Opioid Prescribing Trends and Geographic Variation After Anterior Cruciate Ligament Reconstruction

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Introduction: Opioid prescribing patterns play an important role in the opioid epidemic in the United States. The purpose of this study is to examine the trends and geographic variation in opioid prescribing patterns after anterior cruciate ligament (ACL) reconstruction.

Hypothesis: Regional differences in opioid prescribing patterns after ACL reconstruction are present.

Study Design: Descriptive epidemiology study.

Level of Evidence: Level 4.

Methods: The Truven Health MarketScan Commercial Claims database was used to analyze all patients with perioperative private insurance coverage who underwent ACL reconstruction from January 1, 2010, to November 31, 2017. Total number and morphine milligram equivalents per day (MMED) of opioid prescriptions were examined, and regional and statewide variation was assessed.

Results: A total of 90,068 ACL reconstruction patients who underwent surgery between 2010 and 2017 were included in the study. Overall, 67% received an opioid prescription within 30 days of surgery and 17% received an opioid prescription ≥ 90 MMED. The West (20%) had the highest proportion of patients with an opioid prescription ≥ 90 MMED and the Northeast had the lowest (12%), $P < 0.001$. The number of opioid prescriptions as well as proportion of opioid prescriptions ≥ 90 MMED varied significantly by state, $P < 0.001$. There was a significant increase in number of opioid prescriptions from 2010 to 2017 (62% in 2010 and 83% in 2017; $P < 0.001$). A significant change in the proportion of patients being prescribed ≥ 90 MMED was also present ($P = 0.04$; 15% in 2010, 17% in 2011, 17% 2012, 17% in 2013, 15% in 2014, 20% in 2015, 18% in 2016, and 15% in 2017).

Conclusion: This study shows a trend of increasing opioid prescriptions and geographic variations in the amount and MMED of opioid prescriptions for patients undergoing ACL reconstruction. These data highlight several areas of improvement that state officials and national entities can use to help curb the opioid epidemic and underscore the importance of national guidelines for opioid prescribing.

Clinical Relevance: Knowledge of prescribing patterns after specific procedures may help provide more direct insight and guidance to surgeons and patients regarding postoperative pain management.

Keywords: opioids; opioid abuse; anterior cruciate ligament reconstruction; postoperative pain; geographic variation

Opioid misuse has placed a tremendous socioeconomic burden on the United States. There are approximately 128 opioid-related deaths per day, and the annual estimated economic expenditure for opioid misuse is \$78.5

billion.^{6,10} The United States consumes approximately 80% of the world's production of opioids, despite accounting for <5% of the world's population.¹⁶ The opioid crisis has received significant press in the past few years, and the Department of

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Health and Human Services has labeled it a public health emergency.^{4,11,14} Orthopaedic surgeons have one of the highest opioid prescribing rates of any health care profession.²³

Anterior cruciate ligament (ACL) reconstruction is a painful procedure, and postoperative range of motion and rehabilitation exercises are extremely important; therefore, there has been an emphasis on postoperative pain control.⁷ However, opioids prescribed in the postoperative period may be misused. Anthony et al³ reported that 4.7% of patients undergoing ACL reconstruction were still filling their opioid prescriptions 12 months after their operation. Previous studies have found significant nationwide variation in opioid prescribing patterns after ACL reconstruction in the pediatric population.² However, there remains a paucity of literature regarding more recent epidemiology and regional differences for opioid prescriptions after ACL reconstruction in the adult population. To best assess the risks and benefits of opioid prescriptions for ACL reconstruction, it is important to understand the extent of opioid prescriptions nationally.

Therefore, the purpose of this study was to evaluate opioid prescribing patterns after ACL reconstruction in the United States. We hypothesized that regional differences would exist regarding opioid prescribing patterns after ACL reconstruction.

METHODS

Database

A retrospective review of the Truven Health MarketScan Research Commercial Claims and Encounters database (Truven Health Analytics) from January 1, 2010, to December 31, 2017, was conducted. Because this is deidentified patient information, institutional review board approval was not required. The MarketScan database houses data for more than 45 million privately insured patients younger than 65 years. The database contains information from active employees, early retirees, and dependents insured by employer-sponsored health plans. Data are contained in a Health Insurance Portability and Accountability Act complaint manner.

Patient Sample

Adult patients that underwent a primary ACL reconstruction from April 2010 to November 2017 were included. Patients were identified using Current Procedure Terminology codes (29888 and 27248) and International Classification of Diseases, 9th Revision and 10th Revision, Clinical Modification, codes (717.83, 84.42, S83.519, S83.511, S83.12, and M23.61x). Patients with a concomitant diagnosis of malignancy or infection, those who did not have continuous insurance enrollment 3 months before and 1 month after surgery, and those with unknown geographic location for surgery were excluded. Patients that had an opioid prescription 90 to 12 days before surgery were also excluded; prescriptions made within 2 weeks before surgery were considered anticipatory measures (Figure 1).

Outcomes

The primary outcome was geographic and regional variation in opioid prescriptions within 30 days of ACL reconstruction. The morphine milligram equivalents per day (MMED) was calculated for each person utilizing opioids. The MMED was calculated using the following formula:

$$\text{MMED} = \frac{\text{strength per unit} \times \text{metric quantity} \times \text{MME conversion factor}}{\text{days supply}}$$

High opioid dose was defined as an MMED ≥ 90 . The Centers for Disease Control and Prevention recommends avoiding opioid doses of ≥ 90 MMED because of the increased risk of overdose.

The secondary outcome was to assess for annual trends in opioid prescriptions and high-dose opioid prescriptions after ACL reconstruction.

Statistical Analysis

Continuous and categorical data were reported as mean $\pm$ SD and count (%), respectively. Chi-square test was performed to determine significant regional and geographic differences in opioid prescription. A Cochran-Armitage test of trend was performed to assess for trends of opioid prescriptions from 2010 to 2017. Statistical significance was set at $P < 0.05$. All statistical analysis was performed using SAS software (Version 9.4, SAS Institute).

RESULTS

Overall, 90,068 adult patients who underwent an ACL reconstruction were included in this study (Figure 1). A total of 35,795 (40%) patients were women, and the mean age was 33 ± 11 years (Table 1). In all, 60,502 (67%) of 90,068 patients had an opioid prescription within 30 days of surgery, and 14,983 (17%) patients had an opioid prescription ≥ 90 MMED.

There was significant regional and geographic variation in opioid prescription after ACL reconstruction. The percentage of patients receiving an opioid prescription was the highest in the South (70%) and lowest in the Northeast (64%), $P < 0.001$. The West (20%) had the highest percentage of patients with an opioid prescription ≥ 90 MMED and the Northeast had the lowest (12%), $P < 0.001$. Opioid prescriptions significantly varied by state, ranging from 84% in Maine to 46% in West Virginia ($P < 0.001$) (Figure 2). The states with the highest percentage of opioid prescriptions ≥ 90 MMED were Maine (41%), Idaho (36%), Alaska (32%), Oklahoma (31%), and Montana (29%) (Figure 2).

There was a significant increase in opioid prescriptions from 2010 to 2017 ($P < 0.001$; 62% in 2010, 64% in 2011, 64% in 2012, 64% in 2013, 65% in 2014, 82% in 2015, 83% in 2016, and 83% in 2017). A significant change in percentage of patients being prescribed ≥ 90 MMED was also present with a peak in 2015 ($P = 0.04$; 15% in 2010, 17% in 2011, 17% in 2012, 17% in 2013,

Figure 1. Flowchart demonstrating exclusion criteria and the final sample used. ACL, anterior cruciate ligament; MME, morphine milligram equivalents.

15% in 2014, 20% in 2015, 18% in 2016, and 15% in 2017). This significant change was evident across all regions.

DISCUSSION

This study shows important trends and variations in opioid prescription patterns for patients undergoing ACL reconstruction. When examining regional trends, the South had the highest percentage of patients receiving any opioid prescription, whereas the West had the highest percentage of patients with opioid prescriptions ≥ 90 MMED. In statewide comparison, significant variation was present with several states having a percentage of opioid prescriptions ≥ 90 MMED of 30% or greater. Furthermore, we saw an overall increase in the amount of opioid prescriptions from 2011 to 2017 and a significant change in the percentage of patients receiving prescriptions ≥ 90 MMED, peaking in 2015.

Opioid use and prevention has garnered abundant attention over the past 2 decades. Numerous programs and initiatives have been developed to curb the use of opioids and help improve the

opioid problem in the United States.¹ Despite these initiatives, this study shows that opioid use after ACL reconstruction increased in the United States from 62% of patients in 2011 to 83% of patients in 2017. Furthermore, geographic variation in prescribing patterns is present, with many states having 30% or more of patients receiving opioid prescriptions of ≥ 90 MMED. These findings are concerning given that MMED is directly proportional to opioid strength and supply prescribed, which are factors associated with addiction, overdose, and death.^{19,20,23,31} For example, the risk of overdose has been shown to increase 9-fold with prescriptions of 100 MMED compared with prescriptions of 20 MMED or less.^{9,17,25} Knowledge of these data may help encourage the establishment of guidelines for opioid prescription writing after ACL reconstruction, with special attention to limiting prescriptions to lower MMED levels. Widespread adoption of these guidelines may help decrease the statewide variation in MMED of opioid prescriptions shown in this study.

Geographic variations in prescribing patterns for opioids have been shown previously in large, national studies as well as for patients with specific musculoskeletal issues, including back pain

Table 1. Demographic data on 90,068 patients who underwent anterior cruciate ligament reconstruction from 2010 to 2017

Demographics	n (%)
Age ^a	33 ± 11
Sex	
Male	54,273 (60)
Female	35,795 (40)
Employee relation	
Employee	50,217 (56)
Spouse	15,998 (18)
Child/other	23,853 (26)
Region	
Northeast	18,556 (21)
Midwest	18,858 (21)
South	31,267 (35)
West	21,377 (24)
Employment status	
Full-time	36,594 (41)
Part-time	647 (0.7)
Retiree	659 (0.7)
Other ^b	52,827 (58)

^aReported as mean ± SD.

^bIncludes employees and their families who are subject to the Consolidated Omnibus Budget Reconciliation Act, long-term disability recipient, surviving spouse, unknown.

and ankle sprains.^{8,18,22,28} There may be several explanations for state variation in opioid prescribing, such as state policies, public awareness, different postoperative pain regimens, utilization procedures, prescriber habits, preferred payer lists, and regional differences.^{18,33} State variations in opioid overdose, emergency room visits, and deaths have also been reported.^{26,29,30} In a large, national analysis of opioid prescribing patterns, Schieber et al²⁸ showed regional variations in duration, rate, amount, and strength of opioid prescriptions across the United States from 2006 to 2017. Interestingly, many of the states with higher prescribing patterns found overlap with states found to have higher prescribing patterns in our study.²⁸ This finding not only helps validate our study's findings but also reiterates geographic variability in prescription patterns and illustrates the importance

Figure 2. Geographic variation in (a) proportion of opioid prescriptions and (b) opioid prescriptions ≥ 90 MMED within 30 days after anterior cruciate ligament reconstruction. MMED, morphine milligram equivalents per day.

of national guidelines for opioid prescribing. Further research is needed to determine the exact reasons for geographic variation in prescribing patterns and whether public awareness, different multimodal pain regimens, or state laws play a role in these trends.

The findings of this study are important for state programs and lawmakers and may help in opioid intervention strategies. State health officials are responsible for providing guidance, laws, and recommendations for opioid prescribing. In 2018, the National Conference of State Legislatures (NCSL) adopted guidelines for opioid prescribing that included regulations for over 25 states.²¹ Importantly, some states with the highest proportion of MMED prescribing seen in our study, such as Washington, Montana, and Idaho, have not adopted the NCSL guidelines because they use other entities for prescribing guidelines.²¹ Furthermore, these are somewhat broad guidelines for all prescribers and do not necessarily provide specific guidance on various orthopaedic procedures. Although some states have reported improvements in opioid-related overdoses and deaths, whether these new initiatives help change national prescribing patterns in orthopaedics is still to be determined.^{12,13,15,27} This leaves an opportunity for academic societies such as the American Academy of Orthopaedic Surgeons to intervene and provide recommendations to help guide

Figure 3. Annual proportions of patients prescribed opioids and those prescribed high dose opioids (≥ 90 MMED) by region and their associated 95% logit confidence intervals: (a) Northeast, (b) Midwest, (c) South, and (d) West. MMED, morphine milligram equivalents per day.

orthopaedic surgeons on a national level. This is especially important because orthopaedic surgeons have the most experience with treating postoperative pain for any given orthopaedic procedure, such as ACL reconstruction.

This study has several limitations. The MarketScan database only includes data for privately insured patients and does not include data for Medicare or Medicaid beneficiaries. However, most patients who undergo ACL reconstruction are privately insured.⁵ Additionally, the database cannot capture data on opioids that patients obtain or ingest without use of a prescription, such as from friends or family. Like all administrative databases, the MarketScan database may be subject to coding error. Moreover, the database only contains prescriptions covered by private insurance; therefore pharmacy records may be a more accurate method of assessing opioids utilization.

CONCLUSION

This study shows important trends and geographic variations in the amount and MMED of opioid prescriptions for patients

undergoing ACL reconstruction. These data highlight several areas of improvement that state officials and national entities can use to help curb the opioid epidemic and improve opioid prescribing patterns in orthopaedics. Furthermore, knowledge of prescribing patterns after specific procedures may help provide more direct insight and guidance to surgeons and patients regarding postoperative pain management.

REFERENCES

1. American Academy of Physical Medicine and Rehabilitation. *Opiates for low back pain*. Accessed April 20, 2020. <https://www.choosingwisely.org/clinician-lists/aapmr-opiates-for-low-back-pain/>
2. Anandaraajan D, Talwar D, Wells L. Significant nationwide variation exists in opioid prescription rates amongst pediatric patients with ACL injuries: a retrospective cohort study. *Orthop J Sports Med*. 2019;7(3 suppl):2325967119S00084.
3. Anthony CA, Westermann RW, Bedard N, et al. Opioid demand before and after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2017;45:3098-3103.
4. Azar AM. *Renewal of determination that a public health emergency exists*. Published April 12, 2020. Accessed April 12, 2020. <https://www.phe.gov/emergency/news/healthactions/phe/Pages/opioid-19apr2019.aspx>

5. Buller LT, Best MJ, Baraga MG, Kaplan LD. Trends in anterior cruciate ligament reconstruction in the United States. *Orthop J Sports Med.* 2015;3:2325967114563664.
6. Centers for Disease Control and Prevention Mortality. *CDC WONDER*. US Department of Health and Human Services; 2018. Accessed August 12, 2020. <https://wonder.cdc.gov>
7. Chung KS, Noonan B. A practical review of the mechanisms of pain and pain management following ACL reconstruction. *Orthopedics.* 2006;29:999-1005.
8. Delgado MK, Huang Y, Meisel Z, et al. National variation in opioid prescribing and risk of prolonged use for opioid-naïve patients treated in the emergency department for ankle sprains. *Ann Emerg Med.* 2018;72:389-400.e1.
9. Dowell D, Haegerich TM, Chou R. CDC guideline for prescribing opioids for chronic pain—United States, 2016. *JAMA.* 2016;315:1624-1645.
10. Florence CS, Zhou C, Luo F, Xu L. The economic burden of prescription opioid overdose, abuse, and dependence in the United States, 2013. *Med Care.* 2016;54:901-906.
11. Harris AB, Marrache M, Jami M, et al. Chronic opioid use following anterior cervical discectomy and fusion surgery for degenerative cervical pathology. *Spine J.* 2020;20:78-86.
12. HealthData.gov. *Wide-ranging Online Data for Epidemiologic Research (WONDER)*. Accessed April 20, 2020. <https://www.cdc.gov/drugoverdose/data/>
13. Johnson H, Paulozzi L, Porucznik C, Mack K, Herter B. Decline in drug overdose deaths after state policy changes—Florida, 2010-2012. *MMWR Morb Mortal Wkly Rep.* 2014;63:569-574.
14. Leopold SS, Beadling L. Editorial. The opioid epidemic and orthopaedic surgery—no pain, who gains? *Clin Orthop Relat Res.* 2017;475:2351-2354.
15. Lyapustina T, Rutkow L, Chang H-Y, et al. Effect of a “pill mill” law on opioid prescribing and utilization: the case of Texas. *Drug Alcohol Depend.* 2016;159:190-197.
16. Manchikanti L, Fellows B, Ailani H, Pampati V. Therapeutic use, abuse, and nonmedical use of opioids: a ten-year perspective. *Pain Physician.* 2010;13:401-435.
17. Manchikanti L, Kaye AM, Knezevic NN, et al. Responsible, safe, and effective prescription of opioids for chronic non-cancer pain: American Society of Interventional Pain Physicians (ASIPP) guidelines. *Pain Physician.* 2017;20(2 suppl):S3-S92.
18. McDonald DC, Carlson K, Izrael D. Geographic variation in opioid prescribing in the U.S. *J Pain.* 2012;13:988-996.
19. Miller M, Barber CW, Leatherman S, et al. Prescription opioid duration of action and the risk of unintentional overdose among patients receiving opioid therapy. *JAMA Intern Med.* 2015;175:608-615.
20. Paulozzi LJ, Zhang K, Jones CM, Mack KA. Risk of adverse health outcomes with increasing duration and regularity of opioid therapy. *J Am Board Fam Med.* 2014;27:329-338.
21. *Prescribing policies: states confront opioid overdose epidemic*. National Conference of State Legislatures. Accessed April 20, 2020. <https://www.ncsl.org/research/health/prescribing-policies-states-confront-opioid-overdose-epidemic.aspx>
22. Raad M, Pakpoor J, Harris AB, et al. Opioid prescriptions for new low back pain: trends and variability by state. *J Am Board Fam Med.* 2020;33:138-142.
23. Ray WA, Chung CP, Murray KT, Hall K, Stein CM. Prescription of long-acting opioids and mortality in patients with chronic noncancer pain. *JAMA.* 2016;315:2415-2423.
24. Ringwalt C, Gugelmann H, Garrettson M, et al. Differential prescribing of opioid analgesics according to physician specialty for Medicaid patients with chronic noncancer pain diagnoses. *Pain Res Manag.* 2014;19:179-185.
25. Rosenberg JM, Bilka BM, Wilson SM, Spevak C. Opioid therapy for chronic pain: overview of the 2017 US Department of Veterans Affairs and US Department of Defense clinical practice guideline. *Pain Med.* 2018;19:928-941.
26. Rudd RA, Aleshire N, Zibbell JE, Gladden RM. Increases in drug and opioid overdose deaths—United States, 2000-2014. *Am J Transplant.* 2016;16:1323-1327.
27. Rutkow L, Chang H-Y, Daubresse M, Webster DW, Stuart EA, Alexander GC. Effect of Florida's prescription drug monitoring program and pill mill laws on opioid prescribing and use. *JAMA Intern Med.* 2015;175:1642-1649.
28. Schieber LZ, Guy GP Jr, Seth P, et al. Trends and patterns of geographic variation in opioid prescribing practices by state, United States, 2006-2017. *JAMA Netw Open.* 2019;2:e190665.
29. Scholl L, Seth P, Kariisa M, Wilson N, Baldwin G. Drug and opioid-involved overdose deaths—United States, 2013-2017. *MMWR Morb Mortal Wkly Rep.* 2019;67:1419-1427.
30. Weiss AJ, Elixhauser A, Barrett ML, Steiner CA, Bailey MK, O'Malley L. Opioid-related inpatient stays and emergency department visits by state, 2009-2014: Statistical Brief #219. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Agency for Healthcare Research and Quality; 2006. Accessed April 20, 2020. <http://www.ncbi.nlm.nih.gov/books/NBK441648/>.
31. Zedler B, Xie L, Wang L, et al. Risk factors for serious prescription opioid-related toxicity or overdose among Veterans Health Administration patients. *Pain Med.* 2014;15:1911-1929.
32. Zerzan JT, Morden NE, Soumerai S, et al. Trends and geographic variation of opiate medication use in state Medicaid fee-for-service programs, 1996 to 2002. *Med Care.* 2006;44:1005-1010.

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