Arthroplasty Today 34 (2025) 101726

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

# Toward Opioid-Free Total Hip Arthroplasty: A Retrospective Study of a Targeted Opioid Reduction Program in 229 Patients

Mary L. Noyes, BA[a, b], Kamli N.W. Faour, BA[a, b], Zoë A. Walsh, MPH[b], Catherine M. Call, BA[a, b], Johanna A. Mackenzie, MPH[b], Adam J. Rana, MD[a, b, *]

[a] Tufts University School of Medicine, Boston, MA, USA
[b] MMP Orthopedics & Sports Medicine, Maine Medical Center, Portland, ME, USA

ARTICLE INFO

*Article history:*
Received 10 March 2025
Received in revised form
24 April 2025
Accepted 27 April 2025
Available online 20 June 2025

*Keywords:*
Total hip arthroplasty
Total joint arthroplasty
Opioid
Patient-reported outcome measure

ABSTRACT

*Background:* Prescription opioids leftover following arthroplasty surgery pose risks to patients and communitys. The purpose of this study was to capture opioid utilization patterns following primary total hip arthroplasty before and after a targeted intervention to decrease postoperative opioid prescription quantity. We hypothesized that reducing discharge pill count would not impact pain or functional outcomes.

*Methods:* Primary total hip arthroplasties performed by a high-volume, fellowship-trained arthroplasty surgeon between October 2022 and January 2024 were retrospectively evaluated for study inclusion; 229 patients met inclusion criteria. Beginning in April 2023, the surgeon gradually implemented a 38% reduction in postoperative opioid prescribing from 40 to 24 pills. Opioid consumption was evaluated by patient-reported pill count at the first postoperative visit. Patients were sorted into 2 groups: "preintervention" (n = 157) and "postintervention" (poI) (n = 72). Preintervention patients received between 300 and 420 oral morphine equivalents and poI patients received between 240 and 299.99 oral morphine equivalents. Demographics, pill counts, refills, 30-day emergency department visits, function (Hip Disability and Osteoarthritis Outcome Score Joint Replacement), pain (visual analog scale), and satisfaction scores were analyzed.

*Results:* Proportion of discharge prescription remaining at 2-week postoperative visit did not differ significantly between intervention groups ($P = .33$). There were no differences in opioid refill requests ($P = .82$), function ($P = .75$), or satisfaction with functional improvement ($P = .61$). Patients in the poI group reported lower pain at 6 weeks postoperatively ($P < .05$). There were no differences in 30-day emergency department visits between groups ($P = .57$).

*Conclusions:* Results support that arthroplasty surgeons can prescribe smaller quantities of opioids without compromising care. Such interventions can help reduce the number of prescription opioids available for misuse and diversion.



## Introduction

Despite policy shifts and public health interventions, the opioid epidemic persists with devastating outcomes [1]. Opioid analgesics are commonly prescribed following surgical interventions, and despite their association with adverse effects, remain highly used for their effective management of acute postoperative pain [2]. Prior studies have shown that large quantities of unused opioids are retained by patients following surgical recovery [3]. Although these medications can provide short-term benefit to patients by reducing pain and increasing ability to participate in postoperative physical therapy, the risks of abuse and diversion should not be ignored. Studies suggest that more than 50% of misused opioids come from the leftover prescriptions obtained from a friend or family member's supply [4]. Between 1999 and 2021, nearly 280,000 people within the United States died from opioid overdose involving prescription medications [5]. By 2021, the number of deaths had increased to nearly 5 times the number reported in 1999 [5].

* Corresponding author. Division of Joint Replacement, MMP Orthopedics & Sports Medicine, 5 Bucknam Road Suite 1D, Falmouth, ME 04105, USA. Tel.: +1 207 781 1551.
*E-mail address:* adam.rana@mainehealth.org

https://doi.org/10.1016/j.artd.2025.101726

In addition to the dangers posed by the diversion of leftover opioids, greater quantities of opioids prescribed postoperatively have been associated with increased opioid utilization [6-8]. Higher postsurgical consumption may be a contributor to long-term opioid usage and the development of opioid use disorder [9-11]. Findings suggest that a number of opioid-naive patients become chronic opioid users after postoperative exposure, including 4% of total hip arthroplasty (THA) patients and 8% of total knee arthroplasty patients [9,10,12-14]. Orthopaedic surgeons are the third highest prescribers of opioids among physicians, accounting for between 7.7% and 8.8% of opioid prescriptions in the United States [15]. Given that primary THA is one of the most common elective surgeries performed, with an estimated annual procedure volume ranging from 572,000 to 633,000 by 2030 [16-18], opioids prescribed following THA likely account for a significant number of pills and offer a clear area for study and intervention within the field of arthroplasty and medicine [19-21]. The purpose of this study was to evaluate the efficacy of a targeted opioid reduction intervention to decrease opioids available for misuse and diversion following THA. We hypothesized that a decrease in postoperative oral morphine equivalents (OMEs) prescribed to patients for pain management could reduce opioid retention without an increase in pain, 30-day emergency department (ED) visits, refills, or a decrease in functional outcomes.

## Material and methods

### *Study parameters*

All elective primary THA procedures performed by a single high-volume, fellowship-trained orthopaedic surgeon at our institution between October 2022 and January 2024 were retrospectively evaluated for study eligibility based on the inclusion and exclusion criteria detailed in Figure 1. All patients received a multimodal analgesic protocol standard to our institution, outlined in Supplemental Table 1.

Beginning in April 2023, a quality improvement initiative was undertaken to reduce the standard postoperative opioid prescription from 420 OMEs to 240 OMEs. This change occurred over a period of months as the surgeon and advanced practice provider team updated their protocols. Per institutional protocol, opioids for postoperative pain management were prescribed by an advanced practice provider associated with the surgeon at the preoperative history and physical appointment. This study originated as a quality improvement initiative and was deemed exempt on institutional review board review.

Patients were sorted into 2 groups based on their discharge opioid quantity for analysis: preintervention (prI) (n = 157) and postintervention (poI) (n = 72). prI patients received between 300 and 420 OMEs and poI patients received between 240 and 299.99 OMEs. Patients prescribed outlier doses of 20-150 morphine milligram equivalents (MMEs) (n = 6) and 180 MMEs (n = 1) were excluded. Primary outcomes of interest were postoperative opioid utilization, pain, and function. Secondary outcomes of interest included patient satisfaction and 30-day ED visits. Demographic, operative, and hospital data were obtained from the institutional electronic medical record, including age, sex, body mass index, and Charlson Comorbidity Index. Operative variables collected included procedure duration, length of stay, transfusion, and occurrence of intraoperative complications. Hospital-reported outcomes captured ED visits within 30 days of the initial procedure. Patient-reported outcome measures were obtained from the electronic

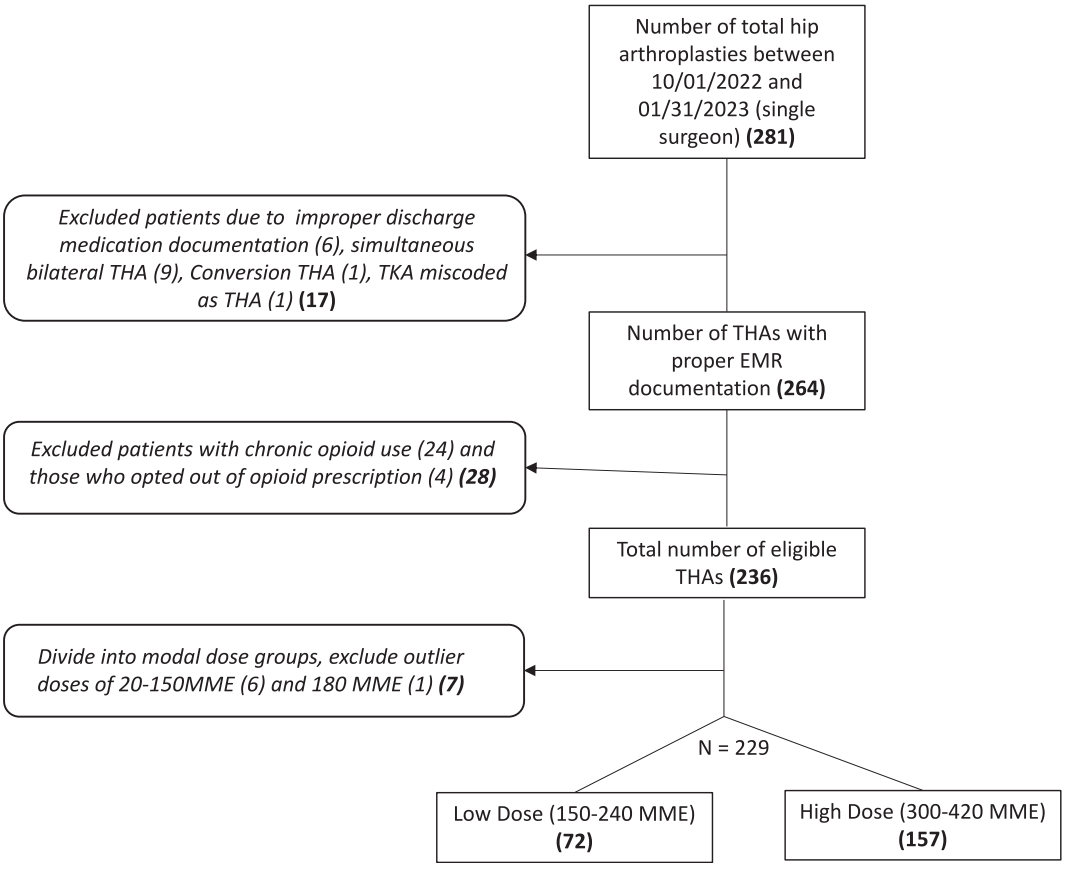


**Figure 1.** Study inclusion and exclusion criteria.

medical record and included the visual analog scale pain score and Hip Disability and Osteoarthritis Outcome Score Joint Replacement (HOOS JR) functional score at the preoperative and 6-week postoperative timepoints. Satisfaction scores evaluating pain relief, functional improvement, meeting of expectations, and surgeon satisfaction were collected at 6 weeks postoperatively. Opioid utilization data included discharge opioid prescription, 2-week postoperative pills remaining count, and postoperative opioid refill requests within 2 weeks of the initial procedure.

### *Data analysis*

All outcomes were assessed with respect to discharge OME. Pearson's Chi-square test and Fisher's exact test were used to determine statistical significance between proportions. The Mann-Whitney U test was used when comparing sample means. A threshold of $P < .05$ was considered significant. A power analysis was conducted to evaluate the adequacy of the sample size for detecting differences in the consumption of 200 or more MMEs following THA between the prI and poI groups. The analysis was based on a 2-sided confidence interval of 95%. The power of the study was calculated using both normal approximation and normal approximation with continuity correction, resulting in power estimates of 82.27% and 76.46%, respectively. All analyses were performed using R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria).

## Results

### *Patient demographics*

A total of 229 primary THA cases were included in this study (Table 1). There was no significant difference in mean age ($P = .20$), body mass index ($P = .24$), sex ($P = 1.00$), mean updated Charlson Comorbidity Index ($P = .52$), mean preoperative HOOS JR interval score ($P = .06$), or mean preoperative pain ($P = .21$) between groups. Private health insurance was the predominant healthcare coverage type (79%), with comparable distributions of Medicare and Medicaid between intervention groups.

### *Operative and hospital data*

Few differences in operative and hospital variables were observed between groups (Table 2). Mean length of procedure ($P = .98$, 39-149), intraoperative MMEs ($P = .61$, 0-116.5), postoperative care unit MME ($P = .69$, 0-134), and postoperative length of stay ($P = .62$, 5.6-102.5) were not significantly different between prI and poI groups. There were no significant differences in discharge disposition. Patient-reported predischarge pain scores ($P = .03$, 0-9) differed between groups, with those in the prI group reporting higher pain scores than those in the poI group (Table 3).

### *Opioid usage*

Between 2022 and 2024, mean discharge opioid quantity was reduced by 43% from 318.69 OMEs to 182.67 OMEs (Fig. 2). Mean proportion of pills remaining at the 2-week postoperative visit was unchanged between groups ($P = .33$) (Table 3). Notably, postoperative pill count data at 2 weeks were only available for 158 of 229 patients (69%) in the cohort. Further analysis comparing patients with and without 2-week pill count data revealed no significant differences in demographics (Supplemental Table 2). Narcotic refill request rates did not differ between groups ($P = .82$) (Table 3).

**Table 1**
Cohort demographics.

| Characteristic | Overall N = 229 | Preintervention N = 157 | Postintervention N = 72 | *P* value |
|---|---|---|---|---|
| Age (mean ± SD) | 66.2 ± 11.0 | 65.6 ± 11.4 | 67.6 ± 10.2 | .20 |
| Sex (n, % women) | 135 (58.9%) | 93 (59.2%) | 42 (58.3%) | 1.00 |
| Race (n, %) | | | | |
| American Indian and Alaska Native | 1 (0.4%) | 1 (0.6%) | 0 (0.0%) | - |
| Asian | 1 (0.4%) | 1 (0.6%) | 0 (0.0%) | - |
| Black or African American | 1(0.4%) | 1 (0.6%) | 0 (0.0%) | - |
| Multiracial | 2 (0.9%) | 1 (0.6%) | 1 (1.4%) | - |
| Native Hawaiian and Other Pacific Islander | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | - |
| White or Caucasian | 222 (96.9%) | 151 (96.2%) | 71 (98.6%) | - |
| Declined, other, unknown | 2 (0.9%) | 2 (1.3%) | 0 (0.0%) | - |
| Ethnicity | | | | |
| Hispanic | 1 (0.4%) | 1 (0.6%) | 0 (0.0%) | - |
| Non-Hispanic | 225 (98.3%) | 153 (97.5%) | 72 (100%) | - |
| Declined, unknown | 3 (1.3%) | 3 (1.9%) | 0 (0.0%) | - |
| BMI (mean ± SD) | 29.2 ± 5.6 | 29.5 ± 5.7 | 28.5 ± 5.3 | .24 |
| BMI category | | | | |
| Underweight | 2 (0.9%) | 2 (1.3%) | 0 (0.0%) | .84 |
| Healthy weight | 53 (23.1%) | 35 (15.3%) | 18 (7.9%) | .77 |
| Overweight | 81 (35.4%) | 52 (33.1%) | 29 (40.3%) | .37 |
| Obese | 89 (38.9%) | 67 (42.7%) | 22 (30.6%) | .11 |
| CCI (mean ± SD) | 0.3 ± 0.8 | 0.2 ± 0.7 | 0.3 ± 0.9 | .52 |
| Insurer category | | | | |
| Government | 47 (20.5%) | 30 (19.1%) | 17 (23.6%) | .54 |
| Private | 181 (79.0%) | 126 (80.3%) | 55 (76.4%) | .62 |
| Workers comp | 1 (0.4%) | 1 (0.6%) | 0 (0.0%) | 1.00 |
| Preoperative diagnosis | | | | |
| DJD/OA | 228 (99.6%) | 157 (100%) | 71 (98.6%) | - |
| ON | 1 (0.4%) | 0 (0.0%) | 1 (1.4%) | - |
| Fracture | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | - |
| ASA rating (mean ± SD) | 2.2 ± 0.5 | 2.2 ± 0.5 | 2.2 ± 0.4 | .86 |

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson Comorbidity Index; DJD, degenerative joint disease; OA, osteoarthritis; ON, osteonecrosis; SD, standard deviation.

**Table 2**
Postoperative variables.

| Characteristic | Overall N = 229 | Preintervention N = 157 | Postintervention N = 72 | *P* value |
|---|---|---|---|---|
| Anesthesia | | | | |
| General | 229 (100%) | 157 (100%) | 72 (100%) | 1.00 |
| Anesthesia time (min) (mean ± SD) | 93.3 ± 15.2 | 94.6 ± 17.1 | 90.6 ± 9.5 | .16 |
| Procedure duration (min) (mean ± SD) | 54.5 ± 13.1 | 55.2 ± 15.2 | 52.9 ± 6.3 | .98 |
| Room duration (min) (mean ± SD) | 84.8 ± 14.2 | 89.1 ± 16.2 | 85.1 ± 7.8 | .17 |
| Mean length of stay (h) (mean ± SD) | 15.7 ± 11.1 | 15.4 ± 11.3 | 16.3 ± 11.0 | .62 |
| Cemented (yes) | 1 (0.4%) | 1 (0.6%) | 0 (0.0%) | - |
| EBL (mL) | 28.7 | 27.9 | 30.6 | .69 |
| Blood transfusion (yes) | 0 | 0 | 0 | - |
| Intraoperative MME | 44.9 | 45.8 | 43.2 | .61 |
| PACU MME | 32.2 | 31.9 | 32.8 | .69 |

EBL, estimated blood loss; MME, morphine milligram equivalent; PACU, postoperative care unit; SD, standard deviation.

*Outcomes*

Complication rates were similarly low between prI and poI cohorts ($P = 1.00$) (Table 3). There was no change in ED visit rates ($P = .57$), readmission rates ($P = 1.00$), or infection rates ($P = 1.00$) between intervention groups.

Mean 6-week postoperative HOOS JR interval score for function ($P = .75$), 6-week satisfaction of functional improvement ($P = .61$), 6-week satisfaction of pain relief ($P = .71$), and 6-week satisfaction with meeting expectations ($P = .62$) did not differ between groups. Mean 6-week surgeon satisfaction also remained unchanged ($P = .29$). Mean 6-week pain as measured by the visual analog scale was significantly lower in the poI group than in the prI group ($P = .05$) (Table 4).

## Discussion

*Trends in opioid prescription usage*

Our data demonstrate that on average, patients consumed far fewer OMEs than prescribed for postoperative THA pain management, even when given smaller prescription. The results of our present single-surgeon, single-institution study build on a growing body of orthopaedic literature reporting on postoperative opioid prescribing patterns as an area for improvement. Premkumar et al found that following total knee arthroplasty, approximately two-thirds of patients had leftover opioids [22]. Bhashyam et al evaluated opioid use after foot and ankle procedures and found that patients only used a mean of 47.6% of their prescribed postsurgical opioid pills [23]. Sports medicine literature reveals a similar pattern, with studies reporting that adult and pediatric patients undergoing sports orthopaedic surgery are prescribed 2.5-3 times the number of pills used [24]. Our findings similarly implicate discharge prescription quantity as an area for targeted interventions to decrease opioid misuse and diversion.

*Noninferior outcomes between intervention groups 6 weeks postoperatively*

In our small cohort study, functional and satisfaction scores were not significantly different between intervention groups at the 6-week postoperative timepoint. Notably, the poI cohort reported significantly less pain than the prI cohort ($P = .05$). There was no increase in refill requests or 30-day ED visits observed among the poI cohort. These findings suggest that patients experience noninferior outcomes when prescribed lower quantities of postoperative opioids. Previous work has shown no association between the quantity of postoperative pain medication prescribed and patient satisfaction or refill requests [7,21,25]. Our findings help refute the concern that reduced opioid prescribing may be associated with increased patient pain, lower patient satisfaction, increased refill requests, and higher rates of emergency services utilization for inadequate pain control.

Previous studies have found that patients who are prescribed more opioids tend to consume more, and our findings are consistent with this occurrence [6,7,25]. On average, patients consumed 36% of their prescription regardless of whether they were in the prI or poI group. Additionally, the poI group reported lower postoperative pain. These results support that a reduction in opioid prescribing, when used in conjunction with multimodal analgesia strategies, can decrease opioid usage, increase satisfaction, and enhance early recovery [26-28]. The finding of lower pain at 6 weeks is noteworthy and suggests the possibility that minimal opioid protocols are not only noninferior but perhaps superior to more opioid-centric musculoskeletal pain management regimens. Similar results were reported in a recent randomized controlled trial of 315 patients randomized to an opioid-sparing or opioid-

**Table 3**
Postoperative variables.

| Characteristic | Overall N = 229 | Preintervention N = 157 | Postintervention N = 72 | *P* value |
|---|---|---|---|---|
| Any refill requests | 32 | 23 | 9 | .82 |
| Consumed 200+ MME | 25 (15.8%) | 22 (20.8%) | 3 (5.8%) | **.02** |
| Proportion of postoperative prescription remaining | 64% | 66% | 60% | .33 |
| Any complication | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 1.00 |
| ED visit within 30 d | 2 (0.9%) | 1(0.6%) | 1 (1.4%) | .57 |
| Readmission within 90 d | 1 (0.4%) | 1(0.6%) | 0 (0.0%) | 1.00 |
| 90-d infection rate, n (%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 1.00 |

ED, emergency department; MME, morphine milligram equivalent.
For all analyses, significant values in bold and defined as $P < .05$.

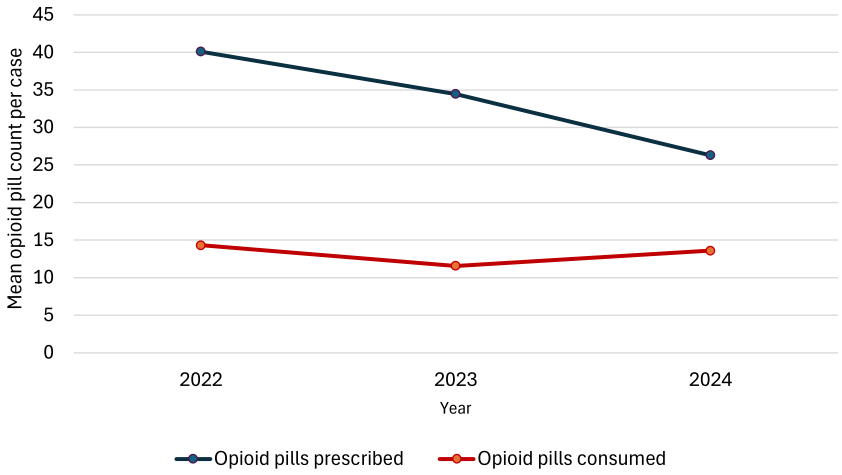


**Figure 2.** Mean discharge opioid quantity of study participants between 2022 and 2024.

containing regimen across 5 common orthopaedic procedures (primary single-level or 2-level anterior cervical discectomy and fusion or anterior cervical discectomy and arthroplasty for degenerative disease, primary first carpal metacarpal arthroplasty, primary hallux valgus or hallux rigidus correction, elective primary total shoulder or reverse total shoulder arthroplasty, and primary THA), with findings that pain levels were significantly lower in the opioid-free group at 12 hours and 2 weeks postoperatively [29]. Such findings build on the earlier work of Jolissaint et al within the shoulder literature who reported shoulder arthroplasty patients on an opioid-free regimen had significantly lower pain scores at 12 hours, 24 hours, and 2 weeks postoperatively compared to those on a traditional opioid-containing regimen [30]. It remains unclear what is driving this observed reduction in pain; whether it is impacted by greater patient education among those in the opioid-sparing groups, differences in patient pain expectations between patient groups or other variables thus far unaccounted for. Multimodal analgesia methods are currently used in our practice (Supplemental Table 1), and our findings suggest that further reducing opioid quantity in the setting of synergistic modalities may positively impact pain control and highlight the role for future work in this area of study.

### *Limitations*

Data from a single high-volume arthroplasty surgeon at a single institution were included, limiting the generalizability of the results to other settings and patient populations. The power analysis indicated that the study had sufficient power (82.27% using normal approximation and 76.46% with continuity correction) to detect a significant difference in MME consumption between the prI and poI groups. However, the study is limited by the relatively small sample size of the poI group, which may affect the generalizability of the findings. Survey studies such as this one may be influenced by the inaccurate recall of opioid utilization (recall bias); the social stigma surrounding opioid use may influence patients to report lower utilization. In addition, 17% of the patients eligible for inclusion in our study were excluded (Fig. 1), with reasons for exclusion including improper discharge medication documentation, miscoding, chronic opioid use, and outlier opioid use. Despite demographic variables showing no significant differences between patients with postoperative pill count data available and those without, postoperative pill counts were only available for 69% of the study cohort. There is the possibility the collected pill count data are misrepresentative of the larger group. No distinction was made between opioid-naive and opioid-tolerant patients, although research demonstrates that the required opioid dosage for adequate pain control varies depending on opioid tolerance, and future studies would benefit from considering this variable [31]. Future studies should aim to include larger sample sizes and objective measures of MME consumption to enhance the robustness and reliability of the results.

**Table 4**
Patient-reported outcome measures.

| Characteristic | Overall N = 229 | Preintervention N = 157 | Postintervention N = 72 | *P* value |
|---|---|---|---|---|
| Function | | | | |
| Mean preoperative HOOS JR interval score | 51.2 | 49.1 | 54.1 | .06 |
| Mean 6-wk HOOS JR interval score | 75.8 | 74.9 | 76.9 | .75 |
| Pain | | | | |
| Mean preoperative pain overall | 5.7 | 6.0 | 5.4 | .21 |
| Mean predischarge pain score | 3.1 | 3.3 | 2.7 | **.03** |
| Mean 6-wk pain overall | 2.2 | 2.6 | 1.7 | **.046** |
| Satisfaction | | | | |
| Average of 6-wk satisfaction functional improvement | 8.4 | 8.4 | 8.4 | .61 |
| Average of 6-wk satisfaction met expectations | 8.6 | 8.5 | 8.8 | .62 |
| Average of 6-wk satisfaction pain relief | 8.7 | 8.6 | 8.8 | .86 |
| Average of 6-wk satisfaction surgeon | 9.8 | 9.9 | 9.7 | .29 |

HOOS JR, Hip Disability and Osteoarthritis Outcome Score Joint Replacement.
For all analyses, significant values in bold and defined as $P < .05$.

## Conclusions

After 2-week postoperative pill counts revealed a persistently high volume of residual opioid medication following primary THA, a targeted intervention to decrease standard postoperative opioid prescribing was implemented, reducing OME from 420 to 240. There were no unintended effects of opioid reduction; worsened pain, decreased function or satisfaction, increased refills, or more ED visits were not observed. Importantly, the poI group reported significantly less pain at the 6-week postoperative timepoint. These findings suggest that arthroplasty surgeons may be able to prescribe smaller quantities of opioid pills for postoperative pain management following THA without compromising patient outcomes. Such interventions should be considered to reduce opioid misuse and diversion in our communities.

## Conflicts of interest

Adam Rana received royalties from Smith & Nephew; received speakers bureau/paid presentations for Smith & Nephew; is a paid consultant for Smith & Nephew; and is a board member of the Eastern Orthopaedic Association and AAHKS. All other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2025.101726.

## CRediT authorship contribution statement

**Mary L. Noyes:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Kamli N.W. Faour:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation. **Zoë A. Walsh:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis, Data curation. **Catherine M. Call:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis. **Johanna A. Mackenzie:** Writing – review & editing, Visualization, Methodology, Investigation, Formal analysis, Data curation. **Adam J. Rana:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Data curation, Conceptualization.

## References

[1] Scholl L, Seth P, Kariisa M, Wilson N, Baldwin G. Drug and opioid-involved overdose deaths—United States, 2013–2017. Morb Mort Wkly Rep 2019;67:1419.
[2] Shanthanna H, Ladha KS, Kehlet H, Joshi GP. Perioperative opioid administration. Anesthesiology 2021;134:645–59.
[3] Bicket MC, Long JJ, Pronovost PJ, Alexander GC, Wu CL. Prescription opioid analgesics commonly unused after surgery: a systematic review. JAMA Surg 2017;152:1066–71.
[4] Lipari RN, Hughes A. How people obtain the prescription pain relievers they misuse. Rockville (MD): Substance Abuse And Mental Health Services Administration (US); 2013.
[5] Wide-ranging online data for epidemiologic research (WONDER). Atlanta, GA: CDC: National Center for Health Statistics; 2022.
[6] Howard R, Fry B, Gunaseelan V, Lee J, Waljee J, Brummett C, et al. Association of opioid prescribing with opioid consumption after surgery in Michigan. JAMA Surg 2019;154:e184234.
[7] Bateman BT, Cole NM, Maeda A, Burns SM, Houle TT, Huybrechts KF, et al. Patterns of opioid prescription and use after cesarean delivery. Obstet Gynecol 2017;130:29–35.
[8] Osmundson SS, Raymond BL, Kook BT, Lam L, Thompson EB, Schornack LA, et al. Individualized compared with standard post-discharge oxycodone prescribing after cesarean birth: a randomized controlled trial. Obstet Gynecol 2018;132:624.
[9] Brummett CM, Waljee JF, Goesling J, Moser S, Lin P, Englesbe MJ, et al. New persistent opioid use after minor and major surgical procedures in US adults. JAMA Surg 2017;152:e170504.
[10] Sun EC, Darnall BD, Baker LC, Mackey S. Incidence of and risk factors for chronic opioid use among opioid-naive patients in the postoperative period. JAMA Intern Med 2016;176:1286–93.
[11] Brat GA, Agniel D, Beam A, Yorkgitis B, Bicket M, Homer M, et al. Postsurgical prescriptions for opioid naive patients and association with overdose and misuse: retrospective cohort study. BMJ 2018;360:j5790.
[12] Alam A, Gomes T, Zheng H, Mamdani MM, Juurlink DN, Bell CM. Long-term analgesic use after low-risk surgery: a retrospective cohort study. Arch Intern Med 2012;172:425–30.
[13] Clarke H, Soneji N, Ko DT, Yun L, Wijeysundera DN. Rates and risk factors for prolonged opioid use after major surgery: population based cohort study. BMJ 2014;348:g1251.
[14] Goesling J, Moser SE, Zaidi B, Hassett AL, Hilliard P, Hallstrom B, et al. Trends and predictors of opioid use following total knee and total hip arthroplasty. Pain 2016;157:1259.
[15] Trasolini NA, McKnight BM, Dorr LD. The opioid crisis and the orthopedic surgeon. J Arthroplasty 2018;33:3379–3382.e1.
[16] Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. JBJS 2007;89:780–5.
[17] Sloan M, Premkumar A, Sheth NP. Projected volume of primary total joint arthroplasty in the US, 2014 to 2030. JBJS 2018;100:1455–60.
[18] Kurtz S, Mowat F, Ong K, Chan N, Lau E, Halpern M. Prevalence of primary and revision total hip and knee arthroplasty in the United States from 1990 through 2002. JBJS 2005;87:1487–97.
[19] Howard R, Waljee J, Brummett C, Englesbe M, Lee J. Reduction in opioid prescribing through evidence-based prescribing guidelines. JAMA Surg 2018;153:285–7.
[20] Brown CS, Vu JV, Howard RA, Gunaseelan V, Brummett CM, Waljee J, et al. Assessment of a quality improvement intervention to decrease opioid prescribing in a regional health system. BMJ Qual Saf 2021;30:251–9.
[21] Roberts KC, Moser SE, Collins AC, McCardel BR, Schultz KA, Schaffer NE, et al. Prescribing and consumption of opioids after primary, unilateral total hip and knee arthroplasty in opioid-naive patients. J Arthroplasty 2020;35:960–965.e1.
[22] Premkumar A, Lovecchio F, Stepan J, Sculco P, Jerabek S, Della Valle AG, et al. Characterization of opioid consumption and disposal patterns after total knee arthroplasty. Bone Jointt J 2019;101(Supple_C):98–103.
[23] Bhashyam AR, Keyser C, Miller CP, Jacobs J, Bluman E, Smith JT, et al. Prospective evaluation of opioid use after adoption of a prescribing guideline for outpatient foot and ankle surgery. Foot Ankle Int 2019;40:1260–6.
[24] Capelle JM, Reddy PJ, Nguyen AT, Israel HA, Kim C, Kaar SG. A prospective assessment of opioid utilization post-operatively in orthopaedic sports medicine surgeries. Arch Bone Joint Surg 2021;9:503.
[25] Sekhri S, Arora NS, Cottrell H, Baerg T, Duncan A, Hu HM, et al. Probability of opioid prescription refilling after surgery: does initial prescription dose matter? Ann Surg 2018;268:271–6.
[26] Lamplot JD, Wagner ER, Manning DW. Multimodal pain management in total knee arthroplasty: a prospective randomized controlled trial. J Arthroplasty 2014;29:329–34.
[27] Maheshwari AV, Blum YC, Shekhar L, Ranawat AS, Ranawat CS. Multimodal pain management after total hip and knee arthroplasty at the Ranawat Orthopaedic Center. Clin Orthop Relat Res 2009;467:1418–23.
[28] Peters CL, Shirley B, Erickson J. The effect of a new multimodal perioperative anesthetic regimen on postoperative pain, side effects, rehabilitation, and length of hospital stay after total joint arthroplasty. J Arthroplasty 2006;21:132–8.
[29] Turk R, Averkamp B, Hietpas K, Michalek C, Leas D, Odum SM, et al. An opioid-free perioperative pain protocol is noninferior to opioid-containing management: a randomized controlled trial. J Bone Joint Surg Am 2025;107:665–77.
[30] Jolissaint JE, Scarola GT, Odum SM, Leas D, Hamid N, Chapman TM, et al. Opioid-free shoulder arthroplasty is safe, effective, and predictable compared with a traditional perioperative opiate regimen: a randomized controlled trial of a new clinical care pathway. J Shoulder Elbow Surg 2022;31:1499–509.
[31] Patanwala AE, Jarzyna DL, Miller MD, Erstad BL. Comparison of opioid requirements and analgesic response in opioid-tolerant versus opioid-naïve patients after total knee arthroplasty. Pharmacotherapy. J Hum Pharmacol Drug Ther 2008;28:1453–60.

**Supplemental Table 1**
Multimodal analgesic protocol for total hip arthroplasty.

| Timing | Primary THA |
|---|---|
| Night before procedure | • Pregabalin 75 mg, PO |
| Morning of procedure | • Acetaminophen 1000 mg, PO |
| Preoperative holding bay | • Oxycontin 10 mg, PO |
| Intraoperative management | • Dexamethasone 10 mg<br>• Limited opioid use |
| Postoperative | • Acetaminophen 1000 mg, PO, every 8 h<br>• Celecoxib 200 mg, every 12 h for 14 d<br>• Pregabalin 50 mg (if > 70 y old) or 75 mg (if < 70 y old) every 12 h for 3 d<br>• Oxycodone 5 mg tablets, PO, 1-2 tablets PRN for breakthrough pain up to every 4 h, maximum 6 tablets per day |
| Postoperative standard opioid script | • Oxycodone 5 mg, 24 pills |

PO, per os; PRN, pro re nata; THA, total hip arthroplasty.

**Supplemental Table 2**
Comparison of demographics between patients with postoperative pill consumption data available and patients without postoperative pill data available.

| Characteristic | Has postoperative pill count data, N = 158 | Missing postoperative pill count data, N = 71 | P value |
|---|---|---|---|
| Intervention group (% of group) | | | |
| Preintervention | 106 (67.5%) | 51 (32.5%) | .54 |
| Postintervention | 52 (72.2%) | 20 (27.8%) | |
| Age (mean ± SD) | 65.49 ± 10.8 | 67.88 ± 11.4 | .08 |
| Sex (n, % women) | 89 (56.3%) | 46 (64.8%) | .25 |
| Race (n, %) | | | |
| American Indian and Alaska Native | 1 (0.6%) | 0 (0.0%) | .54 |
| Asian | 1 (0.6%) | 0 (0.0%) | |
| Black or African American | 0 (0.0%) | 1 (1.4%) | |
| Multiracial | 2 (1.3%) | 0 (0.0%) | |
| Native Hawaiian and Other Pacific Islander | 0 (0.0%) | 0 (0.0%) | |
| White or Caucasian | 153 (96.8%) | 69 (97.2%) | |
| Declined, other, unknown | 1 (0.6%) | 1 (1.4%) | |
| Ethnicity | | | |
| Hispanic | 1 (0.6%) | 0 (0.0%) | .78 |
| Non-Hispanic | 155 (98.1%) | 70 (98.6%) | |
| Declined, unknown | 2 (1.3%) | 1 (1.4%) | |
| BMI (mean ± SD) | 29.51 ± 5.6 | 28.39 ± 5.5 | .14 |
| CCI (mean ± SD) | 0.27 ± 0.8 | 0.25 ± 0.7 | .75 |
| Insurer category | | | |
| Government | 30 (19.0%) | 17 (23.9%) | .64 |
| Private | 127 (80.4%) | 54 (76.1%) | |
| Workers comp | 1 (0.6%) | 0 (0.0%) | |
| Preoperative diagnosis | | | |
| DJD/OA | 157 (99.4%) | 71 (98.6%) | 1.00 |
| ON | 1 (0.6%) | 0 (0.0%) | |
| Fracture | 0 (0.0%) | 0 (0.0%) | |
| ASA rating (mean ± SD) | 2.19 ± 0.5 | 2.18 ± 0.4 | .87 |

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson Comorbidity Index; DJD, degenerative joint disease; OA, osteoarthritis; ON, osteonecrosis; SD, standard deviation.