

Original Article

Opioid Requirement After Anterior Cruciate Ligament Surgery: Opioid Use After Anterior Cruciate Ligament Surgery Is Low With a Multimodal Approach, and Fifteen Oxycodone 5-mg Tablets Are Sufficient

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Purpose: To prospectively determine opioid consumption in patients undergoing anterior cruciate ligament (ACL) repair and reconstruction and to develop evidence-based prescription guidelines following ACL surgery. **Methods:** This multicenter prospective study enrolled patients undergoing ACL reconstruction and repair. Subject demographics and opioid prescriptions were recorded at enrollment. All patients were given education on opiate use and followed the same perioperative, multimodal analgesic regimen. Following surgery, patients were given postoperative “pain journals” to document visual analog scale pain scores and daily opioid consumption for the first 7 postoperative days and on postoperative visit at 14 days. **Results:** In total, 50 patients were included in this analysis between the ages of 14 and 65 years. Patients were prescribed a median of 15 oxycodone 5-mg pills and consumed a median of 2 pill postoperatively (range 0-19 pills). 38% of patients consumed 0 opioid pills, 74% of patients consumed ≤ 5 opioid pills, and 96% of patients consumed ≤ 15 opioid pills. Patients reported a mean daily visual analog scale value of 2.8 of 10; mean satisfaction with pain management was high at 4.1/5 on a Likert satisfaction score. Overall, patients consumed a mean 34% of their opioid prescriptions, leaving 436 opioid pills not consumed. **Conclusions:** This study suggests that current expert panels may be recommending an excessive volume of opioids. Based on our findings, we recommend that patients be prescribed no more than 15 Oxycodone 5-mg tablets following ACL surgery. Despite this lower volume prescription, mean pain scores remained below 3 of 10, patient satisfaction with pain control remained high, and 66% of opiate medication prescribed was not used. **Level of Evidence:** II, prospective prognostic cohort investigation.

Proper postoperative pain management is crucial for patients undergoing anterior cruciate ligament (ACL) surgery. Opioids are commonly prescribed as the

pain management standard of care.¹⁻³ Although opioids can effectively reduce acute pain, this benefit must be weighed against the rise of potential addiction. Prescription opioid use has quadrupled over the last 2 decades along with rates of overdose and morbidity, contributing to the opioid epidemic prevalent in the United States today.⁴⁻⁷

Currently, opioid prescriptions following ACL surgery vary substantially and are largely based on expert panels due to the lack of evidence-based research.^{3-5,8} As recently as 2019, Stepan et al.² recommended up to 60 pills based on expert panel consensus. Furthermore, in one prospective study, surgeons at the Orthopedic Institute for Children at UCLA prescribed adolescents 40 5-mg oxycodone pills following anterior cruciate ligament reconstruction (ACLR). They found that patients consumed less than half of their prescribed pills.⁹ These volumes of pills are hazardously large, as the Centers for Disease Control and Prevention warns

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Table 1. Multimodal Analgesic Protocol and Postoperative Medication for ACL Surgery

Timing	Medication	Dose and Route	
Preoperative (in holding area)	Acetaminophen	1,000 mg p.o.	
	Celecoxib	200 mg p.o.	
	Gabapentin	400 mg p.o.	
Perioperative End of surgery	Ketorolac	15 mg IV	
	Bupivacaine/Marcaine	20/20 mL, subcutaneous injection	
	Morphine	7 mg, intra-articular injection	
	Marcaine	10 ml, intra-articular injection	
	Ketorolac	15 mg, intra-articular injection	
Postoperative (pain management)	Ketorolac	15 mg IV	
	Over-the-counter	Acetaminophen	1000 mg p.o. q8 for 5 days
		Ibuprofen	800 mg p.o. q6 for 5 days
	Prescription	Oxycodone	5 mg p.o. q4 as needed, 15 tablets

ACL, anterior cruciate ligament, IV, intravenously; p.o., per oral; q4, q6, q8, every 4, every 6, and every 8 hours.

that just a 5-day supply is sufficient to develop opioid dependence.¹⁰ This potentially overprescribing practice places a vulnerable population at risk for opiate misuse.^{3,8}

Orthopaedic surgeons do not possess evidence-driven regimens for opioid prescriptions after ACL surgery.^{11,12} As a result, establishing clear evidence-based guidelines for opioid prescription after ACL surgery is necessary to reduce opioid misuse and help combat the opioid epidemic in the United States. The purposes of this study were to prospectively determine opioid consumption in patients undergoing ACL repair and reconstruction and to develop evidence-based prescription guidelines after ACL surgery. We hypothesized that with a multimodal approach to pain management, patients would require fewer opioids than traditional guidelines suggest with a high rate of patient satisfaction.

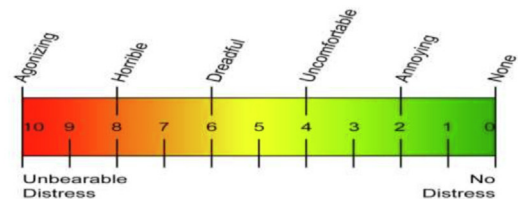
Methods

This multicenter, nonrandomized prospective observational study was approved by the Greenwich Hospital Institutional Research Board (#2019007). Patients were recruited from August 2019 to January 2022 at Orthopaedic & Neurosurgery Specialists (Greenwich, CT). Eligible patients were those who met the following criteria: procedure type of ACLR or repair; willingness to fill out the “pain journal,” ability to understand the

informed-consent process and to document informed consent before completion of any study-related procedure; and ability to read, comprehend, and complete patient-reported outcome measures in English. Patients were excluded from the study if they met any of the following criteria: pregnant; documented history of drug or alcohol abuse; known allergy or intolerance to opioids; and/or revision surgeries.

Patient age, sex, surgery laterality, graft type, and relevant concomitant procedures were recorded at enrollment. In addition, patient comorbidity factors, such as smoking status, history of depression, and previous opioid use were collected at the time of recruitment. For the purpose of this study, previous opioid use was defined as any use of opioids within a patient’s lifetime. The principal investigator (P.M.S.) or a trained, authorized site delegate performed patient eligibility assessments and patient recruitment.

Patients followed a standardized analgesic protocol (Table 1). This protocol consisted of a multimodal approach consisting of nonsteroidal anti-inflammatory drugs, acetaminophen, and opioids. Surgeons



Day 1

AM – After Waking up

VAS Pain Score	
No. of times woken up from pain	
No. of Oxycodone Taken	
No. of Other Pain Relievers Taken (type, dosage)	

8 hours – After Waking up

VAS Pain Score	
No. of Oxycodone Taken	
No. of Other Pain Relievers Taken (type, dosage)	

PM – before sleep

VAS Pain Score	
No. of Oxycodone Taken	
No. of Other Pain Relievers Taken (type, dosage)	

How satisfied were you with your pain management today? (Circle one)

1	2	3	4	5
Not at all satisfied	Not very satisfied	Neutral	Somewhat satisfied	Very satisfied

Fig 1. Day 1 of knee pain journal. Subjects were instructed to complete this page at home for each postoperative day and on postoperative visit 1. The gradient at the top of the page was provided as a reference for patients to rate their pain as a visual analog scale (VAS) pain score.

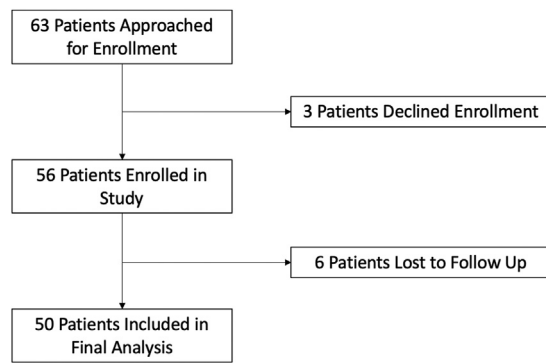


Fig 2. Flow diagram of study involvement.

instructed patients to alternate between acetaminophen and ibuprofen every four hours but not to exceed three doses of acetaminophen daily. Patients were prescribed opioid medication for breakthrough pain.

Patients were provided with a pain journal to record their postoperative data during the first 7 postoperative days (PODs) and on the first postoperative visit (Fig 1). Patients self-reported postoperative opioid consumption, nonopioid analgesic consumption, Likert scale measuring patient satisfaction, and visual analog scale (VAS) pain scores at morning, 8 hours after waking, and before sleep. The principal investigator or a trained, authorized site delegate explained to the patients how to correctly record their pain score and opioid consumption using the provided VAS. VAS responses were displayed as a dash along a 100-mm line ranging from 0 (no distress) to 10 (agonizing in pain). Following surgery, in the postanesthesia care unit, VAS scores and administered pain medication were recorded when the patient was fully alert. Patients were contacted via telephone on POD 1 to confirm adequate pain control and were reminded to complete their pain journal. Patients were instructed to return the completed pain journal to their physician at their first postoperative visit (ranging from POD 7 to 12) to complete their involvement in the study.

Data from the journal were organized in an Excel spreadsheet (Microsoft, Redmond, WA) for data analysis and evaluation. Opioid consumption was converted to milligrams of morphine equivalents (MMEs) for accurate data analysis. Statistical analysis was obtained by t-tests, analysis of variance, or χ^2 test. State databases were reviewed to ensure opioids were not obtained from any additional physicians.

Results

A total of 63 patients were assessed for eligibility in this study, 56 of whom were enrolled. Three patients declined to participate. Six patients were lost to follow-

up, and 50 patients were included in the final analysis (Fig 2). Mean subject age was 33 years (range 14-65 years). In total, 44% of patients were male and 56% were female (Table 2).

Patients were prescribed a median of 15 oxycodone 5-mg pills (range 5-15) and consumed a median of 2 pills postoperatively. Mean postoperative opioid consumption was 4.0 pills (range 0-19 pills). In total, 38% (n = 19) of patients consumed 0 opioid pills, 74% (n = 37) of patients consumed 5 or fewer opioid pills, and 96% (n = 48) of patients consumed 15 or fewer opioid pills (Fig 3). In addition, 78% (n = 39) of patients discontinued opioid use after POD 4 (Fig 4). Overall, patients consumed a mean 34% of their opioid prescriptions and 436 oxycodone 5 mg pills were not consumed.

Patients reported a mean daily VAS value of 2.8 of 10; mean satisfaction with pain management was high at 4.1 of 5 on a Likert satisfaction score. In total, 46 patients were satisfied with their pain management and 4 patients were dissatisfied—3 of these 4 had recognized comorbidities. Five patients (10%) called their physician because of pain—3 of these 5 had a recognized comorbidity.

The patient's sex did not significantly affect pain scores ($P = .63$) or opioid consumption ($P = .15$). Male

Table 2. Patient Demographics

Characteristic	n
Mean age, y	33
Sex	
Male	22
Female	28
Laterality	
Left	27
Right	23
Procedure and graft type	
ACL reconstruction	46
Hamstring	22
Patella	15
Quadriceps	8
Allograft	1
ACL repair	4
Smoking status	
Nonsmoker	45
Smoker (current or former)	5
History of depression	
No	45
Yes	5
Previous opioid usage	
No	41
Yes	9
Age, y	
14-18	11
19-24	11
25-34	5
35-44	7
45+	16

ACL, anterior cruciate ligament.

Cumulative (POD 0 - POD 14) Opioid Consumption by % of Patients

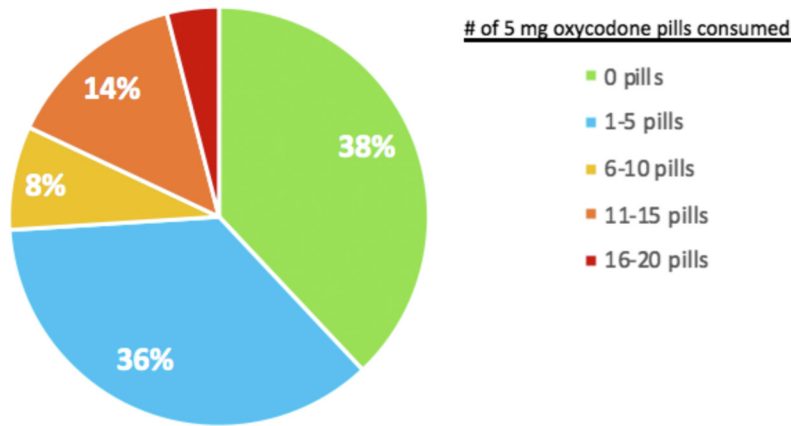


Fig 3. Opioid consumption following anterior cruciate ligament surgery. (POD, postoperative day.)

patients (n = 22) consumed an average of 2.8 ± 4.2 pills postoperatively (median = 1, range = 0-15) and reported an average VAS pain score of 2.9. Female patients (n = 28) consumed an average of 4.9 ± 5.7 pills (median = 2.5, range = 0-19) and reported an average VAS pain score of 2.7. Analysis of variance revealed that autograft type did not significantly affect opioid consumption ($P = .5$) or pain scores ($P = .48$).

Smokers (current or former) did not consume significantly more opioids ($P = .87$) and did not have worse pain scores ($P = .12$). Patients reporting a history of depression also did not consume more pills ($P = .18$) or have worse pain ($P = .92$). Patients with previous opioid use did not report worse pain ($P = .13$) but did consume significantly more opioids in the first 2 weeks postoperatively ($P = .014$). Age did not significantly

affect opioid consumption ($P = .31$). However, patients aged 25-34 years reported significantly worse pain scores than those aged 35-44 years ($P = .033$) and those 45 years and older ($P = .027$) (Table 3).

Discussion

The principal finding of this study is that 96% of patients undergoing ACL surgery adequately managed their pain control with less than or equal to 15 oxycodone 5 mg pills. Furthermore, 74% of patients consumed fewer than 5 oxycodone 5-mg pills. Despite low opioid consumption, mean pain scores remained below 3 of 10 and patient satisfaction with pain control remained high. These data suggest that using a multimodal approach to pain management with an emphasis on patient education may curb the volume of opioid

Mean Percentage of Patients Consuming Opioids and VAS Pain Scores by Post-Operative Day

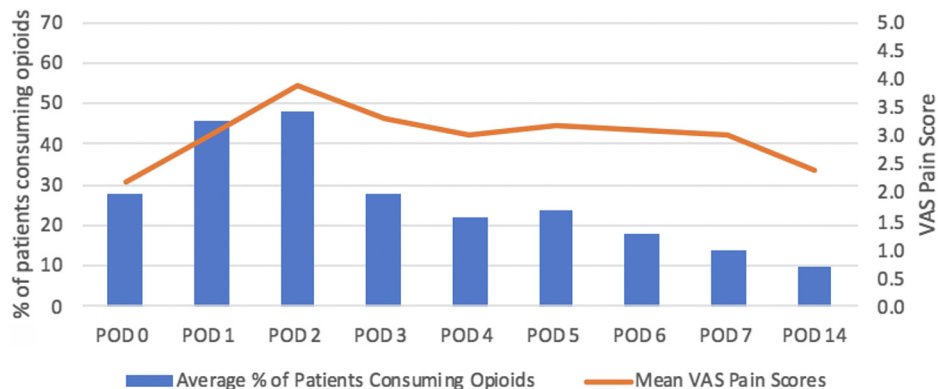


Fig 4. Mean visual analog scale (VAS) pain score and mean opioid consumption in # of 5mg oxycodone pills. (POD, postoperative day.)

Table 3. Characteristics of Patients Undergoing ACL Surgery Grouped by Mean Opioid Prescriptions and VAS Pain Score

Characteristic (n)	Opioid Consumption	P Value	VAS Score	P Value
Sex				
Male (22)	2.8	.15	2.9	.63
Female (28)	4.9		2.7	
Autograft type				
Hamstring (22)	5.3	.55	3.1	.48
Patella (15)	3.4		2.6	
Quadriceps (8)	3.6		3.4	
Smoking status				
Nonsmoker (45)	4.0	.87	2.7	.12
Smoker (current or former) (5)	3.6		3.9	
History of depression				
No (45)	3.6	.18	2.8	.92
Yes (5)	7.0		2.9	
Previous opioid usage				
No (41)	3.1	.014*	2.6	.13
Yes (9)	7.8		3.5	
Age, y				
14-18 (11)	4.0	.31	2.8	.074*
19-24 (11)	2.4		3.0	
25-34 (5)	8.4		4.6	
35-44 (7)	2.9		2.3	
45+ (16)	4.1		2.3	

ACL, anterior cruciate ligament; VAS, visual analog scale.

*Statistical significance.

pills. As such, current expert panels may be recommending an excessive volume of opioids. On the basis of our findings, we recommend that patients be prescribed no more than 15 oxycodone 5-mg tablets following ACL surgery.

It is imperative for orthopaedic surgeons to implement methods to reduce the use and misuse of opioids postoperatively. Current literature has shown the effectiveness of procedure-specific opioid prescribing guidelines regarding decreasing prescription quantities.^{12,13} This is highlighted by a retrospective review of more than 2,000 patients showing a 38% reduction in prescribed MME after guideline implementation. These authors observed a 14% reduction in opioid prescriptions for knee arthroscopy when guidelines were followed.¹³ Although guidelines have shown to reduce opioid consumption, it is important to distinguish between consensus-based guidelines and evidence-based guidelines, as they are inconsistent at the time of this study. Overton et al.⁸ convened an expert panel and recommended between 0 and 20 tablets (oxycodone 5 mg) following ACLR. To underscore the inconsistency of expert panels, Stepan et al.² proposed procedure-specific guidelines based on a consensus model. Their expert panel recommended 60 opioid pills (hydro-morphone 2 mg, oxycodone 5 mg, or hydrocodone 5 mg) after ACLR using an autograft.

Alternatively, orthopaedic surgeons can rely on observational studies to guide prescription quantities.

Moutzouros et al.¹⁴ prescribed 10 emergency oxycodone 5-mg pills in their nonopioid study. They found that patients who consumed opioids consumed 2.3 pills (7.7 MME), which equates to a 23% use rate among users. This low use rate leaves many pills available for misuse or diversion. It is important to note that 45% of patients were able to manage their pain opioid free.¹⁴ Furthermore, Hartwell et al.¹⁵ performed a randomized controlled trial in which they assessed the feasibility of reducing opioid prescriptions following ACLR. The study found that 81% of all patients managed pain successfully with 15 or fewer opioid pills. Surprisingly, the authors found that patients in the low prescription group (30 pills) consumed similar quantities of opioids when compared with the high prescription group (60 pills). This reinforces the common finding that use rates are low among current opioid prescriptions.

The findings of this present investigation are supported by Sayegh et al.,¹⁶ who reported that patients undergoing ACLR consumed a mean 15.3 pills (oxycodone 5 mg or tramadol 50 mg) when prescribed a maximum of 20 tablets. The lack of refills and short duration of opioid consumption confirmed that lower quantities of opioids are sufficient for effective postoperative pain management after ACLR. The senior author's analogous studies regarding opioid consumption after knee arthroscopy similarly validate patient satisfaction in the context of low opioid prescriptions. Kamdar et al.¹⁷ prospectively found that patients reported high satisfaction scores and low pain scores while consuming no more than 5 opioid pills following knee arthroscopy. In addition, 92% of their patients discontinued opioids by the second postoperative day.¹⁷ Our data suggest that 20 to 60 opioid pills of any type far exceed the amount of opioid medication required for adequate pain control after ACLR. Low consumption in the present study can be attributed the fact that all our patients were educated on postoperative opioid consumption, and each patient adhered to a strict multimodal analgesic protocol.

The present study demonstrates the importance of a multimodal approach in reducing patient dependence on narcotics. Keeping pain controllable in the perioperative period has many benefits such as decreased hospital stay, decreased rate of readmissions, and fewer postoperative complications.¹⁸ Before multimodal analgesia, patients relied on parenteral narcotics, which were associated with side effects such as nausea, lethargy, ileus, urinary retention, etc.¹⁸ Multimodal analgesia can target pain at multiple points in the pathway such as local tissue, nervous transmission, and perception. A retrospective review of patients undergoing ACLR found that after institution of a multimodal protocol, the mean number of opioids prescribed decreased 45% and refill requests decreased 17.8%.¹⁹

Moutzouros et al.²⁰ demonstrated in their randomized controlled trial that patients receiving a multimodal nonopioid regimen (acetaminophen, gabapentin, ketorolac, diazepam, and meloxicam) reported similar pain scores and satisfaction scores to patients in the traditional opioid group. Furthermore, studies indicate that regional anesthesia significantly reduces opioid use. In one study, perioperative opioid use was significantly reduced when receiving adductor canal blocks.²¹

Limitations

This study is not without limitations. Recording the amount of pain medication consumed may have biased patients against using pain medication. It is also possible that patients may have inaccurately reported the pills consumed since pill bottles were not collected for count at the first postoperative visit. While state databases were reviewed for external opioid prescriptions, patients may have obtained opioid medication from an outside source. Furthermore, because an a priori analysis was not completed before start of the study, the statistically insignificant findings reported in this paper might be underpowered due to sample size. Given the timeline through the early pandemic period, there were difficulties with patient recruitment. Finally, this study excluded patients with a history of narcotic dependence or revision surgeries and therefore only reflects opioid consumption patterns in individuals who are not in either circumstance.

Conclusions

This study suggests that current expert panels may be recommending an excessive volume of opioids. On the basis of our findings, we recommend that patients be prescribed no more than 15 oxycodone 5-mg pills following ACL surgery. Despite this lower-volume prescription, mean pain scores remained below 3 of 10, patient satisfaction with pain control remained high, and 67% of opiate medication prescribed was not used.

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