

# The Association of Cannabis and Tobacco Use With Postoperative Complications after Ankle and Hindfoot Arthrodesis

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## Abstract

**Background:** The purpose of this study was to investigate the association between cannabis use and postoperative complications following ankle and hindfoot arthrodesis.

**Methods:** A retrospective cohort study using a large national insurance database from 2010 to 2022 was conducted. All patients who underwent ankle or hindfoot arthrodesis with at least 2 years' follow-up were included. Patients were divided into 4 groups: cannabis-only users, tobacco-only users, cannabis and tobacco users, and nonuser controls. Groups were matched 1:4 with nonuser controls based on demographic variables and comorbidities. Also, both cannabis and tobacco users were matched 1:4 with tobacco-only users based on demographics and comorbidities. Medical complications within 90 days of surgery and surgery-specific complications within 2 years were compared between groups with multivariable logistic regressions.

**Results:** Compared with nonuser controls, cannabis users only were not at increased risk of 90-day medical complications or 2-year surgical complications. Tobacco use alone was associated with increased risk of postoperative admission (OR 1.32, 95% CI 1.21–1.43) and emergency department (ED) utilization (OR 1.57, 95% CI 1.48–1.66) within 90 days as well as infection (OR 1.24, 95% CI 1.18–1.30), hardware removal (OR 1.12, 95% CI 1.07–1.18), nonunion (OR 1.33, 95% CI 1.27–1.40), and wound dehiscence (OR 1.38, 95% CI 1.27–1.49) within 2 years of surgery compared with nonuser controls. Compared with tobacco-only use, combined cannabis and tobacco use was associated with increased risk of ED visits within 90 days (OR 1.45, 95% CI 1.30–1.62) and nonunion within 2 years of surgery (OR 1.19, 95% CI 1.05–1.35).

**Conclusion:** These findings suggest that although cannabis use alone was not associated with a higher risk of postoperative complications, its concurrent use with tobacco was linked to greater rates of adverse outcomes.

**Level of Evidence:** Level III, retrospective case control study.

**Keywords:** Ankle arthrodesis, ankle fusion, cannabis, tobacco, complications

## Introduction

Ankle and hindfoot arthrodesis are commonly performed procedures to relieve pain and improve function in those with debilitating joint disease.<sup>13,20</sup> Despite their effectiveness, complications after these procedures have been found to be around 10%–30% in some studies.<sup>18,30,33</sup> Complications following ankle and hindfoot arthrodesis include nonunion, infection, wound dehiscence, amputation, and tibial stress fractures.<sup>21</sup> Prior research has found an increased complication rate in active tobacco users, noting that active users have about a 4

times elevated relative risk for nonunion compared with non-smokers.<sup>7,23</sup> Despite the well-documented negative effects of tobacco use, the influence of other substances, such as cannabis, remain less clear.

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In the United States, 24 states have legalized cannabis for recreational use and 38 states have legalized it for medical use.<sup>5</sup> Consequently, cannabis use among Americans has grown markedly, with an estimated 17% of adults reporting usage in 2024.<sup>3,12,11</sup> In comparison, tobacco usage has declined in recent years, with only 12% of adults reporting usage in 2024.<sup>10</sup> With the increasing usage of cannabis, it becomes crucial to consider its potential impact on surgical outcomes.

Recent research has explored the risks for postoperative complications in patients who use cannabis, including in several orthopaedic procedures such as lumbar fusion, total knee arthroplasty, and total hip arthroplasty.<sup>15,24,36</sup> However, no study has examined the association between cannabis use with complications following ankle or hindfoot arthrodesis. Thus, the aim of this study was to investigate the association between cannabis use and postoperative outcomes following ankle and hindfoot arthrodesis. The authors hypothesized that cannabis use would be associated with increased medical and surgical complications compared with no cannabis use.

## Methods

### Data Source

The PearlDiver Mariner Database (PearlDiver Inc, Colorado Springs, CO), a commercially available administrative claims database which contains deidentified patient data from 2010 to 2022, was queried for this study. The “M165Ortho” data set within PearlDiver was used that contains a sample of 165 million patients. This data set allows users to longitudinally track patient complications and outcomes using *International Classification of Diseases, Ninth (ICD-9)* and *Tenth Revision (ICD-10)*, as well as *Current Procedural Terminology (CPT)* codes. PearlDiver data is Health Insurance Portability and Accountability Act (HIPAA) compliant, and therefore approval from our institutional review board was deemed exempt for this study.

### Study Design

A retrospective cohort study was performed to evaluate the association of cannabis use with outcomes after ankle or hindfoot arthrodesis. We identified arthrodesis patients with procedural *ICD* and *CPT* codes (Appendix). Patients were excluded if they had codes for diabetic neuropathy or any infectious process on the day of surgery. Additionally, patients with a history of ankle arthroplasty were excluded. Only patients with continuous follow-up 6 months before and 2 years after their index procedure were included to limit potential transfer bias.

Cannabis users were identified by any patient with any cannabis-related *ICD* codes without any tobacco-related

codes. Tobacco users were identified by any patients with a tobacco-related *ICD* code without any cannabis-related codes. Patients with codes for both cannabis and tobacco use were included in a combined use group. Controls were defined by any patients who met inclusion criteria that did not have any tobacco- or cannabis-related diagnoses. This methodology was adapted from Winter et al<sup>37</sup> who evaluated the effect of smokeless tobacco on complications after ankle and hindfoot arthrodesis and has been successfully applied to multiple studies on outcomes after orthopaedic procedures.<sup>9,34,35</sup>

### Propensity Score Matching

The resulting cohort of arthrodesis patients were divided into 4 groups; cannabis-only users, tobacco-only users, combined cannabis and tobacco users, and nonuser controls. Cannabis-only users, tobacco-only users, and combined users were each propensity score matched 1:4 with unique nonuser controls based on the following parameters: age, sex, Elixhauser Comorbidity Index (ECI), diabetes, and obesity. Finally, combined cannabis and tobacco users were matched 1:4 with tobacco-only users based on the same parameters listed above. In total, there were 4 separate propensity score matches for each comparison; cannabis only vs controls, tobacco only vs controls, combined use vs controls, and tobacco only vs combined use.

### Outcome Measures

Complications within 90 days of the procedure, including pulmonary embolism, deep vein thrombosis, pneumonia, acute kidney injury, urinary tract infection, postoperative emergency department (ED) visits, and readmissions, were assessed for all groups. Surgical complications within 2 years of the index procedure, including infection, hardware removal, nonunion, and wound dehiscence, were assessed for all matched groups.

### Statistical Analysis

Demographic variables and comorbidities were compared between groups with *t* tests for continuous variables and  $\chi^2$  for categorical variables. Rates of postoperative complications were compared using multivariable logistic regressions controlling for age, gender, ECI, and alcohol abuse. Additionally, all demographic variables and comorbidities statistically significant between groups as seen in Table 1 were controlled for in the appropriate regressions. A Bonferroni correction was applied, and statistical significance was set to  $P < .005$ . All analyses were performed using R software (R Foundation for Statistical Computing, Vienna, Austria) provided within the PearlDiver database.

**Table 1.** Demographic Variables and Comorbidity Characteristics of Each Cohort.<sup>a</sup>

Comorbidities	Cannabis (n = 380)		Control (n = 1520)		P Value	Tobacco (n = 25,114)		Control (n = 33,250)		P Value	Both Tobacco and Cannabis (n = 2294)		P Value	Both Tobacco and Cannabis (n = 2291)		P Value	Tobacco (n = 8320)		P Value
	Number (%)	Number (%)	Number (%)	Number (%)		Number (%)	Number (%)	Number (%)	Number (%)		Number (%)	Number (%)		Number (%)	Number (%)		Number (%)	Number (%)	
Age (SD)	39.5 (17.7)	39.0 (18.0)	.63	55.8 (13.4)	54.2 (17.6)	<.001	44.3 (13.3)	43.3 (19.0)	.005	44.3 (13.3)	45.5 (13.2)	<.001	44.3 (13.3)	45.5 (13.2)	<.001	44.3 (13.3)	45.5 (13.2)	<.001	
Male	214 (56.3)	861 (56.6)	.95	12487 (49.7)	13427 (40.4)	<.001	1293 (56.3)	4887 (55.7)	.58	1291 (56.4)	4549 (54.7)	.16	1291 (56.4)	4549 (54.7)	.16	1291 (56.4)	4549 (54.7)	.16	
Female	166 (43.7)	659 (34.4)		12627 (50.3)	19823 (59.6)		1001 (43.6)	3889 (44.3)		1000 (43.6)	3771 (45.3)		1000 (43.6)	3771 (45.3)		1000 (43.6)	3771 (45.3)		
ECL mean (SD)	3.83 (3.65)	3.57 (3.51)	.20	4.53 (3.44)	3.64 (3.15)	<.001	5.53 (3.94)	5.02 (4.08)	<.001	5.52 (3.95)	5.34 (4.21)	.05	5.52 (3.95)	5.34 (4.21)	.05	5.52 (3.95)	5.34 (4.21)	.05	
Alcohol abuse	101 (26.6)	93 (6.1)	<.001	3789 (15.1)	1467 (4.4)	<.001	1099 (47.9)	568 (6.5)	<.001	1097 (47.9)	1726 (20.7)	<.001	1097 (47.9)	1726 (20.7)	<.001	1097 (47.9)	1726 (20.7)	<.001	
CKD	52 (13.7)	231 (15.2)	.51	5744 (22.9)	6635 (20.0)	<.001	413 (18.0)	2070 (23.6)	<.001	412 (18.0)	1666 (20.0)	.03	412 (18.0)	1666 (20.0)	.03	412 (18.0)	1666 (20.0)	.03	
COPD	133 (35.0)	51 (33.6)	.64	12502 (49.8)	10718 (32.2)	<.001	1300 (56.7)	3522 (40.1)	<.001	1299 (56.7)	4246 (51.0)	<.001	1299 (56.7)	4246 (51.0)	<.001	1299 (56.7)	4246 (51.0)	<.001	
CHF	25 (6.6)	103 (6.8)	.98	2627 (10.5)	2787 (8.4)	<.001	167 (7.3)	1028 (11.7)	<.001	167 (7.3)	982 (11.8)	<.001	167 (7.3)	982 (11.8)	<.001	167 (7.3)	982 (11.8)	<.001	
CAD	52 (13.7)	240 (15.8)	.35	8818 (35.1)	8258 (24.8)	<.001	620 (27.0)	2120 (24.2)	.005	622 (27.1)	2387 (28.7)	.16	622 (27.1)	2387 (28.7)	.16	622 (27.1)	2387 (28.7)	.16	
Obesity	198 (52.1)	816 (53.7)	.62	14703 (58.5)	17073 (51.3)	<.001	1232 (53.7)	4776 (54.4)	.56	1233 (53.8)	4809 (57.8)	<.001	1233 (53.8)	4809 (57.8)	<.001	1233 (53.8)	4809 (57.8)	<.001	
Diabetes	123 (32.4)	454 (29.9)	.38	12148 (48.4)	13861 (41.7)	<.001	985 (42.9)	3679 (41.9)	.39	984 (43.0)	3749 (45.1)	.08	984 (43.0)	3749 (45.1)	.08	984 (43.0)	3749 (45.1)	.08	
RA	20 (5.3)	81 (5.3)	1.00	2299 (9.2)	2816 (8.5)	.004	158 (6.9)	689 (7.9)	.13	158 (6.9)	664 (8.0)	.09	158 (6.9)	664 (8.0)	.09	158 (6.9)	664 (8.0)	.09	
Hypertension	211 (55.5)	825 (54.3)	.70	20559 (81.9)	23998 (72.2)	<.001	1681 (73.3)	5760 (65.6)	<.001	1679 (73.3)	6225 (74.8)	.14	1679 (73.3)	6225 (74.8)	.14	1679 (73.3)	6225 (74.8)	.14	

Abbreviations: CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; ECl, Elixhauser Comorbidity Index; RA, rheumatoid arthritis.  
<sup>a</sup>Boldface indicates significance ( $P < .05$ ).

## Results

### Cohort Characteristics

After applying exclusion criteria, there were 61,705 ankle or hindfoot arthrodesis patients eligible for analysis. In total, 28 453 patients (46%) were documented as using either cannabis, tobacco, or both based on ICD coding. More specifically, 380 (0.62%) used cannabis only, 25 774 (42%) used tobacco only, and 2299 (3.7%) used both cannabis and tobacco. The cannabis-only group was the youngest of the cohorts (mean 39.5, SD 17.7) and had the highest proportion of males (56.3%). The tobacco-only cohort was the oldest of the cohorts (mean 55.8, SD 13.4) and was 50.3% male. Patients who used both tobacco and cannabis had the highest average ECI (5.53, SD 3.94) compared with other cohorts.

In terms of comorbidities, alcohol abuse was significantly higher in the cannabis group (26.6%) compared with its nonuser control (6.1%) ( $P < .001$ ), in the tobacco group (15.1%) compared with its nonuser control (4.4%) ( $P < .001$ ), and in the combined tobacco and cannabis group (47.9%) compared with its nonuser control group (6.5%) ( $P < .001$ ). There were no differences in obesity between the cannabis-only cohort and nonuser controls (52.1% vs 53.7%,  $P = .62$ ) as well as in the combined tobacco and cannabis group compared with nonuser controls (53.7% vs 54.4%,  $P = .56$ ). Tobacco users had significantly higher rates of obesity compared with the nonuser controls (58.5% vs 51.3%,  $P < .001$ ). Similarly, there were no differences in diabetes between the cannabis-use-only group and nonuser controls (32.4% vs 29.9%,  $P = .38$ ) as well as the combined use group and nonuser controls (42.9% vs 41.9%,  $P = .39$ ). Tobacco users had significantly higher rates of diabetes compared with nonuser controls (48.4% vs 41.7%,  $P < .001$ ). Additional demographic variables and comorbidities compared between groups and their respective controls can be found in Table 1.

### Ninety-Day Medical Complications

When comparing cannabis only use to their respective controls, there were no significant differences in the risk of 90-day medical complications. Tobacco use alone was associated with a higher risk of hospital admissions (5.8% vs 3.6%; OR 1.32, 95% CI 1.21-1.43) and ED visits (14.7% vs 8.7%; OR 1.57, 95% CI 1.48-1.66) compared with controls. Similarly, tobacco and cannabis combined use was associated with a higher risk of hospital admissions (8.4% vs 5.6%; OR 1.43, 95% CI 1.16-1.76) and ED visits (29.8% vs 12.2%; OR 2.86, 95% CI 2.51-3.27) compared with controls. Lastly, when comparing the combined use of tobacco and cannabis to tobacco use only, combined use was associated with a significantly higher risk of ED visits (29.7% vs

20.9%; OR 1.45, 95% CI 1.30-1.62). The number and percentage of 90-day medical complications compared between groups are demonstrated in Table 2.

### Two-Year Surgical Complications

There were no significant differences observed in infection rates, hardware removal, nonunion, or wound dehiscence when comparing cannabis-only use to their respective controls. Tobacco-only use was associated with a significantly higher risk of infection (16.4% vs 11.8%; OR 1.24, 95% CI 1.18-1.30), hardware removal (15.8% vs 13.8%; OR 1.12; 95% CI 1.07-1.18), nonunion (15.5% vs 11.1%; OR 1.33, 95% CI 1.27-1.40), and wound dehiscence (6.3% vs 4.0%; OR 1.38, 95% CI 1.27-1.49) compared with controls. Similarly, tobacco and cannabis combined use was associated with a higher risk of infection (23.3% vs 15.0%; OR 1.72, 95% CI 1.51-1.97), hardware removal (20.4% vs 16.1%; OR 1.24, 95% CI 1.08-1.42), nonunion (19.6% vs 10.8%; OR 1.90, 95% CI 1.64-2.20), and wound dehiscence (9.5% vs 5.2%; OR 1.86, 95% CI 1.52-2.27). When comparing the combined use of tobacco and cannabis to tobacco only use, combined use was associated with a significantly higher risk of nonunion (19.6% vs 16.4%; OR 1.19, 95% CI 1.05-1.35). The number and percentage of 2-year surgical complications compared between groups is displayed in Table 2.

## Discussion

This main finding of this study was that there were no significant differences in outcomes between cannabis users and nonuser controls. Combined cannabis and tobacco use was found to be associated with worse outcomes compared with tobacco alone. Specifically, combined use was associated with higher rates of ED visits within 90 days, and nonunion within 2 years of the index procedure compared with tobacco use alone. These findings suggest that although cannabis use alone does not significantly affect postoperative outcomes following ankle and hindfoot arthrodesis, the combined use of cannabis and tobacco is associated with a greater risk of complications. Based on the observed associations, surgeons should be mindful of the associated risks of combined cannabis and tobacco use when evaluating patient risk factors and developing postoperative care plans.

Previous studies investigating the effect of cannabis use on orthopaedic procedures have yielded mixed results. For instance, in patients undergoing total shoulder arthroplasty, cannabis use alone was not associated with adverse postoperative outcomes.<sup>6</sup> However, contrasting findings were observed in studies examining total knee arthroplasty, where cannabis use was associated with increased rates of infection, venous thromboembolism, and revision surgery.<sup>17,31,32,36</sup> Additionally, in patients undergoing spinal fusion, cannabis

**Table 2. Ankle and Hindfoot Arthrodesis 90-Day Medical and 2-Year Joint Complications.<sup>a</sup>**

Complications	Cannabis (n = 380)		Control (n = 1520)		OR (95% CI)		Tobacco (n = 25,114)		Control (n = 33,250)		OR (95% CI)		Both Tobacco and Cannabis (n = 2294)		Control (n = 8776)		OR (95% CI)		Both Tobacco and Cannabis (n = 2291)		Tobacco (n = 8320)		OR (95% CI)	
	Number (%)	Number (%)	Number (%)	Number (%)	OR (95% CI)	Number (%)	Number (%)	Number (%)	Number (%)	OR (95% CI)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	
90-d medical complications																								
PE	0 (0)	<11	19 (1.3)	<0.001 (NA)	123 (0.5)	174 (0.5)	0.75 (0.59-0.96)	<11	34 (0.4)	1.08 (0.44-2.36)	<11	27 (1.2)	37 (0.4)	0.83 (0.37-1.71)										
DVT	<11	<11	19 (1.3)	1.68 (0.60-4.03)	330 (1.3)	404 (1.2)	0.96 (0.82-1.11)	27 (1.2)	103 (1.2)	0.98 (0.59-1.60)	27 (1.2)	136 (1.6)	0.70 (0.45-1.06)											
Pneumonia	<11	<11	19 (1.3)	2.22 (0.64-6.66)	338 (1.3)	328 (1.0)	1.05 (0.89-1.23)	36 (1.6)	133 (1.5)	0.86 (0.55-1.33)	35 (1.5)	130 (1.6)	1.05 (0.70-1.55)											
AKI	<11	<11	19 (1.3)	1.22 (0.40-3.29)	533 (2.1)	507 (1.5)	1.08 (0.95-1.24)	47 (2.0)	222 (2.5)	0.94 (0.64-1.38)	48 (2.1)	234 (2.8)	0.87 (0.61-1.21)											
UTI	<11	27 (1.8)	57 (3.8)	0.59 (0.20-1.46)	634 (2.5)	817 (2.5)	0.94 (0.84-1.05)	59 (2.6)	251 (2.6)	0.91 (0.64-1.26)	59 (2.6)	213 (2.6)	1.08 (0.79-1.47)											
Admission	17 (4.5)	57 (3.8)	57 (3.8)	1.04 (0.55-1.85)	1458 (5.8)	1205 (3.6)	1.32 (1.21-1.43)	193 (8.4)	488 (5.6)	1.43 (1.16-1.76)	191 (8.3)	600 (7.2)	1.13 (0.94-1.35)											
ED visits	53 (13.9)	191 (12.6)	191 (12.6)	1.04 (0.72-1.47)	3683 (14.7)	2888 (8.7)	1.57 (1.48-1.66)	683 (29.8)	1072 (12.2)	2.86 (2.51-3.27)	680 (29.7)	1737 (20.9)	1.45 (1.30-1.62)											
2-y joint complications																								
Infection	53 (13.9)	198 (13.0)	198 (13.0)	1.04 (0.72-1.47)	4109 (16.4)	3926 (11.8)	1.24 (1.18-1.30)	534 (23.3)	1319 (15.0)	1.72 (1.51-1.97)	534 (23.3)	1684 (20.2)	1.16 (1.03-1.31)											
Hardware removal	55 (14.5)	247 (16.3)	247 (16.3)	0.89 (0.64-1.23)	3973 (15.8)	4579 (13.8)	1.12 (1.07-1.18)	467 (20.4)	1413 (16.1)	1.24 (1.08-1.42)	465 (20.3)	1514 (18.2)	1.08 (0.95-1.21)											
Nonunion	42 (11.1)	161 (10.6)	161 (10.6)	1.04 (0.71-1.51)	3888 (15.5)	3687 (11.1)	1.33 (1.27-1.40)	450 (19.6)	948 (10.8)	1.90 (1.64-2.20)	449 (19.6)	1361 (16.4)	1.19 (1.05-1.35)											
Wound dehiscence	23 (6.1)	51 (3.4)	51 (3.4)	1.66 (0.95-2.84)	1578 (6.3)	1337 (4.0)	1.38 (1.27-1.49)	217 (9.5)	453 (5.2)	1.86 (1.52-2.27)	217 (9.5)	623 (7.5)	1.24 (1.04-1.47)											

Abbreviations: AKI, acute kidney injury; DVT, deep vein thrombosis; ED, emergency department; OR, odds ratio; PE, pulmonary embolism; UTI, urinary tract infection.

<sup>a</sup>Boldface indicates significance ( $P < .005$ ).



was associated with higher rates of nonunion compared with controls.<sup>2</sup> These disparate results highlight the complexity and variability in how cannabis use may affect different types of orthopaedic procedures. For foot and ankle procedures, cannabis-only users undergoing open reduction and internal fixation for ankle fractures had no significant differences in outcomes compared with nonuser controls, but combined cannabis and tobacco users had worse outcomes.<sup>9</sup> We found similar results in patients undergoing ankle and hindfoot arthrodesis. These findings, combined with prior literature on foot and ankle procedures, suggest that tobacco is associated with worse outcomes whereas cannabis use does not appear to be associated with increased complication rates.

Cannabis use has previously been suggested to affect surgical outcomes through several mechanisms. For example, cannabis use has been shown to negatively affect bone healing, increasing bone turnover and reducing bone mineral density.<sup>19</sup> When broken down, metabolites of cannabis bind to cannabinoid receptors that are also present in the skeletal system and may regulate osteoblast and osteoclast activity.<sup>22,28</sup> Additionally, cannabis use has been associated with immunosuppressive properties, potentially increasing the risk of postoperative infection.<sup>8,25</sup> Our findings suggest that cannabis use alone does not appear to be associated with adverse postoperative outcomes following ankle and hindfoot arthrodesis, although further research is needed to clarify these results in the context of previous literature. The reason for this is ultimately unclear but may be due to several factors. First, much of the literature regarding the effects of cannabis use is limited to animal studies. It is possible the dosage and frequency of cannabis use among humans is insufficient to exert a measurable impact on surgical outcomes. Second, the duration and timing of cannabis use relative to the surgery were unable to be accounted for and may affect complication rates. Chronic, long-term use may have different effects compared with occasional or short-term use. Prior literature has found that tobacco cessation in the weeks leading up to surgery significantly reduces the overall complication rate.<sup>29</sup> Although our study lacks data on the timing of cannabis use relative to surgery, it is worth considering that the cessation of cannabis use in the days or weeks prior to surgery could have potentially influenced outcomes. Future studies are warranted to determine how the dosage, frequency, and timing of cannabis use in relation to surgery affect outcomes.

Tobacco use, on the other hand, is a well-documented modifiable risk factor for adverse outcomes after a variety of orthopaedic procedures, including ankle and hindfoot arthrodesis.<sup>4,7,26,37</sup> Tobacco use has been shown to have immunosuppressive effects, impair wound and bone healing, and increase inflammation throughout the body, increasing the risk for adverse outcomes.<sup>1,14,16,27</sup> The results in the present study support this, in that tobacco use was associated with increased risk of all 2-year surgery-specific

complications including nonunion, hardware removal, infection, and wound dehiscence. Interestingly, this effect was increased among combined tobacco and cannabis users, as combined use was associated with an increased risk of nonunion compared with tobacco alone. This may be due to an enhanced negative effect on bone healing. It is also possible that people who use both tobacco and cannabis tend to consume higher quantities of tobacco or cannabis, as they may have different substance use behaviors. This increased consumption could further exacerbate the negative effects on postoperative outcomes. Further research is needed to better understand the interplay between these substances and their impact on surgical outcomes.

### Limitations

This study has several limitations, some of which are inherent to large data sets. For example, there may have been coding errors or undocumented complications that affected the results. These errors, however, likely had a minimal effect given the large sample size. In this study, cannabis use was determined on the presence of associated *ICD* codes. It is possible, particularly given the increasing legalization and normalization of cannabis use, that many patients who use cannabis were not documented as such. This likely accounts for the observed prevalence of cannabis use (0.62%) being significantly lower than national estimates, which been shown to be around 17%.<sup>11</sup> On the other hand, tobacco users were overrepresented (42%) compared with national estimates (12%).<sup>10</sup> The reason for this is ultimately unclear, but may reflect selection bias, as tobacco users may be more likely to undergo these procedures because of tobacco's association with comorbidities and risk profiles. It is also likely that tobacco use is more regularly documented in the medical record compared with cannabis or other drug use. Moreover, this study was unable to account for the duration, frequency, method of consumption, and quantity of tobacco or cannabis use, all which likely affect postoperative complications. The authors could also not account for variables that may have increased the likelihood of postoperative complications such as lifestyle. The authors attempted to mitigate these confounders by matching based on age, gender, ECI, diabetes, and obesity and accounting for additional comorbidities in the regression analyses. Despite these limitations, this study provides valuable insight into the associations between cannabis use and adverse outcomes after ankle and hindfoot arthrodesis.

### Conclusion

This study found that although cannabis use alone was not linked to adverse postoperative outcomes following ankle and hindfoot arthrodesis, the combined use of cannabis and tobacco was associated with a greater risk of complications

compared with tobacco alone. This combined use was associated with higher rates of nonunion and may be linked to adverse effects on bone healing. However, it is important to note that the underrepresentation of cannabis users and overrepresentation of tobacco users in this study population compared with national averages may have influenced these findings, limiting their generalizability. Based on the observed associations, surgeons should be mindful of the associated risks of combined cannabis and tobacco use when evaluating patient risk factors and developing postoperative care plans. Future research should focus on understanding how the dosage, frequency, and timing of cannabis use in relation to surgery effect outcomes.

## Ethical Approval

PearlDiver data is Health Insurance Portability and Accountability Act (HIPAA) compliant, and therefore approval from our institutional review board was deemed exempt for this study.

## Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Todd A. Kile, MD, reports general disclosures from Fusion Orthopedics as unpaid consultant, not relevant to this work. Disclosure forms for all authors are available online.

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**Appendix.** Codes for Inclusion Criteria.

Diagnosis	CPT/ICD Code(s)
<b>Inclusion criteria</b>	
Any ankle/hindfoot arthrodesis	ICD-9-P-8111, ICD-9-P-8113, ICD-9-P-8114, ICD-9-P-8112, ICD-10-P-0SGF03Z, ICD-10-P-0SGF04Z, ICD-10-P-0SGF05Z, ICD-10-P-0SGF07Z, ICD-10-P-0SGF0JZ, ICD-10-P-0SGF0KZ, ICD-10-P-0SGF0ZZ, ICD-10-P-0SGF33Z, ICD-10-P-0SGF34Z, ICD-10-P-0SGF35Z, ICD-10-P-0SGF37Z, ICD-10-P-0SGF3JZ, ICD-10-P-0SGF3KZ, ICD-10-P-0SGF3ZZ, ICD-10-P-0SGF43Z, ICD-10-P-0SGF44Z, ICD-10-P-0SGF45Z, ICD-10-P-0SGF47Z, ICD-10-P-0SGF4JZ, ICD-10-P-0SGF4KZ, ICD-10-P-0SGF4ZZ, ICD-10-P-0SGG03Z, ICD-10-P-0SGG04Z, ICD-10-P-0SGG05Z, ICD-10-P-0SGG07Z, ICD-10-P-0SGG0JZ, ICD-10-P-0SGG0KZ, ICD-10-P-0SGG0ZZ, ICD-10-P-0SGG33Z, ICD-10-P-0SGG34Z, ICD-10-P-0SGG35Z, ICD-10-P-0SGG37Z, ICD-10-P-0SGG3JZ, ICD-10-P-0SGG3KZ, ICD-10-P-0SGG3ZZ, ICD-10-P-0SGG43Z, ICD-10-P-0SGG44Z, ICD-10-P-0SGG45Z, ICD-10-P-0SGG47Z, ICD-10-P-0SGG4JZ, ICD-10-P-0SGG4KZ, ICD-10-P-0SGG4ZZ, CPT-27870, CPT-29899, CPT-27871, CPT-28705, CPT-28725, CPT-29907, CPT-28715
<b>Exclusion criteria</b>	
Infection/inflammatory process	ICD-9-D-71107, ICD-9-D-71137, ICD-9-D-71147, ICD-9-D-71157, ICD-9-D-71167, ICD-9-D-71177, ICD-9-D-71187, ICD-9-D-71197, ICD-9-D-71627, ICD-9-D-73007, ICD-9-D-73017, ICD-9-D-73027, ICD-9-D-73087, ICD-9-D-73097, ICD-10-D-M00071, ICD-10-D-M00072, ICD-10-D-M00079, ICD-10-D-M00171, ICD-10-D-M00172, ICD-10-D-M00179, ICD-10-D-M00271, ICD-10-D-M00272, ICD-10-D-M00279, ICD-10-D-M00871, ICD-10-D-M00872, ICD-10-D-M00879, ICD-10-D-M01X71, ICD-10-D-M01X72, ICD-10-D-M01X79, ICD-10-D-M60070, ICD-10-D-M60071, ICD-10-D-M60072, ICD-10-D-M65171, ICD-10-D-M65172, ICD-10-D-M65179, ICD-10-D-M71171, ICD-10-D-M71172, ICD-10-D-M71179, ICD-10-D-M86071, ICD-10-D-M86072, ICD-10-D-M86079, ICD-10-D-M86171, ICD-10-D-M86172, ICD-10-D-M86179, ICD-10-D-M86271, ICD-10-D-M86272, ICD-10-D-M86279, ICD-10-D-M86371, ICD-10-D-M86372, ICD-10-D-M86379, ICD-10-D-M86471, ICD-10-D-M86472, ICD-10-D-M86479, ICD-10-D-M86571, ICD-10-D-M86572, ICD-10-D-M86579, ICD-10-D-M86671, ICD-10-D-M86672, ICD-10-D-M86679, ICD-10-D-M868X7
Simultaneous distal fusion, osteotomy, and Achilles tendon lengthening procedures	CPT-27606, CPT-28300, CPT-28735, CPT-28737, CPT-28740
Prior/simultaneous total ankle replacement	CPT-01486, ICD-9-P-8156