral repair, acetabular rim trimming, and femoral osteochondroplasty. Surgical and postoperative interventions were recorded. All patients underwent acetabular rim trimming, 72 of 73 (99%) underwent labral repair, and 68 of 73 (93%) underwent femoral osteochondroplasty. Moreover, 3 of 73 patients (4%) underwent acetabular microfracture, 1 of 73 (1%) underwent hamstring repair, and 1 of 73 (1%) underwent trochanteric bursectomy.

Table 2 displays the 2- and 6-week postoperative opioid use outcomes in OMEs for the entire study sample, as well as for patients with and without opioid use in the 2 weeks preceding surgery. These results are presented given the considerable impact of opioid use before surgery on postoperative opioid use as shown in Table 3. For reference, 7.5 OMEs is equivalent to 1 oral 5-mg oxycodone pill (Appendix Table 2, conversion factors list, available at www.arthroscopyjournal.org). Compared with patients not reporting preoperative opioid use, patients with preoperative opioid use took 3.3 times as much in the first 2 weeks after surgery and took 3.9 times as much in the first 6 weeks after surgery. In terms of oral 5-mg oxycodone pills, patients with preoperative opioid use consumed an average of nearly 79 pills (Quartile 1, 55 pills; Quartile 3, 111 pills) compared with approximately 20 pills (Quartile 1, 1 pill; Quartile 3, 28 pills) consumed by patients without preoperative opioid use. Patients without preoperative opioid use consumed less than 225 OMEs (thirty 5-mg oxycodone pills) about 80% of the time compared with less than 20% of the time for patients with preoperative opioid use. Results of further opioid measurements such as in-hospital opioid use, prescribed amounts, and remaining opioids are described in Appendix Table 3 (available at www.arthroscopyjournal.org).

Multivariate outcome models were constructed that incorporated all preoperative and operative factors that first met a univariate threshold of $P < .1$ (Table 3). All

Table 2. Two- and Six-Week Opioid Use for Entire Study Sample and Divided by Patients With and Without Opioid Use 2 Weeks Before Surgery (Unadjusted Results)

Outcome	Entire Sample	Without Preoperative Opioid	With Preoperative Opioid
2-wk OMEs (n = 73)	172.3 (173)	113.8 (120.7)	380.8 (172.9)
6-wk OMEs (n = 67)	250.8 (278.6)	152.5 (181.4)	591.7 (292.9)
2-wk OMEs <225 (n = 73)	49 of 73 (32.8%)	46 of 57 (80.7%)	3 of 16 (18.8%)
6-wk OMEs <225 (n = 67)	43 of 67 (35.8%)	41 of 52 (78.8%)	2 of 15 (13.3%)

NOTE. Data are presented as average (standard deviation) or proportion (percentage).
OME, oral morphine equivalent.

univariate *P* values are displayed in Appendix Table 4 (available at www.arthroscopyjournal.org). In multivariate models, patients reporting opioid use in the 2 weeks preceding surgery showed significantly increased 2-week opioid use ($P < .001$), 6-week opioid use ($P < .001$), rates of 2-week opioid use exceeding 225 OMEs (equivalent to thirty 5-mg oxycodone pills) ($P < .001$), and rates of 6-week opioid use exceeding 225 OMEs ($P < .001$). Further results regarding the other opioid measurement outcomes (in-hospital use, prescribed amounts, and remaining amounts) are described in Appendix Table 5 (available at www.arthroscopyjournal.org).

Patients' time to their first day with no opioid use after surgery was analyzed against patient characteristics (Fig 2). Of 73 patients, 64 (88%) completed the home booklet and were included in the analysis. For patients without preoperative opioid use, greater than 50% of patients achieved their first day without opioid use between days 4 and 5 compared with days 12 and 13 for patients with preoperative opioid use. Univariate Cox proportional hazards ratios were calculated for each characteristic listed in Table 1, and all factors achieving $P < .1$ on univariate analysis were included in a multivariate model. Preoperative opioid use and active ROM rehabilitation patients were the only factors that achieved the univariate significance threshold for increasing the time it took for patients to cease opioid use, and both of these factors were significantly associated in a multivariate Cox proportional hazards model.

Table 3. Multivariate Outcome Modeling Incorporating All Preoperative and Operative Factors From Table 1 That Met Univariate Significance Threshold of $P < .1$ for 2- and 6-Week Postoperative Opioid Use Outcomes

Outcome	Patient or Operative Characteristic	Adjusted Estimate or Odds Ratio (95% CI)	*P* Value
2-wk OMEs (n = 73)	Opioid use in 2 wk before surgery	253.84 (171.22, 336.46)	<.001
	PCS (out of 52)	2.45/point (−0.44, 5.33)	.096
	PHQ (out of 24)	−1.19/point (−8.75, 6.37)	.75
	iHOT-12 (out of 100)	0.23/point (−1.88, 2.33)	.83
	ASA	−1.62/ASA (−68.82, 65.59)	.96
6-wk OMEs (n = 67)	Opioid use in 2 wk before surgery	385.29 (241.64, 528.95)	<.001
	Prior ipsilateral hip surgery	161.31 (−52.23, 374.86)	.136
	Active ROM surgeon	66.3 (−40.12, 172.72)	.22
	PCS (out of 52)	2.58/point (−1.96, 7.11)	.26
	PHQ (out of 24)	4.78/point (−8.3, 17.86)	.47
	ASA	33.75/point (−73.07, 140.57)	.53
	BMI	−2.11/point (−12.06, 7.84)	.67
	Procedure duration (hours)	−7.05/h (−131.23, 117.13)	.91
	iHOT-12 (out of 100)	0.11/point (−3.22, 3.43)	.95
2-wk OMEs >225 (n = 73)	Opioid use in 2 wk before surgery	17.14 odds ratio (3.74, 78.56)	<.001
	Prior ipsilateral hip surgery	9.61 odds ratio (0.78, 118.22)	.077
	Active ROM surgeon	2.52 odds ratio (0.7, 9.07)	.156
	PCS (out of 52)	0.99 unit odds ratio/point (0.93, 1.04)	.61
	iHOT-12 (out of 100)	1.00 unit odds ratio/point (0.96, 1.05)	.88
	PHQ (out of 24)	0.99 unit odds ratio/point (0.86, 1.15)	.91
6-wk OMEs >225 (n = 67)	Opioid use in 2 wk before surgery	24.87 odds ratio (4.16, 148.51)	<.001
	Prior ipsilateral hip surgery	9.28 odds ratio (0.71, 120.72)	.074
	Active ROM surgeon	1.96 odds ratio (0.51, 7.49)	.32
	PCS (out of 52)	0.98 unit odds ratio/point (0.92, 1.03)	.43
	PHQ (out of 24)	0.99 unit odds ratio/point (0.84, 1.15)	.87
	Procedure duration (hours)	1.12 unit odds ratio/h (0.22, 5.78)	.89
	iHOT-12 (out of 100)	1 unit odds ratio/point (0.96, 1.04)	.92

NOTE. Data are presented as adjusted estimate or odds ratio (lower 95% confidence interval, upper 95% confidence interval).
ASA, American Society of Anesthesiologists; BMI, body mass index; iHOT-12, International Hip Outcome Tool; OME, oral morphine equivalent; PCS, Pain Catastrophizing Scale; PHQ, Patient Health Questionnaire; ROM, range of motion.

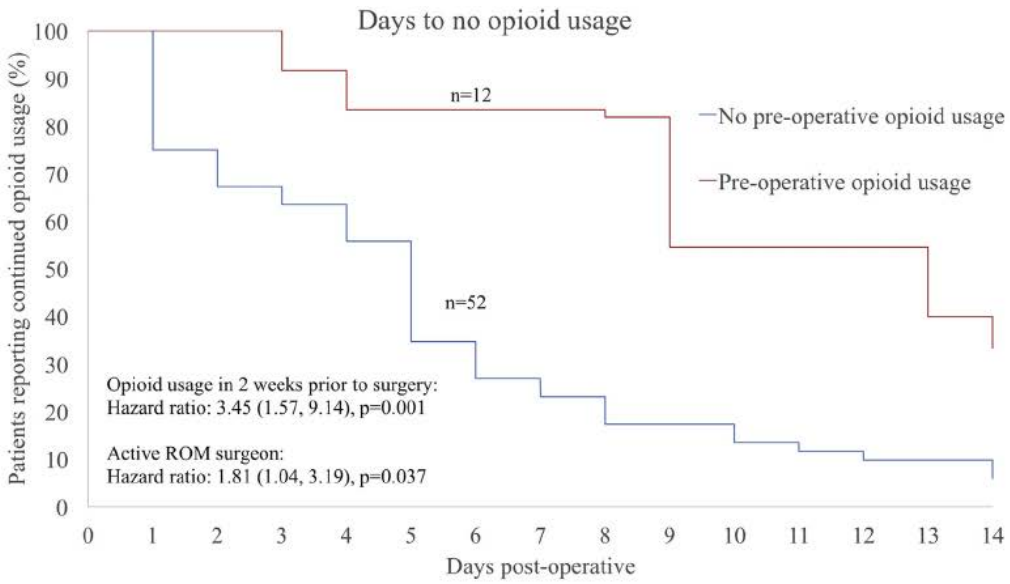

Fig 2. Kaplan-Meier curve showing differential rates of patients achieving their first day with no reported opioid use between those with preoperative opioid use and those without preoperative opioid use among all patients completing the home booklet (n = 64). Results of multivariate significance testing are displayed in the bottom left corner, indicating that prior opioid use and treatment by the active range-of-motion (ROM) surgeon were significantly associated with increased time to the first day without opioid use. Results broken down by treating surgeon are not shown.

Daily opioid use for all patients who completed the home booklet (64 of 73 patients, 88%) was displayed from the preoperative to 14-day postoperative period (Fig 3) and broken down based on patient-reported opioid use in the 2 weeks before surgery. Univariate Student *t* tests were carried out between the 2 groups, with *P* values displayed for each day. Patients with opioid use in the 2 weeks before surgery consumed significantly more opioids at all time points except for postoperative days 13 and 14.

Appendix Table 6 (available at www.arthroscopyjournal.org) describes the relations between baseline preoperative

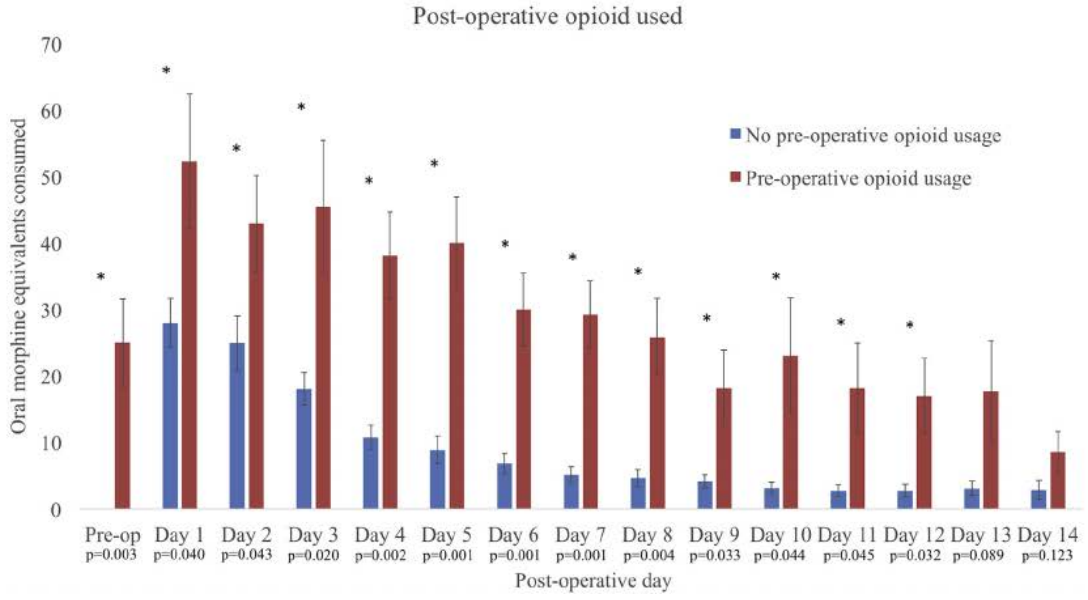

Fig 3. Fourteen-day opioid use in patients with and without preoperative opioid use (64 patients with completed booklets, comprising 12 with preoperative opioid use and 52 without preoperative opioid use). *P* values are displayed below each day label. Asterisks indicate $P < .05$. (Pre-op, preoperative.)

patient characteristics and the risk factor of preoperative opioid use. All factors with univariate $P < .1$ were included in a multivariate logistic regression model describing each factor's association with preoperative opioid use. Higher BMI values and American Society of Anesthesiologists scores were significantly associated with preoperative opioid use in the multivariate model. To provide further clinical context of the impact of opioid use before surgery on postoperative functional outcomes, Appendix Table 7 (available at www.arthroscopyjournal.org) displays functional outcomes divided by patients with and without preoperative opioid use among the 70 of 73 patients (96%) with complete functional outcomes at 2 weeks postoperatively and the 67 of 73 patients (92%) with complete functional outcomes at 6 weeks postoperatively. Univariate Student *t* tests or ^{2} analysis was performed to assess the differences between these 2 samples. Pain and functional outcomes were not significantly different between these groups.

Discussion

Opioid use in the 2 weeks before surgery was the major risk factor for increased postoperative opioid use and was associated with patients consuming significantly more (3.9 times as much) opioids (591.7 OMEs vs 152.5 OMEs) compared with patients without preoperative opioid use by 6 weeks postoperatively. Opioid prescribing patterns should align with individual patient needs. This study assessed typical postoperative opioid use and correlated preoperative and operative factors to postoperative opioid use and prescribing after hip arthroscopy for FAI syndrome. Consistent with previous reports on total joint arthroplasty,[36] preoperative opioid use proved to be the main determinant of postoperative opioid use. This risk factor was reported in 22% of patients. Of 15 patients with opioid use in the 2 weeks before surgery, 13 (86.6%) used more than thirty 5-mg oxycodone pills (225 OMEs) in the first 6 weeks after surgery compared with only 11 of 52 patients (21.1%) without opioid use in the 2 weeks before surgery. Furthermore, patients without preoperative opioid use consumed very little pain medication between the 2- and 6-week visits (38.7 OMEs, or 5.2 oxycodone 5-mg pills) compared with patients with preoperative opioid use (210.9 OMEs, or 28.1 oxycodone 5-mg pills). The average patient had 376.1 OMEs (50.1 oxycodone 5-mg pills) remaining at the 6-week postoperative visit. Despite increased opioid use, 2- and 6-week pain and functional improvements were similar between these groups.

Besides the clear relation between prior opioid use and postoperative opioid use, several other factors were associated with outcomes. Prior ipsilateral hip surgery was associated with higher odds of requesting additional opioids between the 6-week visit and 90 days postoperatively. However, only 5 of 73 patients (6.8%) had this risk factor, and 2 of these 5 reported prior opioid use. Intra-procedure opioid use was significantly increased with elevated patient BMI, and postoperative in-hospital opioid use was significantly higher in younger patients and among patients treated by the surgeon who prescribed active ROM as part of the rehabilitation protocol. The surgeon who prescribed active ROM for rehabilitation also prescribed significantly more opioids to his patients by 6 weeks postoperatively. However, differences in use between the surgeons were not statistically significant on multivariate analysis. Furthermore, home opioid use was not significantly affected by the surgeon's rehabilitation strategy preference.

Several psychological and physiological factors could partially explain the difference in opioid consumption between patients with and without preoperative opioid use. First, patients with preoperative opioid use reported lower function along with higher pain, depression, and pain catastrophizing than patients without preoperative opioid use. The combination of these factors could contribute to heightened pain leading to greater opioid use after surgery[16-19] and may have been the reason that some of these factors were associated with opioid use on univariate analysis. However, we did not find that these factors remained correlated in multivariate models of opioid use, suggesting that their effect was either minimal or encompassed by the effect of preoperative opioid use. Second, in patients with preoperative opioid use, tolerance to the analgesic effect of opioids may have developed.[37] Last, extended use of opioids has been associated with heightened pain sensation,[20] which could lead to greater postoperative opioid consumption, although we acknowledge that we did not record the duration of time that patients were taking narcotics before surgery.

In addition to the assessment of opioid use in the 2 weeks preceding surgery, the following 2 strategies could potentially reduce the amount of left-over opioid medication: (1) provide patients with several opioid prescriptions for smaller individual amounts[6] and (2) provide patients with explicit instructions on appropriate opioid disposal guidelines.[7] For reference, the US Food and Drug Administration currently recommends that patients either flush their unused opioids down the sink or toilet or return their opioids to a medicine take-back program or Drug Enforcement Administration authorized collector.[38] Last, several studies have evaluated perioperative analgesic strategies that may reduce short-term postoperative opioid use.[39,40] Further evaluation could determine analgesic strategies that reduce home opioid use in addition to reducing immediate postoperative opioid need.

Limitations

Opioid prescription amounts were not standardized. Although standardizing opioid prescriptions was considered during study design, there were no data on the basis of which to gauge an appropriate prescription amount. Therefore, as was part of usual care, prescription amounts were decided in a case-by-case fashion based on surgeon anticipation of potential patient need. Patients who were initially prescribed more pain medication may have used more pain medication simply because of the greater availability. However, despite the lack of standardization, many patients ended the 6-week postoperative period with a considerable amount of left-over pain medication. Furthermore, although patients received oxycodone by default, some patients preferred alternate oral opioid medications other than oxycodone (i.e., hydrocodone or hydromorphone). However, this study accounted for these differences in prescribing patterns through converting opioid use into standard OMEs. In addition, patients treated at our institution routinely stayed in the hospital overnight for monitoring. Other institutions may routinely discharge patients on the same day as surgery. To address this limitation, intra-procedure and post-procedure in-hospital opioids were tabulated. In-hospital post-procedure use was predominantly composed of oral oxycodone and nurse-administered IV hydromorphone. To provide data for those surgeons whose patients are discharged without using IV or in-hospital analgesia, the average patient in this study consumed an OME amount equivalent to 10 oral 5-mg oxycodone pills while still in recovery after the procedure.

A further limitation of this study is that of the 103 patients (22%) eligible for study inclusion, 23 declined to participate. Because these patients did not consent to participate in our research, it is not possible to analyze them to determine whether these patients represented a distinct subpopulation with potentially different baseline characteristics and responses to opioid medication. This could expose the study to selection bias. Furthermore, despite considerable effort on the part of clinical and research staff to ensure study follow-up, 3 of 80 patients (4%) did not return for follow-up, 2 of 80 patients (3%) never brought their opioid prescriptions for pill counting, and 2 of 80 patients (3%) reported using opioids prescribed by other providers, which invalidated their counts of surgeon-prescribed opioids. Therefore, before incomplete study data are taken into consideration, 73 of 80 patients (91%) enrolled in the study had usable study data. However, 6 patients had incomplete primary outcome data during at least 1 postoperative data collection time point. This meant that there was a minimal effective follow-up rate of 84% (67 of 80 patients). However, each patient with follow-up data from the 73 of 80 patients who completed the study was included in every outcome for which he or she had complete data (i.e., even if a patient did not complete the home booklet, he or she was not excluded from contributing to 2- and 6-week opioid use outcomes). Patients declining participation, losses to follow-up, exclusions, and incomplete documentation contribute to potential selection and transfer bias.

As noted earlier, despite repeated reinforcement regarding the importance of accurate measurement of postoperative opioid use, 2 patients reported that they used opioids from outside providers. This invalidated their results because an accurate count of postoperative opioid use could not be made. It is conceivable that other patients could also have used outside opioids. However, to our knowledge, there is not an efficient and affordable way to be absolutely certain that patients are taking opioids prescribed by a specific provider. In addition, although opioid use was closely tracked, postoperative nonsteroidal anti-inflammatory drug (NSAID) use was not measured in this study because of the potentially high rate of patients using previously purchased supplies of over-the-counter NSAIDs rather than the naproxen that was prescribed. This could have prevented obtaining reliable estimates of postoperative NSAID use. Preoperative NSAID use was not associated with postoperative opioid use in multivariate models. However, postoperative NSAID use could have an effect on postoperative opioid use. Last, the results of a high-volume, academic, tertiary care center may not be applicable to all hip arthroscopy providers. Surgeons should validate study findings in their own patient populations because there may be differences from our institution in terms of patient characteristics and operative and postoperative treatment.

Conclusions

Among patients undergoing hip arthroscopy for FAI syndrome, any opioid use in the 2 weeks preceding surgery was the strongest predictor of opioid use after hip arthroscopy. The impact of preoperative opioid use far exceeded the impact of other baseline patient and operative factors. Assessment of preoperative opioid use could be an important factor in guiding postoperative opioid prescribing.

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Appendix Table 1. Surgical and Postoperative Technique and Active ROM Exercise Plan

- Surgical and postoperative technique
  - Patient positioning
    - Traction boots applied
      - One investigator routinely applied boots preoperatively, whereas the other applied the boots in the operating room.
    - Patient positioned supine on HANA traction bed (Mizuho OSI)
    - Perineal post applied
    - Nonoperative leg abducted
    - Covidien sequential compression devices (Medtronic) placed bilaterally
    - Operative area prepared with chlorhexidine
    - Operative area draped
    - Ioban tape (3M) applied to operative area
    - Traction applied to operative leg to open joint space
    - Internal rotation to align landmarks for first portal
  - Anterolateral portal placement
    - First portal (anterolateral) established through intermuscular plane between TFL and sartorius under radiographic guidance
    - Blunt dissection used to widen portal track
    - Anterior portal placed under arthroscopic guidance
  - Capsulotomy
    - Smooth, continuous release of anterior capsule from both anterior ports
      - One investigator routinely shaved the capsular edges, whereas the other investigator did not.
    - Capsule suspended with sutures
  - Chondrolabral junction evaluation and labral repair
    - Osteochondral separation stabilized as clinically indicated
    - Acetabular rim prepared with shaver, radiofrequency ablation, and burr
    - Labrum repaired with suture anchors
      - One investigator used loop sutures, whereas the other investigator used mattress sutures.
  - Femoral neck
    - Femoral osteochondroplasty achieved using radiofrequency ablation and burr
      - One investigator used a T-capsulotomy, whereas the other did not.
    - Traction released
      - One investigator also routinely released boot straps after femoral osteochondroplasty.
  - Capsular closure
    - Complete capsular repair with nonabsorbable suture; intraoperative factors such as joint laxity encouraged further watertight closure
  - Port site closure
    - Dexamethasone and procaine injected
      - One investigator injected at port sites, whereas the other injected intra-articularly.
  - Disposition
    - All patients stayed <24 h in observation
      - Inpatient medications were ordered at the discretion of the orthopaedic house staff and anesthesia staff on duty.
    - All patients discharged home
  - Physical therapy
    - Patients instructed to begin early ROM exercises as indicated based on rehabilitation protocol
      - CPM
        - CPM 4-6 h/d with progressively increasing flexion arc for 3-4 wk
        - Belly laying for 2 h/d
        - Hip brace to be worn at night (0°-20° of flexion)
      - Active ROM
        - Detailed under "Active ROM exercise plan" later in table
    - All patients instructed to begin formal physical therapy within 1 wk after surgery
  - Postoperative medications
    - Oxycodone, 5-10 mg every 4 h, as needed for pain
      - Patients were allowed to request other opioid pain medication based on prior experience (e.g., tramadol, hydrocodone-acetaminophen, or hydromorphone).
    - Acetaminophen as needed for pain
    - Promethazine as needed for nausea
    - Naproxen, 500 mg once daily, for heterotopic ossification prophylaxis
    - Aspirin, 325 mg once daily, for DVT prophylaxis
    - Gabapentin and pregabalin only ordered if clinically indicated
    - Meloxicam and indomethacin only ordered based on patient request
- Active ROM exercise plan
  - Week 1
    - Perform exercises 1, 2, and 3 every hour, with 15 repetitions each.
    - Perform exercises 4 and 5, with 10-20 repetitions, 2-3 times/d.

(continued)

Appendix Table 1. Continued

1. Ankle pumps: Move both feet up and down and around in circles.
2. Quadriceps setting: Tighten the muscle in the front of your thigh by pushing the back of your knee down, and hold for 5 s without holding your breath.
3. Gluteal setting: Tighten your buttock muscles, and hold for 5 s without holding your breath.
4. Short-arc quadriceps: Place a small roll or pillow under your knee. Lift the foot off the bed and straighten the knee. Hold the knee straight for 5 s and then slowly lower the foot down to the bed.
5. Lie face down on your stomach in the prone position or "on your belly" so that your thigh is straight in line with your upper body. Do this on a comfortable surface. Work up to lying in the prone position for 2 h/d for the first 2 wk after your operation. This helps to stretch the tissue about the hip joint.
6. Use a stationary bike without resistance for 15-20 min (if you have access to one).

Week 2

With both hands, hold onto a stable support such as a countertop or door frame.

Perform exercises 1-4 for 10-20 repetitions, 2-3 times/d, on the operated leg.

Perform these exercises only on the operated leg because exercises on the nonoperative hip will cause you to bear weight on the operated side.

1. Hip abduction gravity eliminated with mild resistance: While lying on your back, slide your leg out to the side and then return to starting position. Only do this exercise while lying down. Move the operative leg away from midline without lifting the leg off the surface. Keep the knee straight and pointed to the ceiling.
2. Hip and knee bending: While lying on your back, slide your heel along the bed so that the hip and knee bend; then, slide the foot back down.
3. Standing hip flexion: Move your leg forward, keeping the knee straight, and return to starting position. Do not lean backward.
4. Standing knee flexion: Bend your knee so that your foot moves toward the buttocks. Keep the thigh straight, and do not let it extend backward.

Week 3

Begin to add stretching

1. Hamstring: Stand with the heel propped on a low table with the knee straight. Gently and slowly lean forward at the waist. Hold the stretch for 30 s.
2. Standing hip-knee flexion: Bend the hip and knee of the involved leg up as if marching in place.

Week 4

1. Standing hip abduction: Move your leg straight out to the side, and then return to starting position. Do not move your body or let your leg turn inward or outward. Do not add extra weight to your leg.
2. Hip abduction gravity eliminated with mild resistance: While lying on your back, slide your leg out to the side and then return to starting position; this time, add a TheraBand or resistance rubber band from about your ankles. Only do this exercise while lying down. Make a loop out of TheraBand or a lightly resistant elastic material. Place the loop around both legs at the ankle level. Keep the nonoperative leg still as a "post" for the TheraBand. Move the operative leg away from midline. Keep the knee straight and pointed to the ceiling.

CPM, continuous passive motion; DVT, deep venous thrombosis; ROM, range of motion; TFL, tensor fascia lata.

Appendix Table 2. Oral Morphine Equivalent Dosage Conversion Chart

Medication	Oral Morphine Milligram Equivalent/1 Unit Medication
IV fentanyl, g	0.25
IV hydromorphone, mg	20
Oral codeine, mg	0.15
Oral hydrocodone, mg	1
Oral hydromorphone, mg	4
Oral meperidine, mg	0.1
Oral oxycodone, mg	1.5
Oral OxyContin (Purdue), mg	1.5
Oral tramadol, mg	0.1

IV, intravenous.

Appendix Table 3. Opioid Use for Entire Study Sample and Divided by Patients With and Without Opioid Use 2 Weeks Before Surgery (Unadjusted Results) for Outcomes Except for 2- and 6-Week Postoperative Opioid Use Outcomes

Outcome	Entire Sample	Without Preoperative Opioid	With Preoperative Opioid
OMEs/d preoperatively	5 (13.4)	0 (0)	23 (20.6)
Intraoperative OMEs (n = 73)	63.9 (28.2)	64.8 (30.1)	60.5 (20.9)
Postoperative in-hospital OMEs (n = 73)	44.8 (47.8)	43.1 (49.1)	50.9 (43.9)
Prescribed OMEs to 6-wk visit (n = 73)	617.5 (315.6)	542.8 (286.2)	883.9 (274.6)
Prescribed OMEs to 90 d postoperatively (n = 73)	657.4 (362.5)	566.7 (302.7)	980.8 (382)
Remaining OMEs at 6-wk visit (n = 67)	376.1 (262.9)	396.2 (269.7)	306.1 (232.5)
Prescribed additional narcotics at or after 6-wk visit up to 90 d postoperatively (n = 73)	11 of 73 (15%)	6 of 57 (10.5%)	5 of 16 (31.2%)

NOTE. Data are presented as average (standard deviation) or proportion (percentage).
OME, oral morphine equivalent.

Appendix Table 4. Univariate Significance Testing of Baseline and Operative Characteristics With Study Outcomes

Characteristic	Intra-procedure OMEs (n = 73)	Postoperative In-Hospital OMEs (n = 73)	2-wk OMEs (n = 73)	Prescribed OMEs to 6-wk Visit (n = 73)	Prescribed OMEs to 90 d Postoperatively (n = 73)	Prescribed Additional Narcotics at or After 6-wk Visit up to 90 d Postoperatively (n = 73)	6-wk OMEs (n = 67)	Remaining OMEs at 6-wk Visit (n = 67)	2-wk OMEs >1.5 × 5 × 30 (30 Oxycodone 5-mg Pills)	6-wk OMEs >1.5 × 5 × 30 (30 Oxycodone 5-mg Pills)
Age	.2901	.0806	.3279	.7134	.9632	.9844	.8601	.2447	.5228	.3489
Female sex	.3456	.7498	.9192	.6144	.8042	.8287	.9041	.5709	.592	.8727
White race	.2466	.6909	.495	.6804	.7558	.6499	.6746	.2855	.8338	.6738
BMI	.0193	.6533	.2964	.4254	.3314	.5293	.0828	.2265	.2151	.2783
ASA	.6178	.1349	.0464	.3206	.1882	.223	.0056	.1313	.1209	.2792
Any opioid use in 2 wk before surgery	.5942	.5694	<.0001	<.0001	<.0001	.056	<.0001	.2449	<.0001	<.0001
Anti-inflammatory use	.6159	.0594	.658	.2532	.5281	.3002	.8064	.2154	.9347	.9273
Pain (out of 10)	.2248	.8734	.6408	.7059	.6822	.6566	.2585	.4557	.4499	.6458
iHOT-12 (out of 100)	.3459	.5792	.083	.2056	.1688	.3549	.01	.4381	.0954	.0726
PHQ (out of 24)	.5785	.4664	.0602	.0433	.036	.6348	.0052	.8303	.0517	.0728
PCS (out of 52, n = 71)	.7552	.3474	.0071	.083	.0894	.2669	.004	.5655	.053	.0456
Prior ipsilateral hip surgery	.6507	.056	.181	.1786	.0246	.0152	.0251	.4211	.0243	.035
Nerve block	.389	.6682	.3742	.7376	.6302	.6302	.2502	.2915	.3418	.1773

Appendix Table 5. Multivariate Outcome Modeling Incorporating All Preoperative and Operative Factors From Table 1 That Met Univariate Significance Threshold of $P < .1$ for Outcomes Other Than 2- and 6-Week Opioid Use Outcomes

Outcome	Patient or Operative Characteristic	Adjusted Estimate or Odds Ratio	*P* Value
Intraoperative OMEs (n = 73)	BMI	1.36/point (0.23, 2.49)	.019
Postoperative in-hospital OMEs (n = 73)	Active ROM surgeon	27.49 (5.45, 49.53)	.015
	Age	−1.05/yr (−1.96, −0.14)	.025
	Prior ipsilateral hip surgery	40.97 (−0.33, 82.28)	.052
	Anti-inflammatory use in 2 wk before surgery	11.6 (−10.14, 33.33)	.29
	iHOT-12 (out of 100)	0.11/point (−3.22, 3.43)	.95
Prescribed OMEs to 6-wk visit (n = 73)	Opioid use in 2 wk before surgery	269.4 (105.21, 433.6)	.002
	Active ROM surgeon	154.53 (18.61, 290.45)	.026
	Procedure duration (hours)	76.26/h (−53.3, 205.82)	.24
	PHQ (out of 24)	2.67/point (−12.8, 18.14)	.73
	PCS (out of 52)	0.55/point (−5.13, 6.23)	.85
Prescribed OMEs to 90 d postoperatively (n = 73)	Opioid use in 2 wk before surgery	322.8 (137.99, 507.62)	<.001
	Active ROM surgeon	141.07 (−12.41, 294.54)	.071
	Procedure duration (hours)	98.19/h (−51.82, 248.2)	.196
	Prior ipsilateral hip surgery	186.08 (−113.68, 485.84)	.22
	PHQ (out of 24)	2.38/point (−15.07, 19.84)	.79
	PCS (out of 52)	0.65/point (−5.75, 7.05)	.84
Prescribed additional narcotics at or after 6-wk visit up to 90 d postoperatively (n = 73)	Prior ipsilateral hip surgery	10.29 odds ratio (1.37, 77.18)	.023
	Opioid use in 2 wk before surgery	3.57 odds ratio (0.84, 15.14)	.084
Remaining OMEs at 6-wk visit (n = 67)	No univariate significance	NA	NA

NOTE. Data are presented as adjusted estimate or odds ratio (95% CI).
NA, not applicable; BMI, body mass index; iHOT-12, International Hip Outcome Tool; NA, not applicable; OME, oral morphine equivalent; PCS, Pain Catastrophizing Scale; PHQ, Patient Health Questionnaire; ROM, range of motion.

Appendix Table 6. Pain and Functional Outcomes for Patients With and Without Preoperative Opioid Use

Outcomes	Without Preoperative Opioid	With Preoperative Opioid	*P* Value
2-wk pain MCID	44 of 54 (81.4%)	12 of 16 (75%)	.58
2-wk pain change	−2.6 (−4.7, −0.5)	−2.4 (−6, 1.2)	.77
6-wk pain MCID	46 of 52 (88.4%)	12 of 15 (80%)	.42
6-wk pain change	−3.4 (−6.2, −0.5)	−3.6 (−10.3, 3.1)	.75
6-wk iHOT-12 MCID	31 of 52 (59.6%)	8 of 15 (53.3%)	.66
6-wk iHOT-12 change	25.2 (19.8, 30.6)	29.5 (12.4, 46.6)	.51

NOTE. Data are presented as average (95% CI) or proportion (percentage).
iHOT-12, International Hip Outcome Tool; MCID, minimal clinically important difference.

Appendix Table 7. Baseline Preoperative Characteristics for Samples With and Without Preoperative Opioid Use

Baseline Characteristics	Without Preoperative Opioid	With Preoperative Opioid	Univariate *P* Value	Multivariate *P* Value	Estimate
Age, yr	35.8 (11.5)	39.2 (10.1)	.29	NS	NS
Female sex	44 of 57 (77.1%)	11 of 16 (68.7%)	.50	NS	NS
White race	50 of 57 (87.7%)	13 of 16 (81.2%)	.52	NS	NS
BMI	25.9 (5.1)	31.1 (5.8)	.002	.016	1.16 unit odds ratio/ point (0.76, 0.97)
ASA	1.7 (0.4)	2.1 (0.5)	<.001	.043	5.81 unit odds ratio/ point (0.03, 0.95)
Anti-inflammatory use in 2 wk before surgery	28 of 57 (49.1%)	9 of 16 (56.2%)	.61	NS	NS
Preoperative pain (out of 10)	5.2 (2.4)	6.2 (2.1)	.125	NS	NS
iHOT-12 (out of 100)	33.1 (18.3)	22.5 (17.2)	.036	.91	1.00 unit odds ratio/ point (0.96, 1.04)
PHQ (out of 24)	5.1 (5.4)	8.2 (5.5)	.057	.74	1.03 unit odds ratio/ point (0.84, 1.13)
PCS (out of 52)	14.5 (14.7)	22.7 (13.2)	.054	.32	1.03 unit odds ratio/ point (0.92, 1.03)
Prior ipsilateral hip surgery	3 of 57 (5.2%)	2 of 16 (12.5%)	.34	NS	NS

NOTE. Data are presented as average (standard deviation) or proportion (percentage).

ASA, American Society of Anesthesiologists; BMI, body mass index; iHOT-12, International Hip Outcome Tool; NS, factor did not meet univariate significance threshold of .1; PCS, Pain Catastrophizing Scale; PHQ, Patient Health Questionnaire.