Research Article

Application and Analysis of the Enhanced Recovery After Surgery Opioid Prescription Protocol in Arthroscopy and Arthroplasty Patients

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ABSTRACT

Introduction: Surgery and postoperative opioid prescriptions are critical periods for potential drug dependence and diversion. Enhanced recovery after surgery (ERAS) pathways aim to improve patient outcomes by leveraging preoperative education, emphasizing nonopioid pain management, and using less invasive surgical techniques. The study hypothesis was that the use of ERAS pathways would decrease postoperative opioid prescribing after arthroscopy and arthroplasty surgeries.

Methods: A retrospective chart review was conducted on patients treated by 11 orthopaedic surgeons at 9 Iowa hospitals from November 2022 to March 2024. Patients were divided into arthroplasty (n = 67) and arthroscopy (n = 33) cohorts. Opioids prescribed before and after ERAS implementation were measured and converted to morphine milligram equivalents (MMEs). Statistical analyses included the Wilcoxon signed rank test, Mann-Whitney *U* test, and chi-squared test.

Results: The mean pre-ERAS prescription size was 389 MMEs (range: 140 to 900 MMEs) for the overall cohort postoperatively, with arthroplasty at 451 MMEs (range: 200 to 900 MMEs) and arthroscopy at 264 MMEs (range: 140 to 450 MMEs). After ERAS, the overall mean size dropped to 194 MMEs (range: 38 to 600 MMEs), with arthroplasty at 210 MMEs (range: 38 to 600 MMEs) and arthroscopy at 161 MMEs (range: 45 to 315 MMEs). Both cohorts saw significant reductions, with a mean 47% reduction in arthroplasty and a mean 33% reduction in arthroscopy (both $P < 0.001$). Statistical analysis found percent reduction of prescription size to be greater in the arthroplasty cohort than in the arthroscopy cohort ($P < 0.001$). Arthroscopy patients had a higher mean percentage of MMEs prescribed leftover (60%) compared with arthroplasty patients (27%; $P < 0.001$).

Conclusion: The study hypothesis was upheld as ERAS pathways resulted in a notable reduction in prescribing of opioids postoperatively

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after both arthroplasty and arthroscopic surgeries. ERAS pathways should continue to be tailored and studied to improve postoperative recovery while decreasing the reliance on opioids postoperatively for pain management.

Fast-track postsurgical recovery first emerged in the 1990s as the concept of using multimodal interventions to minimize stress response and demands on organ function during surgery.[1] Subsequently, "enhanced recovery after surgery" (ERAS) pathways have been developed as a way to decrease postoperative opioid reliance and increase patient outcomes by leveraging preoperative education, emphasizing nonopioid pain management, and using less invasive surgical techniques. Components of these strategies have already shown promise in improving costs of care, length of hospital stay, and postoperative complication rates.[2-6] Although not as extensive as current ERAS data in colorectal and cardiac surgery, for which these pathways were first developed, there is increasing evidence supporting the benefits of ERAS pathways in orthopaedic surgery as well.[7–13]

Particularly, patients in this study received care guided by Goldfinch Health's ERAS pathways. These pathways were proposed as part of the Billion Pill Pledge Program, an initiative to eliminate the overprescribing of opioids postoperatively in the state of Iowa. Goldfinch Health's Billion Pill Pledge ERAS pathways are currently implemented in numerous hospitals across the state of Iowa. Orthopaedic surgery in particular has been identified as a surgical specialty with a trend of overprescribing opioids postoperatively.[14–18]

The goal of this study was to compare the efficacy of ERAS pathways in arthroplasty patients versus arthroscopy patients, two of the most common types of orthopaedic surgeries performed.[19-21] The study hypothesis was that the use of ERAS pathways would decrease postoperative opioid prescribing after both arthroscopy and arthroplasty surgeries.

Methods

Patient Selection

After obtaining institutional review board approval, a retrospective chart review was conducted on patients treated by 11 fellowship-trained board-certified orthopaedic surgeons from November 2022 to March 2024 at nine hospitals in Iowa using the ERAS pathways. This study screened a deidentified database of surgical patients provided by hospitals partnered with a third-party company as part of the Billion Pill Pledge Program (Goldfinch Health). Patients aged 18 to 80 years who underwent either joint arthroplasty or arthroscopic procedures and had complete data on postoperative opioid prescription/consumption were included in the analysis.

Measuring Opioid Quantities

For each patient, a pre-ERAS data set and a post-ERAS data set were extracted from the screened database. Pre-ERAS data were a physician estimate of the opioid quantity the patient would have hypothetically received before ERAS pathway implementation. These estimates were made by the surgeons treating each respective patient based on their pre-ERAS practice habits specific to each procedure. Post-ERAS data were patient-reported data, which measured the actual quantities of postoperative opioids prescribed to them in the period after ERAS protocol implementation. Opioid consumption data were collected only in the post-ERAS data set. As per hospital standing orders updated in accordance with Billion Pill Pledge guidelines, opioid consumption data had been collected routinely by nursing staff by way of patient follow-up over the phone. Variables measured included prescribed quantity, quantity used, and remaining quantity. Pre-ERAS quantities were compared with newly captured post-ERAS quantities to gauge the efficacy of the program in minimizing opioid usage.

All opioid counts were initially measured and reported in absolute pills. Opioid type and dosage in mg for each respective patient were then used to convert data to MMEs in accordance with established conversion factors.[22]

Data Evaluation and Statistical Analyses

The study cohort was split into cohorts based on surgery type, namely arthroplasty and arthroscopy cohorts. Variables for each cohort were pre-ERAS prescribed quantity, post-ERAS prescribed quantity, quantity used, and remaining quantity. For each patient, a percent reduction in prescription was calculated by taking the difference between pre-ERAS and post-ERAS prescribed quantities as a percentage of the pre-ERAS prescribed quantity. Furthermore, for each patient, percent of pills leftover was calculated by taking the remaining quantity of pills as a percentage of the post-ERAS prescribed quantity. Means were calculated for each of these variables and percentages. Dichotomous data measured included the incidence

of a refill request, incidence of zero pills prescribed to a patient, and the incidence of zero pills remaining reported by a patient.

Statistical difference between pre-ERAS and post-ERAS means of the same cohort was evaluated using the Wilcoxon signed-rank test. Means for different cohorts (ie, arthroplasty versus arthroscopy) at the same time point were compared using the Mann-Whitney *U* test. Values of $P < 0.05$ were considered statistically significant, and all tests comparing means were two-tailed. When considering noncontinuous data, chi-squared tests were used to analyze associations in bivariate comparisons. An a priori power analysis was conducted to determine the required sample size for the study. Owing to an abundance of arthroplasty patients relative to arthroscopy patients, an allocation ratio of 2:1 was used in determining the appropriate cohort size. Based on a desired statistical power of 80% ($\beta = 0.20$) to detect an effect size of 0.6 at a significance level of $\alpha = 0.05$, it was determined that 60 participants would be needed in the arthroplasty group and 30 participants in the arthroscopy group. The power analysis was based on a mean percent reduction in prescription size (SD) of 53% (SD: 24%) for all arthroplasty patients and 35% (SD: 32%) for all arthroscopy patients across the database screened in this study. This calculation was conducted using G*Power 3.1.9.7 and ensured that the study was adequately powered to detect significant differences between group mean values. All other analyses were conducted using IBM SPSS Version 29 (IBM). Statistical significance was established at $P < 0.05$.

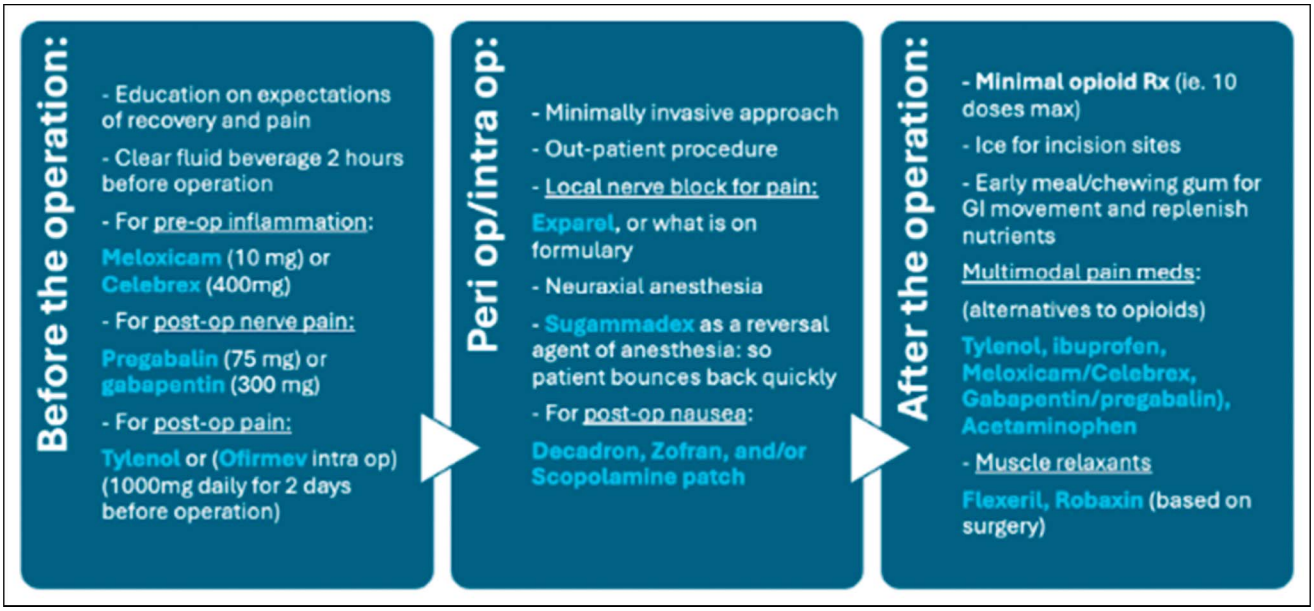
Implementation of Billion Pill Pledge Enhanced Recovery After Surgery Pathways

Each participating hospital was partnered with Goldfinch Health (Figure 1). Facilities and standing orders at each partner site were updated to agree with the Billion Pill Pledge ERAS pathway detailed as follows:

(1) Before surgery: Patients received comprehensive education on pain associated with surgery to manage expectations for recovery. Preoperative hydration was provided 2 hours before surgery using ClearFast or Gatorade. To prevent inflammation, meloxicam 10 mg or celecoxib 400 mg was administered, while nerve pain prophylaxis was achieved through pregabalin 75 mg (preferred) or gabapentin 300 mg (alternative). Preemptive analgesia was achieved with acetaminophen use (1,000 mg daily for 2 days before surgery).

(2) Perioperative/intraoperative: Surgery was made to prioritize minimally invasive techniques, in the outpatient setting, to reduce hospital stays. Neuraxial anesthesia and sedation were used to ensure intraoperative comfort while long-acting local anesthesia in the surgical field (ie, liposomal bupivacaine) provided targeted pain relief at the site of incision. Decadron, Zofran, and/or scopolamine patches were routinely administered to

Figure 1



Flowchart of guidelines set by the Billion Pill Pledge ERAS pathway in practice.

prevent postoperative nausea. In surgeries requiring general anesthesia, sugammadex was used as a reversal agent.

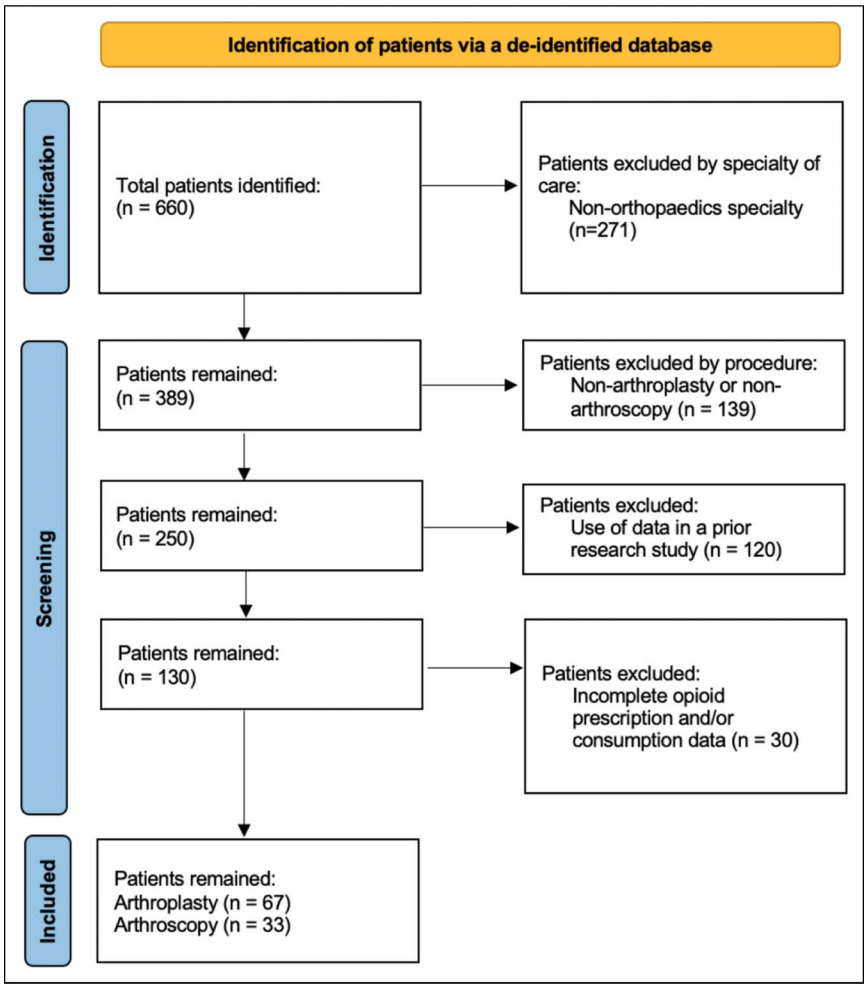
(3) After surgery: Opioid prescriptions were limited to a maximum of 10 doses. However, first-line pain management focused on routine ice application and early oral intake, including chewing gum, to promote gastrointestinal motility. Multimodal pain management strategies based around nonopioid medications were emphasized as the first-line pharmaceutical strategy. The multimodal agents included acetaminophen, selective Cox-2 nonsteroidal anti-inflammatory drugs (ie, meloxicam or celecoxib), pregabalin or gabapentin, Robaxin (when called for, based on surgical surgery), and muscle relaxants such as Flexeril. The 10 doses of opioids were restricted for severe breakthrough pain.

Before the date of surgery, "Prepared for Surgery Tool Kits" were delivered to each patient's home. Kits included hot/cold packs, a complex carbohydrate presurgery drink, chewing gum, a drug disposal kit, and patient education materials. Postoperative nursing follow-ups provided a second opportunity for patient education.

Results

Among the 660 surgical patients included in the used database, 271 were excluded because of other specialties of care such as gynecology, urology, plastic and reconstructive, or general surgery; 139 were excluded because of orthopaedic procedures other than arthroplasty or arthroscopy; 120 were excluded because of use of data in a previous research study; and finally, 30 patients were excluded because of incomplete opioid prescription and/or consumption data (Figure 2). The remaining 100

Figure 2



Flow diagram of study inclusion criteria.

eligible patients were included in this analysis, consisting of 67 arthroplasty and 33 arthroplasty patients. Patients in the arthroplasty cohort had undergone knee, shoulder, and hip arthroplasty, whereas patients in the arthroscopy cohort had undergone knee and shoulder arthroscopy surgeries (Figure 3).

Date of surgery for 19 of 100 patients fell between January 2024 and March 2024. Date of surgery for the remaining 81 of 100 patients fell between November 2022 and December 2023.

Pre–Enhanced Recovery After Surgery Prescriptions

The mean (range) pre-ERAS prescription size for the overall cohort was 389 MMEs (range: 140 to 900 MMEs). The arthroplasty cohort displayed a mean pre-ERAS prescription size of 451 MMEs (range: 200 to 900 MMEs; Table 1). Across the cohort, nine of 67 counts ran higher than 450 MMEs and 24 of 67 ran lower than 450 MMEs. Meanwhile, the arthroscopy cohort displayed a significantly lower mean pre-ERAS prescription size of 264 MMEs (range: 140 to 450 MMEs; $P < 0.001$; Table 1). Across the cohort, five of 33 counts ran higher than 300 MMEs and 18 of 33 ran lower than 300 MMEs.

Post–Enhanced Recovery After Surgery Prescriptions

After implementation of the Goldfinch Health ERAS pathways, the mean (range) prescription size for the overall cohort was 194 MMEs (range: 38 to 600 MMEs). The arthroplasty cohort displayed a mean post-ERAS prescription size of 210 MMEs (range: 38 to 600 MMEs; Table 1). Across the cohort, 13 of 67 prescriptions ran higher than 225 MMEs and 32 of 67 ran lower than 225 MMEs. The mean post-ERAS prescription size in the arthroscopy cohort was once more significantly lower than in the arthroplasty cohort at 161 MMEs (range: 45 to 315 MMEs; $P = 0.002$; Table 1). Across the cohort, nine of 37 prescriptions ran higher than 150 MMEs and nine of 37 prescriptions ran lower than 150 MMEs.

Percent Reduction

Across the overall cohort, there was a significant difference in mean pre-ERAS versus mean post-ERAS prescriptions (389 vs. 194 MMEs; $P < 0.001$) with a mean (range) percent reduction in prescription size of 42%. Both cohorts saw a notable decrease in MMEs prescribed compared with pre-ERAS data (Figure 4). The mean percent reduction was 47% across arthroplasty patients, as opposed to 33% in arthroscopy patients ($P < 0.02$; Table 1 and Figure 5). Across the arthroplasty cohort, 21 of 67 patients saw less than 50% reduction and 26 of 67 experienced greater than 50% reduction in postoperative prescription size. Across the arthroscopy cohort, 20 of 33 patients experienced less than 50% reduction while seven of 33 patients experienced greater than 50% reduction in postoperative prescription size.

Percent Leftover

Of a total of 14,093 MMEs prescribed across the arthroplasty cohort, 3,585 MMEs remained unused. Meanwhile, of a total 5,310 MMEs prescribed to arthroscopy patients, 3,033 MMEs went unused. The arthroplasty cohort displayed a mean (range) quantity used of 157 MMEs (range: 0 to 600 MMEs), compared

Figure 3

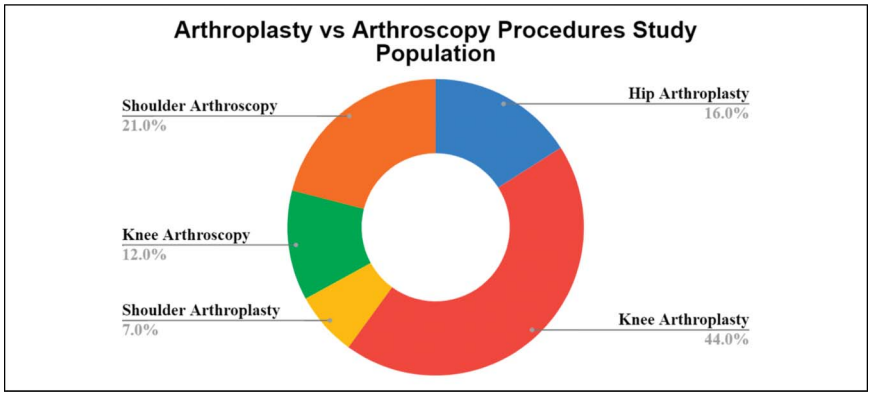


Chart demonstrating breakdown of cohorts by surgery type: knee arthroplasty (n = 44), shoulder arthroscopy (n = 21), hip arthroplasty (n = 16), knee arthroscopy (n = 12), and shoulder arthroplasty (n = 7).

Table 1. Prescription Data

Factor or Variable	Arthroplasty	Arthroscopy	*P*
No. of patients	67	33	—
Mean MMEs prescribed before ERAS	451	264	<0.001
Mean MMEs prescribed after ERAS	210	161	<0.005
Mean % reduction from before ERAS	47	33	<0.05

ERAS = enhanced recovery after surgery
Orthopaedic surgical patients sorted by cohort with corresponding mean pre-ERAS and post-ERAS postoperative prescription quantity and statistical difference across surgeries.

with a mean quantity used of 78 MMEs (range: 0 to 300 MMEs) in the arthroscopy cohort ($P < 0.0001$; Table 2). The mean remaining quantity was found to be 54 MMEs (range: 0 to 270 MMEs) for the arthroplasty cohort, as opposed to 92 MMEs (range: 0 to 280 MMEs) for the arthroscopy cohort ($P < 0.004$). Arthroscopy patients were found to have a significantly higher mean percent MMEs leftover of 60%, compared with arthroplasty patients at 27% ($P < 0.0002$; Figure 5).

Potential for Pill Diversion After Enhanced Recovery After Surgery Implementation

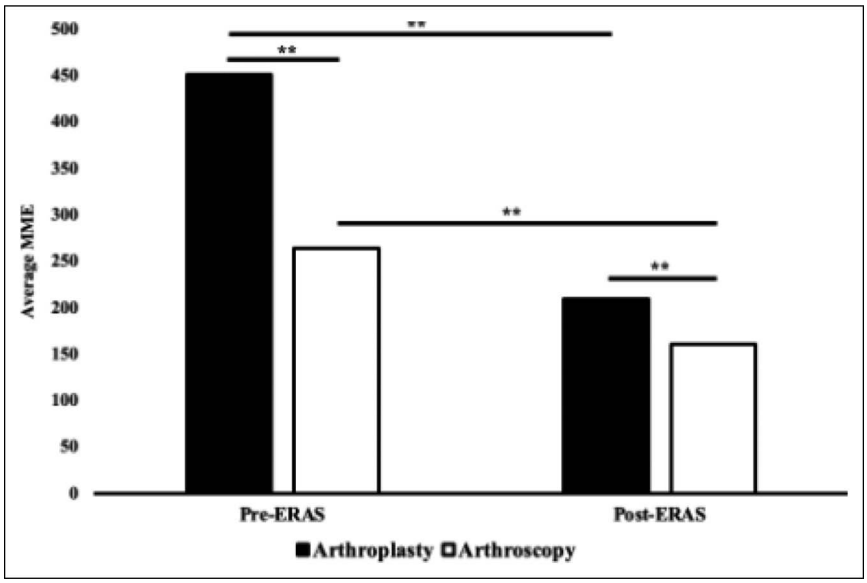
Across the entire cohort, 41 of 100 patients reported a remaining quantity of zero MMEs. The incidence rate for the arthroplasty cohort was 35 of 67 (52%), versus 6 of 33 (18%) for the arthroscopy cohort (Figure 6). A chi-squared test found a significant difference between the incidence of zero MMEs remaining across the two cohorts (P value = 0.001).

Consumption and Refill Rates

Five of 67 patients in the arthroplasty cohort reported consuming zero opioids from their postoperatively prescribed amount. Comparatively, seven of 33 patients in the arthroscopy cohort reported zero opioids consumed. The Fisher exact test found no significant difference between the incidence of zero MMEs consumed across the two cohorts (P value = 0.06).

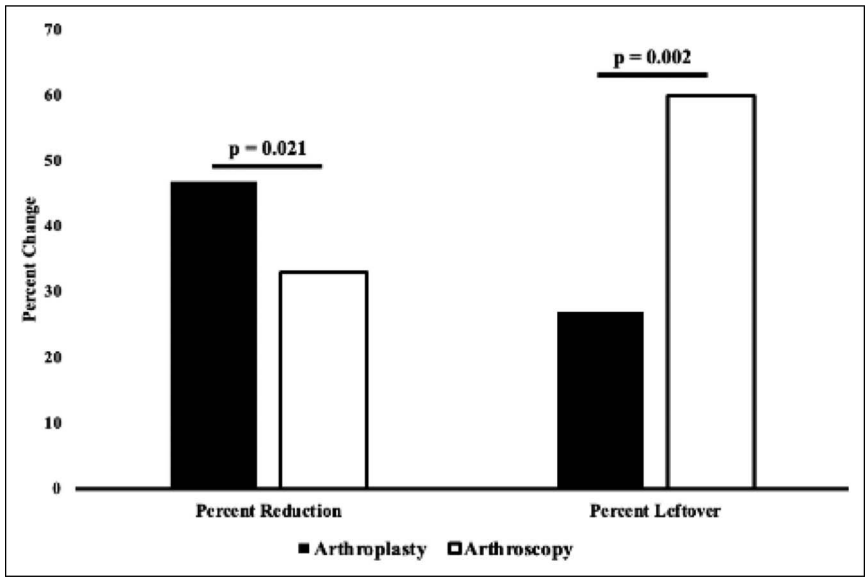
Among 67 patients in the arthroplasty cohort, five requested refills on their opioid prescription within 30 days after surgery. Meanwhile, two of 33 patients in the arthroscopy cohort were reported to have requested refills on their prescription. No significant difference was found between the two cohorts on analysis by way of the Fisher exact test (P value = 1).

Figure 4



Bar chart demonstrating differences in mean postoperative opioid prescription sizes between arthroplasty and arthroscopy patients before and after ERAS pathway implementation, $^{**}P < 0.001$. ERAS = enhanced recovery after surgery.

Figure 5



Bar chart demonstrating intercohort differences in mean percent reduction of postoperative opioid prescriptions and percent of prescribed opioids leftover after implementation of ERAS pathways. ERAS = enhanced recovery after surgery.

Discussion

From when ERAS pathways were first introduced as a system to optimize the physiological state of patients intraoperatively, they have since been recognized widely as a model to potentially improve patient outcomes within orthopaedic surgery.[8] Existing literature supports ERAS pathways as a tool for reducing reliance on postoperative opioid use while having minimal effect on, if not improving, pain, patient satisfaction, and patient-reported outcomes postoperatively.[8–13] Particularly for patients undergoing total joint arthroplasty, ERAS pathways have consistently been evidenced to reduce length of stay, hospitalization costs, nonhome discharge rates, and medication-related adverse reactions postoperatively.[8–13] On the contrary, the effect of ERAS pathways on the postoperative trajectory of arthroscopy patients has been investigated by fewer studies and is a direction for future research.

Currently, the Billion Pill Pledge ERAS pathways are implemented wide-scale irrespective of surgery type or even surgical specialty, across 9 Iowa hospitals. This study aimed to detect any difference in the efficacy of these pathways across patient cohorts undergoing two broad types of orthopaedic surgeries: arthroscopy and arthroplasty. Across the entire patient cohort, there was a drop in postoperatively prescribed opioid quantities, with a markedly greater drop seen in arthroplasty patients than that seen in arthroscopy patients. However, on average, arthroscopy patients accounted for far more MMEs unused compared with their arthroplasty counterparts.

The observed differences in opioid prescribing and consumption between arthroplasty and arthroscopy cohorts may be explained by the inherent differences in these procedures, particularly regarding surgical invasiveness and expected postoperative pain. Arthroplasty procedures are typically associated with greater tissue disruption and postoperative pain compared with arthroscopic procedures.[1,10,13] This could explain the higher baseline and post-ERAS opioid prescribing in the

Table 2. Opioid Usage Data

Factor or Variable	Arthroplasty	Arthroscopy	*P*
No. of patients	67	33	—
Mean MMEs used	157	78	<0.0001
Mean MMEs remaining	54	92	<0.005
Mean % MMEs leftover	27%	60%	<0.0005

Mean consumption, remaining quantity, and percent leftover of postoperative opioid prescription sorted by orthopaedic surgical surgery.

Figure 6

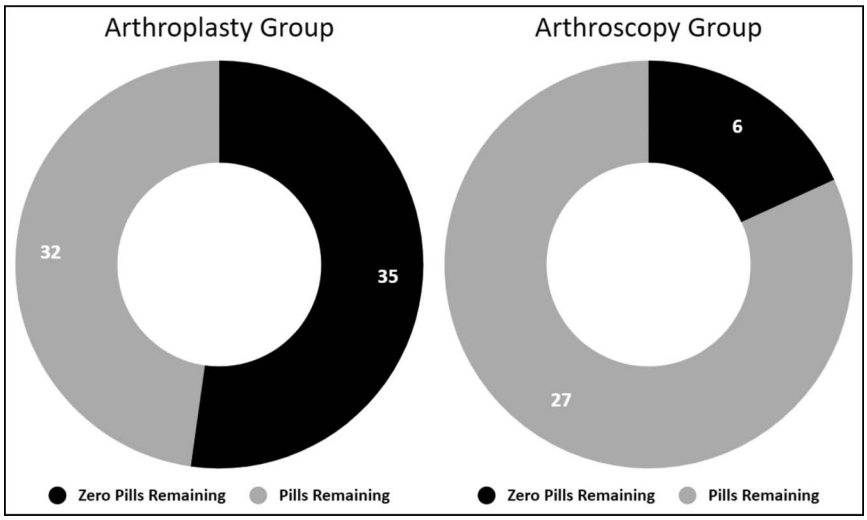


Chart demonstrating incidence of zero MMEs remaining by surgical procedure.

arthroplasty cohort. Conversely, arthroscopic surgeries involve less tissue trauma and generally result in quicker recovery and less reliance on opioids for pain control.[12]

Furthermore, anatomical differences may play a role in the percentage of leftover MMEs observed. Shoulder arthroscopy, for instance, may require fewer opioids because of reduced weight-bearing demands during recovery, potentially contributing to the higher percentage of unused opioids in the arthroscopy cohort.[11,15]

Unlike many past investigations, the study evaluated the effect of an entire pathway on outcomes measured, rather than individual interventional strategies.[8,9,13] Compared with existing literature, which largely focuses on interventions designed for specific surgeries,[4,5,11] this study evaluates pathways that have been designed with a breadth of surgical surgeries in mind.

Comparing Pre–Enhanced Recovery After Surgery Prescription Rates of Surgeries

Comparing pre-ERAS prescription data across the two groups, there was found to be a difference in preexisting prescribing trends by surgery type. The arthroplasty cohort presented with a mean pre-ERAS prescription size of 451 MMEs, drastically larger than that of the arthroscopy cohort at 264 MMEs. Studies investigating postoperative prescriptions after total joint arthroplasty have found prescription sizes ranging from 370 to 750 MMEs in patient cohorts receiving standard care, with no intentional interventions in pain management.[23,24] Similarly, the arthroscopy cohort's recorded mean pre-ERAS prescription size is in concordance with the range of mean prescription sizes found in nonexperimental cohorts of other similar studies, namely 340 to 610 MMEs.[12,25] As per a previous review of eight studies considering 816 patients, mean postoperative prescription sizes were found to be 610 MMEs versus 197 MMEs in shoulder and knee arthroscopy patients, respectively.[25] Owing to constraints in sample size, this study considered shoulder arthroscopy and knee arthroscopy patients to be part of the same cohort. Future studies should aim to verify the existence of any difference in prescribing trends between arthroscopies performed on various surgical sites. This includes hip arthroscopies, which were not evaluated in this study.

Comparing Reduction in Prescription Size Between Surgery Types

The ERAS pathways considered in this study achieved a notable reduction in postoperative opioid prescribing in both cohorts. Efficacy of the recovery pathways seemed to be greater, however, in the arthroplasty cohort compared with the arthroscopy cohort. The effect of these strategies in arthroplasty patients is consistent with literature supporting the use of ERAS pathways to improve the arthroplasty experience from a range of angles including costs, patient outcomes, and opioid use.[7-9] The reduction in mean prescription size in this study's arthroplasty cohort closely mirrors results of a recent study by Van Horne et al[24] evaluating the use of liposomal bupivacaine in ERAS pathways for total joint arthroplasty patients. Another similar study by Law et al[10] demonstrated a 26.3% reduction in mean OMEs prescribed to 600 total joint arthroplasty patients at

discharge. Unlike the Goldfinch Health ERAS pathways, the pathways considered by Law et al did not include the use of bupivacaine, anticonvulsants, or muscle relaxants. Evaluation and comparison of different interventions used in different sets of ERAS pathways have been and continue to be of paramount importance.[8,9,13]

The lower effect observed in arthroscopy patients may be due to lower anticipation of postsurgical pain in this cohort, which could in turn result in healthier opioid consumption habits immediately after surgery. The difference may also be owing to the less intensive nature of the arthroscopy surgery relative to arthroplasty. Less pain experienced could lead to a smaller margin for improvement in opioid consumption habits, particularly by hand of interventions meant for a breadth of surgical surgeries.

In this study, the reduction of prescriptions in the arthroscopy cohort was noted to be 161 MMEs. Comparatively, Duong et al[12] implemented a set of multimodal strategies for knee and shoulder arthroscopy, which successfully reduced the mean postoperative prescriptions from 341.2 OMEs in the control cohort to 40.4 OMEs in the opioid-sparing cohort. This context suggests that arthroscopy may demand more tailored ERAS pathways to achieve the highest reduction of postoperative opioid prescriptions.

Percent MMEs Unused and Drug Diversion

A total of 59 of 100 patients in this study reported leftover opioids, with 25.4% (3,585/14,093) of MMEs prescribed to the arthroplasty cohort and 57.1% (3,033/5,310) of MMEs prescribed to the arthroscopy cohort remaining unused. Previous literature has estimated that 67% to 92% of all surgical patients report unused opioids, with proportions of postoperative opioids unused ranging from 42% to as high as 73%.[26,27] Notably, this study found that the mean percent of MMEs leftover by arthroscopy patients was drastically higher than the mean percent of MMEs leftover by arthroplasty patients. The reported percentage of opioids remaining unused by the arthroplasty cohort is lower than that observed in previous similar studies.[24] By contrast, the mean percent leftover demonstrated by the arthroscopy cohort was higher than that found for shoulder arthroscopy and knee arthroscopy patients (31% and 34% of mean leftover MMEs, respectively) in a recent review of eight studies including 816 patients. Given that it is well documented that most surgical patients do not dispose of leftover medication, this study suggests the need to further tailor ERAS pathways to arthroscopy to minimize the potential for drug diversion in patient communities.[28]

Limitations

While post-ERAS prescription data were more accurately reported by patients, pre-ERAS opioid prescription data were physician estimated based on their typical pre-ERAS practice habits. Unfortunately, owing to the retrospective/deidentified nature of the data set, a database such as the Prescription Drug Monitoring Program could not be used to confirm pre-ERAS or post-ERAS prescription values. The discrepancy in modality of data collection must be acknowledged as a limitation of this study because this allows the potential for pre-ERAS and post-ERAS values to be dependent on provider and patient recall bias, respectively. The deidentified database screened in this study was created on the implementation of the BPP ERAS pathways in all partner hospital sites. Data for surgical cohorts seen before the implementation of the pathways were, therefore, inaccessible, necessitating the use of surgeon estimates to establish pre-ERAS data instead. Owing to this constraint, unlike other similar studies, this study's cohort was not split into a control and experimental cohort. In addition, there was a lack of pre-ERAS data on unused opioids. Because there was no pre-ERAS benchmark for comparison in this regard, the study was unable to assess the utility of Billion Pill Pledge implementation in reducing mean percent MMEs leftover.

This study did not account for the different arthroscopic surgeries performed on patients, nor did it evaluate variation in prescribing trends across different anatomical surgical sites. Future studies should aim to account for these differences and gather ample information to fully portray ERAS efficacy across different orthopaedic surgeries.

Conclusion

Designed with a breadth of surgical specialties in mind, the Billion Pill Pledge ERAS pathways reduced postoperative opioid prescriptions across patients undergoing different arthroscopy and arthroplasty surgeries. Prescriptions after discharge were reduced markedly more in arthroplasty patients than they were in arthroscopy patients, suggesting that these pathways may demonstrate more relative success with certain surgical surgeries, despite their broad applicability. Future studies should incorporate opioid disposal strategies and various surgery-specific interventions into ERAS pathways.

Overall, the Billion Pill Pledge ERAS pathways show promise as a starting point to reduce excess postoperative opioid prescribing across orthopaedics surgeries with the continued need to explore the intersurgery variability of these pathways' efficacy.

References

1. Kehlet H: Multimodal approach to control postoperative pathophysiology and rehabilitation. *Br J Anaesth* 1997;78:606-617.

2. Williams JB, McConnell G, Allender JE, et al: One-year results from the first US-based enhanced recovery after cardiac surgery (ERAS Cardiac) program. *J Thorac Cardiovasc Surg* 2019;157:1881-1888.

3. Coleman SR, Chen M, Patel S, et al: Enhanced recovery pathways for cardiac surgery. *Curr Pain Headache Rep* 2019;23:28.

4. Rendon JL, Hodson T, Skoracki RJ, Humeidan M, Chao AH: Enhanced recovery after surgery protocols decrease outpatient opioid use in patients undergoing abdominally based microsurgical breast reconstruction. *Plast Reconstr Surg* 2020;145:645-651.

5. Kodia K, Stephens-McDonnough JA, Alnajar A, Villamizar NR, Nguyen DM: Implementation of an enhanced recovery after thoracic surgery care pathway for thoracotomy patients—Achieving better pain control with less (schedule II) opioid utilization. *J Thorac Dis* 2021;13:3948-3959.

6. Meyer LA, Lasala J, Iniesta MD, et al: Effect of an enhanced recovery after surgery program on opioid use and patient-reported outcomes. *Obstet Gynecol* 2018;132:281-290.

7. Sharrock NE, Cazan MG, Hargett MJL, Williams-Russo PM, Wilson PD Jr: Changes in mortality after total hip and knee arthroplasty over a ten-year period. *Anesth Analg* 1995;80:242-248.

8. Soffin EM, Gibbons MM, Ko CY, et al: Evidence review conducted for the agency for healthcare research and quality safety program for improving surgical care and recovery: Focus on anesthesiology for total hip arthroplasty. *Anesth Analg* 2019;128:454-465.

9. Soffin EM, Gibbons MM, Ko CY, et al: Evidence review conducted for the agency for healthcare research and quality safety program for improving surgical care and recovery: Focus on anesthesiology for total knee arthroplasty. *Anesth Analg* 2019;128:441-453.

10. Law V, Cohen D, Chan B, et al: Successful implementation of a quality improvement bundle to reduce opioid overprescribing following total hip and knee arthroplasty. *BMJ Open Qual* 2023;12:e002360.

11. YaDeau JT, Soffin EM, Tseng A, et al: A comprehensive enhanced recovery pathway for rotator cuff surgery reduces pain, opioid use, and side effects. *Clin Orthop Relat Res* 2021;479:1740-1751.

12. Duong A, Ponniah AK, VanDeCapelle C, et al: Effect of a postoperative multimodal opioid-sparing protocol vs standard opioid prescribing on postoperative opioid consumption after knee or shoulder arthroscopy. *JAMA* 2022;328:1326.

13. Chen KK, Chan JJ, Zubizarreta NJ, Poeran J, Chen DD, Moucha CS: Enhanced recovery after surgery protocols in lower extremity joint arthroplasty: Using observational data to identify the optimal combination of components. *J Arthroplasty* 2021;36:2722-2728.

14. Johnson SP, Chung KC, Zhong L, et al: Risk of prolonged opioid use among opioid-naïve patients following common hand surgery procedures. *J Hand Surg* 2016;41:947-957.e3.

15. Kumar K, Gulotta LV, Dines JS, et al: Unused opioid pills after outpatient shoulder surgeries given current perioperative prescribing habits. *Am J Sports Med* 2017;45:636-641.

16. Cozowicz C, Olson A, Poeran J, et al: Opioid prescription levels and postoperative outcomes in orthopedic surgery. *Pain* 2017;158:2422-2430.

17. Soffin EM, Waldman SA, Stack RJ, Liguori GA: An evidence-based approach to the prescription opioid epidemic in orthopedic surgery. *Anesth Analg* 2017;125:1704-1713.

18. Sabatino MJ, Kunkel ST, Ramkumar DB, Keeney BJ, Jevsevar DS: Excess opioid medication and variation in prescribing patterns following common orthopaedic procedures. *J Bone Joint Surg Am* 2018;100:180-188.

19. Shichman I, Roof M, Askew N, et al: Projections and epidemiology of primary hip and knee arthroplasty in Medicare patients to 2040-2060. *JB JS Open Access* 2023;8:e22.00112.

20. Siddiqi A, Levine BR, Springer BD: Highlights of the 2021 American joint replacement registry annual report. *Arthroplast Today* 2022;13:205-207.

21. Shah NV, Solow M, Kelly JJ, et al: Demographics and rates of surgical arthroscopy and postoperative rehabilitative preferences of arthroscopists from the Arthroscopy Association of North America (AANA). *J Orthop* 2018;15:591-595.

22. Dowell D, Haegerich TM, Chou R: CDC guideline for prescribing opioids for chronic pain—United States, 2016. *MMWR Recomm Rep* 2016;65:1-49.

23. Wyles CC, Hevesi M, Trousdale ER, et al: The 2018 Chitranjan S. Ranawat, MD Award: Developing and implementing a novel institutional guideline strategy reduced postoperative opioid prescribing after TKA and THA. *Clin Orthop Relat Res* 2019;477:104-113.

24. Van Horne J, Van Horne A, Liao N, Romo-LeTourneau V: Migration of hospital total hip and knee arthroplasty procedures to an ambulatory surgery center setting and postsurgical opioid use: A private practice experience. *Am Health Drug Benefits* 2022;15:21-29.

25. Sheth U, Mehta M, Huyke F, Terry MA, Tjong VK: Opioid use after common sports medicine procedures: A systematic review. *Sports Health* 2020;12:225-233.

26. Bicket MC, Long JJ, Pronovost PJ, Alexander GC, Wu CL: Prescription opioid analgesics commonly unused after surgery: A systematic review. *JAMA Surg* 2017;152:1066-1071.

27. Howard R, Fry B, Gunaseelan V, et al: Association of opioid prescribing with opioid consumption after surgery in Michigan. *JAMA Surg* 2019;154:e184234.

28. Hasak JM, Roth Bettlach CL, Santosa KB, Larson EL, Stroud J, Mackinnon SE: Empowering post-surgical patients to improve opioid disposal: A before and after quality improvement study. *J Am Coll Surg* 2018;226:235-240e3.