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Opioid Use following Open versus Endoscopic Carpal Tunnel Release: A Population Study

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Background: Open (OCTR) and endoscopic carpal tunnel release (ECTR) are both effective treatments for carpal tunnel syndrome, with similar outcomes and complication rates. Given the opioid epidemic, it is important to consider how surgical modality impacts narcotic use. We compared narcotic use after OCTR and ECTR to identify trends and risk factors for prolonged postoperative use.

Methods: We utilized the PearlDiver database to identify patients who underwent OCTR and ECTR between 2008 and 2015. Patients with opioid use were analyzed for trends. Early refills, prolonged postoperative opioid use, and new persistent opioid use were defined by time periods relating to the date of surgery. Age, gender, Charlson comorbidity index (CCI), and surgery type (open versus endoscopic) were analyzed as predictors for opioid use.

Results: A total of 29,583 patients were included: 4125 (14%) ECTR and 25,458 (86%) OCTR. Significantly more OCTR patients filled perioperative prescriptions (62% versus 60%), and the OCTR group filled higher quantities of perioperative opioids (411 OME versus 379 OME). Patients in the OCTR group were also significantly more likely to obtain early refills and to have prolonged postoperative use. There was no difference in the rate of new persistent use.

Conclusions: Compared with ECTR, patients who underwent OCTR filled higher quantities of opioids in the perioperative period, were more likely to obtain early refills, and were more likely to have prolonged postoperative use. These findings suggest either a lower opioid requirement after ECTR or a lower perceived requirement reflected in the difference in prescribing habits between techniques.
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INTRODUCTION

Since the U.S. Department of Health and Human Services declared the opioid crisis a national public health emergency, the rate of opioid overdose has only continued to grow.[1] It is projected that even with current attempts to restrict prescription opioid supply, the annual number of opioid deaths will rise from 33,100 in 2015 to 81,700 by 2025.[2] However, given their efficacy, opioid analgesics remain the standard of care for the treatment of acute postsurgical pain.[3] For many patients, this is the first exposure to opioids.[4] To address this, there is a growing body of literature looking at trends in opioid use and risk factors for prolonged and new persistent opioid use following minor surgery. Estimates for the rates of new persistent narcotic use have been reported from 5.9% to 28%.[5–7] As the most common hand surgery performed in the United States with over 600,000 cases yearly, carpal tunnel release and its impact on opioid use is important to consider.[7,8]

Open and endoscopic techniques for carpal tunnel release are both effective treatments for carpal tunnel syndrome.[9–13] Comparisons of the two techniques have demonstrated that endoscopic surgery may allow for earlier return to work and improved early postoperative strength, but carries a slightly higher risk of median nerve injury. Overall symptom relief and long-term outcomes are comparable.[9–13] When considering cost, studies have shown that endoscopic surgery is more expensive due

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to increased time and equipment required.[14] Although outcomes and costs have been widely studied, the effect of surgical modality on postoperative narcotic use is not yet well characterized. Specifically, there is limited data on the effects of open compared with minimally invasive endoscopic techniques on postoperative narcotic use. Multiple factors including surgeon experience, anesthesia requirement, procedure time, and real or physician perceived pain differences between open and endoscopic procedures may lead to differences in the quantity of opioids patients are prescribed and use postoperatively. Given their similar efficacy, surgical modality is a worthwhile consideration for its potential impact on narcotic use. The specific aims of this study were to compare open versus endoscopic techniques in terms of (1) the formulations and quantities of narcotics filled in the perioperative period, and (2) the rates and risk factors for obtaining an early refill, prolonged postoperative use, and new persistent use. We hypothesized that endoscopic surgery patients would fill fewer narcotic prescriptions.

MATERIALS AND METHODS

Database

This study utilized the Pearldiver Patient Records Database (Colorado Springs, Colo.), a for-fee retrospective nationwide insurance billing database. Because this study required prescription information, the dataset from Humana was used, which is a private insurance company that offers both commercial and Medicare advantage plans with records from over 23 million patients over the period of 2007–2016. PearlDiver provides de-identified patient data and is compliant with the Health Insurance Portability and Affordability Act. Thus, research is exempt from IRB approval.

Study Population

The database was queried for patients with a diagnosis of carpal tunnel syndrome who underwent either endoscopic or open carpal tunnel release, utilizing Current Procedural Terminology (CPT) codes and International Classification of Diseases 9 (ICD-9) Codes. CPT-64721 was utilized for open release, CPT-29848 for endoscopic release, and ICD-9-354.0 for the diagnosis of carpal tunnel syndrome. To capture medical comorbidities and postoperative outcomes, patients had to be at least 19 years of age and Humana insured for 1 year before surgery through 90 days after surgery. To avoid capturing patients who received opioids for other indications, patients were excluded if they underwent any other same-day musculoskeletal procedures or if they were admitted within 90 days after surgery. Both chronic users of opioids and opioid-naive patients were included, as detailed below.

Data Collection

The open and endoscopic surgery groups were evaluated for demographic factors including age, gender, and baseline comorbidities. To quantify comorbidity in a standardized manner, we used the Charlson comorbidity index (CCI), which was included in the dataset, and is a widely utilized and validated numeric scale that weighs comorbid conditions to predict 10-year survival.[15] Data were also collected on acute surgical complications and medical complications occurring within 30 days after surgery using the ICD-9 codes listed in Table 1.

For narcotic data collection, the Food and Drug Administration approval database was utilized to create a comprehensive list of oral opioids for inclusion.[16] Chronic opioid use was defined as having filled at least 1 oral narcotic prescription between 4 months and 30 days before the carpal tunnel procedure. As described by Steiner et. al, prescriptions within 30 days were not included in the definition of preoperative opioid use to reduce the risk of capturing prescriptions that were given in preparation for surgery.[17] Patients without a prescription between 4 months and 30 days prior to surgery were defined as opioid naive.

The perioperative period was defined as 30 days before surgery through 2 days after surgery. To determine quantity of narcotics used in this period, all opioid formulations were converted to the standardized unit of oral morphine equivalents using an online calculator developed by the Agency Medical Directors' Group (ADGME).[18] Prior studies on opioid use after minor hand procedures have defined the perioperative period in different ways, including 7 to even 14 days after surgery.[3,6,19] We chose a more conservative cutoff based on recent literature demonstrating that patients undergoing carpal tunnel surgery in particular are most likely to use opioids within the first 2–3 days after surgery.[20–23]

Early refills were defined as filling a second opioid prescription within the 2 day to 30 day postoperative period. Prolonged postoperative opioid use was defined as filling an additional prescription between 30 and 90 days after surgery. Finally, new persistent narcotic use was defined as previously opioid-naive patients who both filled a perioperative prescription and an additional oral opioid prescription in the 30- to 90-day postoperative period. A

Table 1. ICD-9 Codes for Surgical and Medical Complications

	ICD 9 Code
Acute complications	
Hematoma	998.12
Seroma	998.13
Postoperative infection	998.5, 998.51, 998.59
Cellulitis/abscess	682.9
Dehiscence	998.30, 998.31, 998.32, 998.33
Hemorrhage	998.11
Medical complications	
Sepsis	995.91, 995.92
Septic shock	785.52
Pulmonary embolism	415.11, 415.12, 415.13, 415.19
Ventilator	V46.11
Unplanned intubation	96.0
Acute renal failure	584.5–584.9
Cardiac arrest	427.5
Myocardial infarction (acute)	410.00–410.92
Stroke	434.91
Coma	780.01
Pneumonia	480–486
Urinary tract infection	599
Deep venous thrombosis	453.4
Transfusion	9904, V58.2
Cardiopulmonary complications	997.1

graphic summary of the relevant time periods used in our study is shown in Figure 1.

Statistical Analysis

Descriptive statistics were calculated for demographics, medical comorbidities, and preoperative opioid exposure in the open and endoscopic groups. Multivariate logistic regression was used to examine the effect of open versus endoscopic surgery on the odds of filling a perioperative prescription and obtaining an early refill while controlling for age, sex, CCI, and chronic opioid use. Multivariate regression was also performed to examine the effect of open versus endoscopic surgery on the odds of becoming a new persistent opioid user while controlling for age, gender, and CCI. Finally, descriptive statistics were calculated for the rates of acute surgical and medical complications in the 2 groups, and a sub-analysis was performed to examine the effect of preoperative opioid exposure and prolonged postoperative use on complication rates while controlling for surgical modality. For all regression analyses, odds ratios (ORs) and 95% confidence intervals (CIs) were reported.

RESULTS

A total of 29,583 patients were included, with 4125 (14%) endoscopic patients, and 25,458 (86%) open patients. Demographics are shown in Table 2. The average CCI was slightly lower in the endoscopic group, at 2.17 versus 2.32 ($P < 0.001$); however, both values correspond to 90% 10-year survival and therefore this difference is unlikely to be clinically relevant.[15] A comparison of opioid use pre- and postoperatively between the open and endoscopic groups is shown in Table 3. The percentage of chronic opioid users was similar between the endoscopic and open groups, at 21% and 22% respectively ($P = 0.435$).

Perioperative Opioid Use

On univariate analysis, more patients in the open group filled a perioperative prescription than in the endoscopic group (62% versus 60%; $P = 0.034$). Table 4 shows adjusted odds of filling opioid prescriptions. When controlling for age, gender, and chronic opioid use, open patients were 13% more likely to fill a perioperative prescription than endoscopic patients (CI 1.05–1.21, $P < 0.001$).

The strongest predictor for filling a perioperative prescription was chronic opioid use, with an odds ratio of 2.81 compared with opioid-naive patients (CI 2.63–3.01, $P < 0.001$). The following 4 drugs accounted for over 95% of perioperative prescriptions: codeine/acetaminophen, hydrocodone/acetaminophen, oxycodone/acetaminophen, and oxycodone HCl. After converting doses into oral morphine equivalents, open patients filled higher quantities of opioids than endoscopic patients, at 411 ± 96 OME versus 379 ± 82 OME respectively ($P < 0.001$). This corresponds to approximately 55 tablets of 5-mg oxycodone per patient in the open group and 51 tablets in the endoscopic group.

Risk Factors for Early Refills, Prolonged Postoperative Opioid Use, and New Persistent Opioid Use

In the open group, 16% (n = 3,495) of patients obtained an early refill compared with 14% (n = 577) in the endoscopic group ($P = 0.008$). On multivariate analysis, open patients were 19% more likely to obtain an early refill (CI 1.07–1.33, $P = 0.001$). Open patients also trended toward higher rates of prolonged use (20% versus 18%, $P = 0.052$), and were 13% more likely to have prolonged use (CI 1.02–1.25, $P = 0.021$). Finally, there was an overall 9% rate of new persistent opioid use, which was similar between groups.

The strongest predictor of early refills and prolonged use was chronic opioid use—these patients had 9.23 times the odds of obtaining an early refill (CI 8.59–9.91, $P < 0.001$) and 10.01 times the odds of prolonged use (CI 9.36–10.71, $P < 0.001$) compared with opioid-naive patients.

Opioid Use and Acute Surgical and Medical Complications

Although the rates of medical complications were similar between groups, there was a slightly higher rate of acute surgical complications in the endoscopic group at 0.7% versus 0.3% ($P = 0.007$). Controlling for chronic opioid use, open patients had 1.92 times the odds of an acute complication compared with endoscopic patients (CI 1.11–3.31, $P = 0.019$). In this sub-analysis, chronic

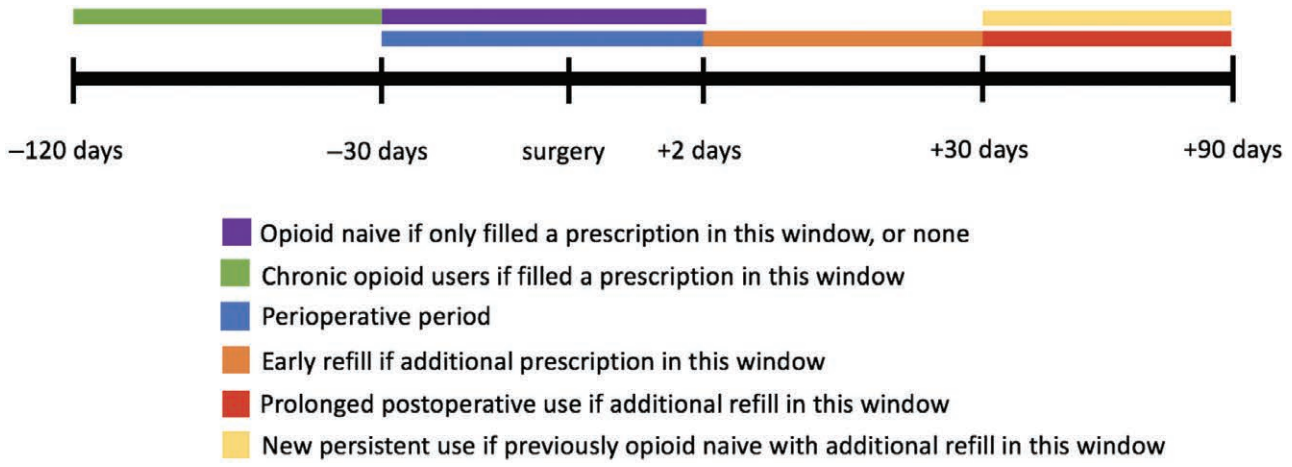

Fig. 1. Graphic summary of time frames.

Table 2. Demographic Details

	Endoscopic, n (%)	Open, n (%)	*P*
Overall cohort	4125 (100)	25,458 (100)	
Gender			
Women	2462 (60)	15,185 (60)	1.0
Men	1663 (40)	10,273 (40)	1.0
Age*			
20–34	50 (1)	259 (1)	0.247
35–49	344 (8)	1783 (7)	0.002
50–64	906 (22)	5080 (20)	0.003
65–79	2200 (53)	13,509 (53)	0.686
80+	643 (16)	4963 (19)	<0.001
Total	4143 (100)	25,594 (100)	
Charlson comorbidity index (mean, SD)	2.16 (2.51)	2.32 (2.57)	<0.001
<2 (>90% 10-year survival)	2793 (68)	16,319 (64)	
3 (77% 10-year survival)	422 (10)	2908 (11)	
4 (53% 10-year survival)	281 (7)	2029 (8)	
5 (21% 10-year survival)	183 (4)	1387 (5)	
6+ (<3% 10-year survival)	446 (11)	2815 (11)	

*Patients with records in the data base at different ages are counted in multiple age group.

Table 3. Opioid Exposure

	Endoscopic, n (%)	Open, n (%)	Total, n (%)	*P*
Overall cohort	4125 (100)	25,458 (100)	29,583 (100)	
Opioid naive	3253 (79)	19,873 (78)	23,126 (78)	0.057
Chronic opioid use	872 (21)	5585 (22)	6457 (22)	0.435
Filled a perioperative prescription	2469 (60)	15,819 (62)	18,288 (62)	0.034
Early refill	586 (14)	4059 (16)	4645 (16)	0.008
Prolonged postoperative use	747 (18)	5003 (20)	5750 (19)	0.052
New persistent opioid use	296 (7)	1939 (8)	2235 (8)	0.605
Avg. OMEs per patient in the perioperative period	379 ± 82	411 ± 96	406 ± 126	<0.001

Table 4. Adjusted Odds of Filling Opioid Prescriptions

	Perioperative Prescription (CI)	*P*	Early Refill (CI)	*P*	Prolonged Use (CI)	*P*	New Persistent Use (CI)	*P*
Surgery								
Endoscopic	1		1		1		1	
Open	1.12 (1.05–1.21)	0.001	1.19 (1.07–1.33)	0.001	1.13 (1.02–1.25)	0.021	1.08 (0.94–1.23)	0.267
Gender								
Women	1		1		1		1	
Men	1.00 (0.95–1.05)	0.928	0.98 (0.91–1.05)	0.541	0.88 (0.82–0.94)	<0.001	0.94 (0.86–1.02)	0.152
Age								
20–34	1		1		1		1	
35–49	0.90 (0.72–1.13)	0.371	1.19 (0.89–1.59)	0.238	1.50 (1.13–1.99)	0.005	1.26 (0.87–1.83)	0.215
50–64	0.79 (0.64–0.98)	0.030	1.08 (0.82–1.42)	0.597	1.59 (1.22–2.09)	<0.001	1.11 (0.77–1.58)	0.578
65–79	0.58 (0.47–0.72)	<0.001	0.53 (0.40–0.70)	<0.001	0.88 (0.67–1.15)	<0.001	0.91 (0.64–1.29)	0.584
80+	0.44 (0.36–0.54)	<0.001	0.34 (0.26–0.46)	<0.001	0.57 (0.44–0.76)	0.341	0.63 (0.44–0.91)	0.013
CCI	1.01 (1.00–1.02)	0.134	1.05 (1.04–1.07)	<0.001	1.05 (1.04–1.07)	<0.001	1.01 (0.99–1.03)	0.297
Opioid use								
Naive	1		1		1		NA	NA
Chronic	2.81 (2.63–3.01)	<0.001	9.23 (8.59–9.91)	<0.001	10.01 (9.36–10.71)	<0.001	NA	NA

opioid use was an independent risk factor for complications; these patients had 1.56 times the odds of an acute surgical complication (CI 1.11–2.19, $P = 0.011$), and 1.26 times the odds of a medical complication (CI 1.05–1.52, $P = 0.015$) compared with opioid-naive patients. Patients with prolonged postoperative opioid use also had higher odds of both acute (OR 1.86, CI 1.32–2.63, $P < 0.001$) and medical complications (OR 1.31, CI 1.08–1.59, $P = 0.006$).

DISCUSSION

Opioids and Carpal Tunnel Release

The appropriate quantity of pain medication to prescribe for acute postoperative pain is not well established. In this study, the average OMEs filled per patient in the overall cohort during the perioperative period was 406 ± 126, and the average number of pills per patient was 47 pills ± 42. For comparison, Wunsch et al reported an average of 213 OMEs per patient in their large database study, but only looked at prescriptions within 7 days after carpal tunnel release.[19] As large database studies have the limitation of capturing unrelated prescriptions, these numbers may be higher than real-world conditions. However, even recent prospective studies have reported averages of 20–30 pills prescribed following elective hand surgery despite substantial evidence that pain is adequately controlled with as few as 5 pills.[3,21,22,24–27] Even when accounting for the inclusion of unrelated prescriptions, our findings further substantiate concern over excessive opioid prescribing practices in general, and draws specific attention to

the field of hand surgery. Moreover, the overall 9% rate of new persistent use in this study supports recent evidence that even short-term exposure to opioids in the postoperative period can increase risk of persistent use.[4–7,17,28]

Surgeons must also consider how prior opioid exposure can influence postoperative narcotic use when writing opioid prescriptions for acute postsurgical pain. Our finding of a 22% rate of chronic opioid use is comparable to many prior studies—notably that of Gause et al, who found a 24% rate in their PearlDiver study on CTR.[7] Other large cohort studies on narcotic use and minor surgery have reported similar rates in the range of 21.5%–24.1%.[3,7,17] Still, surgeons may not be aware of the extent to which their patients are affected. A recent cross-sectional survey study by Menendez et al found that although 94% of over 3000 hand surgeons surveyed felt confident in their ability to prescribe opioids, only 40% routinely asked about prior opioid abuse or dependence.[29] In this study, chronic opioid use increased the odds of early refills and prolonged postoperative use by over 9 times when compared with previously opioid-naive patients, and as such should be considered when writing perioperative prescriptions.

The above discussion of perioperative opioid prescribing is important; however, this study's primary aim was to compare opioid prescribing between endoscopic and open carpal tunnel release which, to our knowledge, has not previously been studied. Open patients were not only more likely to fill a perioperative prescription, but also filled higher initial quantities of opioids overall. Because these represent preoperative prescriptions given in anticipation of postsurgical pain, the difference in quantity between the open and endoscopic groups is likely more reflective of surgeon prescribing practices than patient factors. There are several possible explanations for these findings. First, lower level trainees prescribe higher quantities of opioids in general.[27] As endoscopic CTR is more likely to be performed by hand fellowship-trained surgeons, higher level of training may contribute to lower perioperative prescription quantities found in the endoscopic group. Hand surgeons should emphasize the importance of careful opioid prescribing with trainees, especially for minor procedures that may be treated with alternative analgesia. Furthermore, several studies have shown that quality improvement initiatives targeted at reducing postoperative opioid prescribing are effective.[30–32] Prescriber guidelines, education, and quality improvement interventions targeted at residents in training may further facilitate careful prescribing habits.

Expected differences in pain severity between open and endoscopic techniques may also play a role in a surgeon's decision of how many pills to prescribe for the acute postoperative period. It is possible that open procedures, which require larger incisions, are perceived as being more "painful." However, even if pain is truly increased following open surgery, the vast majority of CTR patients report adequate pain control using a fraction of pills prescribed to them.[21,26,33] For instance, in a prospective study of opioid use following open CTR, patients were prescribed 20 pills on average but only consumed 4 pills.[26] In our study, endoscopic patients received an average of 4 pills more than open patients in the perioperative period. On an individual patient basis this number may seem small, however, it is important to consider the large overall contribution to the pool of unused pills in circulation for potential misuse and abuse, which this study shows may be even higher after open surgery.[24] We suggest prescriber guidelines be modified to include information on the possible higher risk of over-prescribing, specifically following open procedures—a simple modification that could have a large-scale impact on the many patients undergoing open carpal tunnel release yearly.

In terms of early refills and prolonged postoperative use, there are many possible reasons why open patients continued to fill more prescriptions, including a potential true difference in pain severity. Open carpal tunnel release has been associated with higher levels of pillar pain and scar tenderness.[10,34] There is also some evidence suggesting that concomitant hand and wrist pathologies influence surgeons to choose open release.[34,35] As such, pain primarily related to these pathologies or from additional manipulation during surgery may contribute to prolonged postoperative pain. However, there are multiple studies demonstrating equivalent efficacy when directly comparing opioids with alternative analgesics, such as acetaminophen and ibuprofen.[21,22,33] Still, hydrocodone-based analgesia is the most popularly prescribed pain control, and in fact accounted for over 70% of prescriptions in this study at all time points.[3,4,22–24,26] Even small differences in prescribing between the open and endoscopic groups translate to large quantities of additional opioids on a population level when considering open carpal tunnel release is performed far more frequently; for instance, our finding of a 16% (n = 3495) rate of early refill in the open group compared with a 14% (n = 577) rate in the endoscopic group translates to 2918 additional patients receiving early refills over the study period. We suggest strong consideration for alternative analgesia regardless of surgical modality.

Limitations

This study has several limitations. First, the literature varies widely in terms of time periods used to define prolonged and new persistent opioid use.[5,7] However, the 30- to 90-day interval utilized in this study is narrower, and thus more conservative than many previous studies.[5,7] Second, although measures were taken to minimize capturing unintended opioid prescriptions, this is unavoidable when using large datasets. Given the primary aim was to compare opioid use between the open and endoscopic groups rather than analyzing absolute opioid quantities, the impact of this should be minimal given that the groups were similarly distributed. Furthermore, the dataset only reflects the number of prescriptions filled, which does not necessarily reflect the number of pills taken. In addition, although CCI is an effective, standardized tool for comparing overall comorbidity severity, there are many other comorbidities not included in CCI—notably mental-health-related illnesses such as anxiety, depression, and chronic pain that are well linked to opioid use. Because this is a comparative study of 2 surgical modalities, we assume that these were evenly distributed.

CONCLUSIONS

Although the rate of endoscopic carpal tunnel release has grown over recent years, open technique still comprises over 80% of all CTR performed in the United States.[14,36] With over 600,000 carpal tunnel procedures performed per year, even a small difference in the rate of peri- and postoperative opioid exposure between surgical modalities can have large-scale effects. There are many factors to consider when choosing between open and endoscopic carpal tunnel release, including surgeon preference, level of training, and patient preferences. Opioid use implications should not supersede these considerations; however, our findings reveal either a higher risk of over-prescribing following open carpal tunnel release, or a lower opioid requirement following endoscopic surgery. For patients with a history of chronic opioid use or other known risk factors for opioid misuse, surgeons with both open and endoscopic techniques within their arsenal may consider the benefits of performing endoscopic carpal tunnel release. More importantly, hand surgeons should continue to be aware of a potential for over-prescribing, particularly following open procedures, and should strongly consider alternatives to opioid analgesia regardless of surgical modality.

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