

# THE IMPACT OF ISOLATED PREOPERATIVE CANNABIS USE ON OUTCOMES FOLLOWING CERVICAL SPINAL FUSION: A PROPENSITY SCORE-MATCHED ANALYSIS

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## ABSTRACT

**Background:** Cannabis is the most commonly used recreational drug in the USA. Studies evaluating cannabis use and its impact on outcomes following cervical spinal fusion (CF) are limited. This study sought to assess the impact of isolated (exclusive) cannabis use on postoperative outcomes following CF by analyzing outcomes like complications, readmissions, and revisions.

**Methods:** The New York Statewide Planning and Research Cooperative System (SPARCS) was queried for patients who underwent CF between January 2009 and September 2013. Inclusion

criteria were age  $\geq 18$  years and either a minimum 90-day (for complications and readmissions) or 2-year (for revisions) follow-up surveillance. Patients with systemic disease, osteomyelitis, cancer, trauma, and concomitant substance or polysubstance abuse/dependence were excluded. Patients with a preoperative International Classification of Diseases, 9th Edition, Clinical Modification (ICD-9-CM) diagnosis of isolated cannabis abuse (Cannabis) or dependence were identified. The primary outcome measures were 90-day complications, 90-day readmissions, and two-year revisions following CF. Cannabis patients were 1:1 propensity score-matched by age, gender, race, Deyo score, surgical approach, and tobacco use to non-cannabis users and compared for outcomes. Multivariate binary stepwise logistic regression models identified independent predictors of outcomes.

**Results:** 432 patients (n=216 each) with comparable age, sex, Deyo scores, tobacco use, and distribution of anterior or posterior surgical approaches were identified (all  $p > 0.05$ ). Cannabis patients were predominantly Black (27.8% vs. 12.0%), primarily utilized Medicaid (29.6% vs. 12.5%), and had longer LOS (3.0 vs. 1.9 days), all  $p \leq 0.001$ . Both cohorts experienced comparable rates of 90-day medical and surgical, as well as overall complications (5.6% vs. 3.7%) and two-year revisions (4.2% vs. 2.8%,  $p = 0.430$ ), but isolated cannabis patients had higher 90-day readmission rates (11.6% vs. 6.0%,  $p = 0.042$ ). Isolated cannabis use independently predicted 90-day readmission (Odds Ratio=2.0), but did not predict any 90-day complications or two year revisions (all  $p > 0.05$ ).

**Conclusion:** Isolated baseline cannabis dependence/abuse was associated with increased risk of 90-day readmission following CF. Further investigation of the physiologic impact of cannabis on musculoskeletal patients may elucidate significant contributory factors.

**Level of Evidence:** III

**Keywords:** Cannabis, marijuana, cervical spinal fusion, outcomes

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## INTRODUCTION

Cannabis is currently the third most commonly used psychoactive substance worldwide, following alcohol and tobacco. Globally, cannabis use disorder is the most common drug use disorder with 22.1 million cases estimated in 2016.<sup>1</sup> As of May 2021, a total of 36 states and four territories have initiated medical marijuana programs, with 18 states having legalized it for nonmedical use. The prevalence of patients diagnosed during an inpatient stay with cannabis use disorder has continued to rise in recent decades, with an increase from 0.52% to 1.34% between 2002 and 2011.<sup>2</sup> Such expansion may stem from the utilization of cannabis in various medical fields and/or from the easier accessibility to this substance. Cannabis-based medications have demonstrated clinical benefits for sleep disturbances, chemotherapy-associated nausea and vomiting, chronic pain, and multiple sclerosis management.<sup>3</sup> However, various adverse events have been observed, including cardiovascular accidents and strokes.<sup>4,8</sup>

Cervical spinal fusion is a common orthopaedic procedure, most often indicated for degenerative disk disease, cervical spondylosis, and symptomatic cervical spinal stenosis.<sup>9</sup> Rates of cervical fusion have been steadily increasing in recent decades.<sup>9</sup> The rates of complications after cervical fusion depend on surgical approach, with anterior cervical fusion associated with the lowest risk of complications, followed by posterior, and then combined. Previous studies have found the most common postoperative complications to be respiratory, dysphagia, sepsis, and major bleed, with older age being an independent risk factor for such complications.<sup>9,10</sup>

Public opinion regarding cannabis use is evolving, and the literature on the impact of cannabis consumption in orthopaedic surgery is scarce and inconclusive. One study has documented a high prevalence of marijuana use in total joint patients and its resulting postoperative complications.<sup>11</sup> Cannabis has also been associated with lower bone mineral density and increased risk of fracture.<sup>12</sup> A study by Moon et al.<sup>8</sup> using the National Inpatient Sample (NIS) found that among 9.5 million orthopaedic postoperative patients, the use of marijuana was associated with reduced postoperative mortality after total hip, knee, and shoulder arthroplasty and traumatic femur fixation, but increased risk of stroke and cardiac disease in patients undergoing spinal. Other studies have found cannabis to be associated with higher rates of perioperative thromboembolism, neurological complications, respiratory complications, sepsis, and lengths of stay after inpatient spine surgery.<sup>13,14</sup> It has also been shown that cannabis consumption increases the risk of myocardial infarction among patients undergoing a variety of common elective procedures.<sup>15</sup> In contrast,

several studies have found no significant differences in postoperative complications or have recommended the use of marijuana as an analgesic in conjunction with standard postoperative care regimens in patients with musculoskeletal injuries.<sup>16-18</sup>

With the rising use of cannabis in the United States and the dearth of knowledge on its postoperative effects, it becomes essential to identify the impact of baseline cannabis use on surgical outcomes. This study sought to compare adverse outcomes between isolated baseline cannabis users (dependence or abuse) and non-users who underwent cervical spinal fusion and identify independent predictors of these outcomes. This study hypothesized that adverse outcomes would be comparable between the isolated cannabis use and non-use group.

## METHODS

### Data Source

The New York Statewide Planning and Research Cooperative System (SPARCS) was queried to retrieve patient-specific data. SPARCS is an all-payer comprehensive data-reporting system that collects patient characteristics, diagnoses, treatments, services, and charges for each inpatient stay and outpatient visit. Each patient is assigned a unique identifier that allows for longitudinal follow-up. Diagnostic and procedural data are classified according to the International Classification of Diseases, 9th Edition, Clinical Modification (ICD-9-CM).

### Patient Population

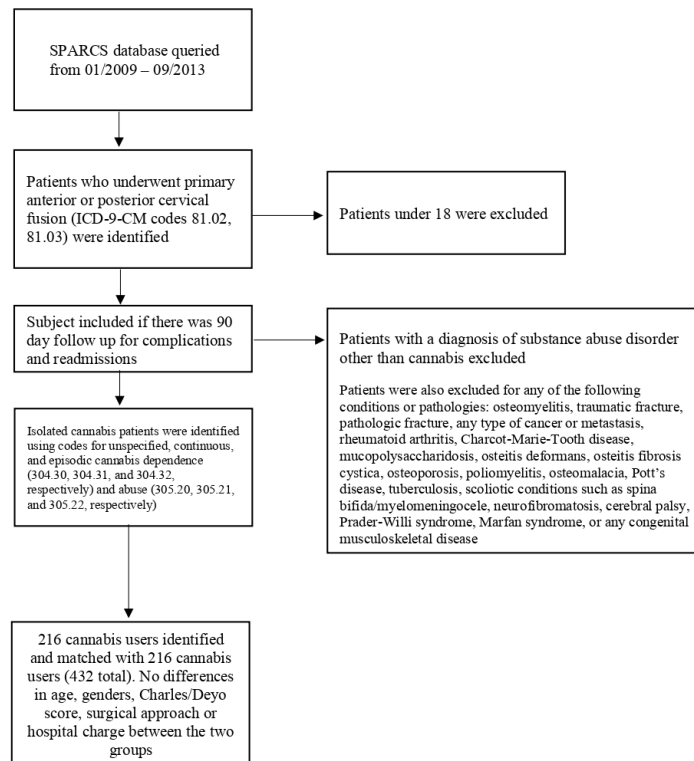
All patients who underwent primary anterior or posterior cervical fusion (ICD-9-CM codes 81.02, 81.03) between January 2009 and September 2013 were identified. Subjects were subsequently included if aged >18 years and if they had follow-up surveillance of 90 days for complications and all-cause readmissions. Subjects included in the analysis cohort also required minimum two-year follow-up surveillance for revision procedures. Within this cohort, isolated cannabis patients were identified with specific ICD-9-CM codes. Diagnoses included unspecified, continuous, and episodic cannabis dependence (304.30, 304.31, and 304.32, respectively) and abuse (305.20, 305.21, and 305.22, respectively) (Figure 1).

### Exclusion Criteria

Patients were excluded for any of the following conditions or pathologies: osteomyelitis, traumatic fracture, pathologic fracture, any type of cancer or metastasis, rheumatoid arthritis, Charcot-Marie-Tooth disease, mucopolysaccharidosis, osteitis deformans, osteitis fibrosis cystica, osteoporosis, poliomyelitis, osteomalacia, Pott's disease, tuberculosis, scoliotic conditions such as spina bifida/myelomeningocele, neurofibromatosis, cerebral

**Table 1. Comparison of Demographics Between Cannabis and Non-Cannabis Users Who Underwent Primary Cervical Fusion**

		Non-Cannabis	Cannabis	p-value
Age		45.1 ±10.6	45.2 ±10.3	0.933
Sex	Male	70.8%	71.3%	0.916
	Female	29.2%	28.7%	
Race	White	66.2%	52.3%	0.001
	Black	12.0%	27.8%	
	Hispanic	10.2%	9.7%	
	Asian	2.8%	0.5%	
	Native American	0.0%	0.5%	
	Other	8.8%	9.3%	
Insurance	Medicare	8.8%	11.6%	<0.001
	Medicaid	12.5%	29.6%	
	Private Insurance	58.8%	37.5%	
	Self-Pay	2.8%	3.2%	
	No Charge	0.0%	0.0%	
	Other	17.1%	18.1%	
Length Of Stay (Days)		1.9 ±1.8	3.0 ± 4.5	<0.001
Total Charges (USD)		\$41,267.88 ±\$36,077.33	\$48,422.29 ±\$61,197.11	0.127
Surgical Approach	Anterior	90.3%	87.0%	0.288
	Posterior	9.7%	13.0%	
Charlson/Deyo		0.11±0.34	0.11 ±0.32	0.935
Tobacco		44.40%	50.0%	0.247



**Figure 1. Flow diagram of the inclusion and exclusion criteria used in this study.**

**Table 2. Comparing the 90-Day Rates of Individual and Overall Complications, 90-Day Readmissions, and Any Revisions Between Cannabis and Non-Cannabis Groups**

Medical Complications	Non-Cannabis	Cannabis	p-value
Acute renal failure	0.0%	0.5%	0.317
Acute myocardial infarction	0.0%	0.5%	0.317
Altered mental status	0.0%	0.0%	-
Anemia	0.5%	1.4%	0.315
Acute respiratory distress syndrome	0.0%	0.5%	0.317
Cardiac	0.0%	0.0%	-
Digestive	0.0%	0.0%	0.317
Deep vein thrombosis	0.5%	0.5%	-
Hematoma	0.5%	0.0%	0.317
Infection	0.5%	0.0%	0.317
Nervous	0.0%	0.5%	0.317
Pulmonary embolism	0.0%	0.0%	-
Pneumonia	0.5%	0.5%	-
Puncture	0.5%	0.0%	0.317
Peripheral vascular disease	0.0%	0.0%	-
Respiratory	0.5%	0.5%	-
Sepsis	0.0%	0.0%	-
Urinary	0.0%	0.5%	0.317
Any medical complication	2.8%	4.6%	0.308
Surgical Complications	Non-Cannabis	Cannabis	p-value
Hemorrhage	0.0%	0.0%	-
Wound disruption	0.0%	0.0%	-
Wound infection	0.5%	0.5%	-
Implant infection	0.0%	0.0%	-
Irrigation debridement	0.0%	0.0%	-
Postoperative dislocation	0.5%	0.0%	0.317
Implant-related complications	0.0%	0.5%	0.317
Central nervous system complications	0.0%	0.0%	-
Dural tear	0.5%	0.0%	0.317
Blood other transfusion	0.0%	0.0%	-
Other unspecified surgical complications	0.0%	0.4%	0.317
Any surgical complication	1.4%	0.9%	0.653
Total Complications	3.7%	5.6%	0.360
Readmissions	6.0%	11.6%	0.042
Revisions	2.8%	4.2%	0.430

palsy, Prader-Willi syndrome, Marfan syndrome, or any congenital musculoskeletal disease. Patients with a co-diagnosis or a prior diagnosis of any other substance use disorder (alcohol, cocaine, barbiturates, opioids, amphetamines, hallucinogens, antidepressants, and mixed/other substances) were also excluded from the analysis (Figure 1).

### Data Collection

The data extracted included patient demographics (age, gender, race, and insurance), hospital-related parameters (length of stay, hospital charges), surgical approaches (anterior or posterior) and 90-day complication rates (individual and overall medical, individual, and overall surgical, and total complications). 90-day all-cause readmissions, and two-year revisions were recorded.

### Statistical Analysis

A 1:1 propensity score-matching algorithm was first developed based on the patients' age, sex, race, Charlson/Deyo score, history of tobacco use, as well as the surgical approach employed for patients undergoing cervical spinal fusion. Patients were then stratified into two groups based on their consumption of cannabis (Cannabis and Non-Cannabis cohorts). Hospital-related parameters, 90-day complications, 90-day all-cause readmissions, and subsequent revision procedures were compared between both groups. Continuous and categorical variables were compared using Student's T-tests and Chi-square analysis, respectively. Multivariate binary stepwise logistic regression models were utilized to identify independent predictors of outcomes, while using age, sex, race, Charlson/Deyo score, and cannabis use as covariates. The threshold for statistical significance was defined as  $p$ -value  $< 0.05$ . All analysis was performed using SPSS software version 24.0 (IBM Corp., Armonk, NY, USA).

## RESULTS

During the study period, 216 cannabis users were identified and 1:1 propensity score-matched to 216 non-cannabis users (432 individuals in total). No significant differences were identified between both patient groups in terms of age ( $p=0.933$ ), gender ( $p=0.916$ ), Charlson/Deyo scores ( $p=0.935$ ), surgical approach used ( $p=0.288$ ), and hospital charges (\$48,422 vs. \$41,268,  $p=0.127$ ) (Table 1).

Cannabis and non-cannabis cohorts experienced comparable rates of individual medical complications, including respiratory complications ( $p=1.000$ ), acute respiratory distress syndrome ( $p=0.317$ ), and pneumonia ( $p=1.000$ ). Individual surgical complications were also comparable between both groups, including implant-related com-

plications ( $p=0.317$ ), dural tears ( $p=0.317$ ), and wound infections ( $p=1.000$ ). Similarly, overall complications ( $p=0.360$ ) and revisions ( $p=0.430$ ) did not statistically differ based on cannabis use. However, cannabis users had significantly higher rates of 90-day postoperative all-cause readmissions (11.6% vs. 6.0%,  $p=0.042$ ). Individual and overall, medical and surgical complications are summarized in Table 2.

Isolated cannabis use was not associated with significantly increased risk of any 90-day individual medical or surgical complications, 90-day overall complications, or two-year revision cervical surgery ( $p>0.05$ ). However, compared to non-cannabis use, isolated cannabis use was significantly associated with 90-day readmission (Odds Ratio [OR]=2.0, 95% CI: 1.004-4.1,  $p=0.049$ ).

## DISCUSSION

As cannabis is becoming more commonly legalized, it is important to elucidate its effects on surgical outcomes. This study sought to identify any association between isolated cannabis use and postoperative outcomes after cervical spinal fusion. The findings in this study are the first to demonstrate that cannabis was associated with 90-day readmissions following cervical fusion. Choy et al.<sup>19</sup> reported on risk factors for readmission following cervical spinal fusion and found age  $>70$  years (OR=1.6,  $p=0.012$ ), renal failure requiring dialysis (OR=3.7,  $p=0.011$ ), anemia (OR=1.6,  $p=0.006$ ), and multilevel fusion (OR=1.6,  $p=0.012$ ) to increase the odds of readmission within 30 days. A previous meta-analysis by Bernatz et al.<sup>20</sup> noted that 30-day readmission following spinal surgeries ranged between 4.2% and 7.4%. The authors additionally reported readmission rates for single institutions (6.6%, 95%CI: 3.8%-11.1%) and multicenter registries (4.7%, 95%CI: 2.3%-9.7%).<sup>20</sup> Additional retrospective studies have identified similar 30-day readmission rates.<sup>19,21</sup> Compared to existing literature, this study found an increased rate of readmission among isolated cannabis users (11.6%). Bernatz and Anderson<sup>20</sup> reported the most common reasons for readmission to be surgical wound complications (39.3%), and medical (including deep venous thromboses, pulmonary embolisms, pneumonias, and urinary tract infections) complications (26.6%). Adogwa et al.<sup>22</sup> also reported readmission rates due to pain intolerance (19.7%) and noted that 26.5% of all readmissions required a revision. While there was no difference in individual medical and surgical complications between the cannabis and non-cannabis group, the increased rate of readmission among cannabis users may comprise of more severe complications. Further studies with prospective patient samples are warranted to identify the specific causes of readmission associated with cannabis consumption.

This study sought to determine the impact of cannabis use on postoperative complications in patients undergoing cervical spine fusions and found no significant difference in rates of complications and revision surgery between patients using and not using cannabis. A prior study found that isolated cannabis use in patient undergoing thoracolumbar spinal fusion was not associated with increased readmissions as well as surgical complications or revision.<sup>23</sup> That study also found a reduction in medical complications in the cannabis users.<sup>23</sup> Lumbar fusion was found to have increased re-operations but no increase in readmissions in cannabis patients.<sup>24</sup> This underscores the need for more research in this area. Prior research has shown a decrease in postoperative mortality associated with cannabis consumption, though an increase in the rate of medical complications in the post-operative period (stroke and DVT more specifically) in patients undergoing common orthopedic procedures.<sup>8</sup> Additionally, studies on trauma patients have also reported a beneficial effect of cannabis use on survival. Nguyen et al.<sup>25</sup> evaluated patients with positive cannabis toxicology tests and identified that positively tested patients carried lower odds of death following traumatic brain injury. A study by Singer et al.<sup>26</sup> reported ICU trauma patients also demonstrated lower mortality rates in patients with positive toxicology tests. The present study excluded patients with use of other substances besides cannabis allowing us to identify the effect of isolated cannabis use. This may account for many of the differences found by the present study. Excluding patients diagnosed with concomitant poly-substance use, a feature unique to this study, may have eliminated the associated increases in complications previously reported in drug-using TKA and THA patients.<sup>8</sup> Further research on the impacts of isolated cannabis use is warranted.

This study carries several limitations. It is a retrospective review of an administrative database. Although SPARCS is noted to collect outpatient data from ambulatory surgery, emergency departments, and hospital extension clinics, the database would not be able to comprehensively account for events that may have occurred outside of inpatient hospitalization, such as primary care or private practice clinics. Therefore, this study is unable to fully account for cannabis use diagnoses that may have occurred outside the inpatient setting. Additionally, this study could not consider variables that relate to cannabis use dependence/abuse. Such variables include the reason for cannabis use (medicinal or recreational), cumulative exposure, concentrations, as well as routes of administration (inhalation, vaporization, etc.).<sup>7</sup> With new changes to ICD-10-CM coding and DSM 5 classification systems, including broader diagnoses of cannabis use disorders, future studies may be better suited to

stratify these patients. This study had a sample size of 216 patients for each cohort due to stringent exclusion of patients with any other documented substance use in order to reduce confounding. Additionally, given the legal status of cannabis at the time this data was recorded, cannabis use was likely underreported, and the percentage of users is likely higher than found in this study.<sup>27,28</sup> Patients who use tobacco were not specifically excluded, given they are not categorized as illicit substances. While its use may serve as a potential confounder, tobacco use was included as a variable in the propensity score-match to address this. Though the regression analysis controlled for age, sex, Charlson/Deyo score, and cervical surgical approach, the authors could not rule out the potential influence that economic and insurance status may have on the included patients. Li et al.<sup>29</sup> found that having private insurance was associated with a lower risk of perioperative medical and surgical complications for shoulder arthroplasty when compared with age-matched and sex-matched Medicaid, Medicare, and uninsured patients. Similar studies on hip arthroplasty have shown significantly higher complication rates in Medicaid and/or Medicare patients than in privately insured patients.<sup>30</sup> Race may also have been a potential confounder. A systematic review conducted by Schoenfeld et al.<sup>31</sup> found that following spine and joint replacement procedures, patients from ethnic and racial minority populations seemed to be at an increased risk of mortality and/or complications. Several studies have demonstrated controlling for hospital location or comorbidities could reduce this potential risk.<sup>32-34</sup> However, this study's propensity-score matching design helped mitigate confounding variables that could interfere with the analysis.

## CONCLUSION

Isolated cannabis use was an independent predictor of 90-day readmissions, but not of revisions or any individual/overall medical or surgical complication(s) following cervical fusion. To the best of our knowledge, there is no currently available study that has investigated the relationship between cannabis use and readmission following cervical fusion. While noting an association between isolated cannabis consumption and readmission rates, this study can assist spine surgeons in optimizing operative outcomes and mitigating postoperative rates of complications, revisions, and readmissions among patients using cannabis. Of interest within this patient cohort is the postoperative analgesic requirements that could contribute to the increase in 90-day readmission rates. Further investigation is warranted to evaluate this further, as well as determine what physiologic impact cannabis has on musculoskeletal patients.

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