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# Comparing the 30-Day Complications Between Smokers and Nonsmokers Undergoing Surgical Fixation of Ankle Fractures

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## Abstract

**Background:** There have been conflicting reports regarding the effect of smoking on complications after surgical treatment of ankle fractures. This study aimed at identifying the complications for which smokers and subgroups of smokers are at a higher risk compared to nonsmokers when undergoing surgery for fixation of rotational ankle fractures.

**Methods:** The American College of Surgeons National Surgical Quality Improvement Program data set from 2008 to 2019 was used to compare the 30-day wound, cardiac, renal, and infectious complications, related readmissions, and return to the operating room between the 2 cohorts.

**Results:** Of 33 741 patients included, 25 642 (76.0%) were nonsmokers and 8099 (24.0%) were smokers. Multivariate analysis showed that smokers were at a higher risk for deep wound infection (OR 2.34, 95% CI 1.48-3.69, $P < .001$), wound dehiscence (OR 2.43, 95% CI 1.56-3.77, $P < .001$), related return to the operating room (OR 1.69, 95% CI 1.36-2.11, $P < .001$), and related readmissions (OR 1.67, 95% CI 1.32-2.09, $P < .001$). Smokers at an increased risk for deep infection included patients between 50 and 59 years (OR 5.75, 95% CI 1.78-18.5, $P = .003$), who were Black (OR 4.24, 95% CI 1.04-17.23, $P = .044$), who had body mass index (BMI) 35 to 39.9 (OR 3.73, 95% CI 1.46-9.50, $P = .006$), or operative times between 60 and 90 minutes (OR 3.64, 95% CI 1.79-7.39, $P < .001$). Smoker subgroups at a higher risk for wound dehiscence included patients between 50 and 59 years (OR 9.86, 95% CI 3.29-29.53, $P < .001$), with operative times between 90 and 120 minutes (OR 4.88, 95% CI 1.89-12.58, $P < .001$), with BMI 30 to 34.9 (OR 3.06, 95% CI 1.45-6.45, $P = .003$) and who underwent spinal/epidural anesthesia (OR 9.31, 95% CI 2.31-37.58, $P = .002$).

**Conclusion:** Smokers were at an increased risk for deep wound infection, wound dehiscence, related reoperations, and related readmissions after ankle fracture surgery. Certain subgroups were at an even higher risk for these complications.

**Level of Evidence:** Level III, retrospective cohort study.

**Keywords:** ankle fracture, complications, outcomes, risk factors, patient characteristics, smoking, smoker

## Introduction

The overall incidence of ankle fractures ranges between 100 and 187 per 100 000 person-years.[12,13,15,22] When unstable or displaced, they are treated surgically with open reduction and internal fixation (ORIF). To improve outcomes, several studies have previously addressed the complications after ankle fracture surgery and tried to identify risk factors for those adverse events.[4,7,9,25,27,28,30,34,41] Diabetes[14,16,23,25-27,49] and obesity[8,24,42] have been identified as risk factors for several complications in ORIF of ankle fractures. Although the prevalence of smoking was 14% in the United States in 2019[11] and around 20% globally,[36] there are still conflicting reports regarding the effect of smoking on outcomes after ankle fracture surgery. Although several studies have found smoking to be a risk factor for complications in ORIF of ankle fractures,[5,21,28,29,32,37,39,40,50] some have failed to show an increased risk in smokers.[4,30,33,35,43]

Moreover, the studies that have identified smoking as a risk factor for certain complications have not analyzed specific subgroups of smokers who might be at an increased risk for those complications.[32,34,38]

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) data set has been used in several studies to investigate outcomes following ankle fracture fixation. Although some have failed to show an increased risk of adverse events in smokers,[4,9,30] others have grouped complications into major and minor adverse events and analyzed independent risk factors for those events combined,[4,7,9] which limits the possibility of drawing sensible clinical inferences. Moreover, the studies that have found association between smoking and certain grouped complications have not attempted stratification of specific complications.[7] We therefore sought to use the ACS-NSQIP database to analyze specific complications for which smokers who undergo surgery for fixation of rotational ankle fractures are at an increased risk compared with nonsmokers, and to further stratify the cohorts into subgroups, based on age, gender, race, body mass index (BMI), operative times, anesthesia type, fracture type, and other comorbidities, to identify smokers who might be at an even higher risk of developing those complications.

## Materials and Methods

### Study Design

This was a retrospective cohort study using data from the ACS-NSQIP database that includes more than 150 variables collected on surgical patients from 719 centers across the United States and other countries. Although operative treatment techniques, postoperative protocols, and surgeon experience are not standardized, the ACS-NSQIP uses a prospective, peer-controlled, validated database to measure the 30-day risk-adjusted surgical outcomes. A site's trained and certified Surgical Clinical Reviewer captures these data using a variety of methods including medical chart abstraction.[2] In accordance with our institutional guidelines, which follow the US Code of Federal Regulations for the Protection of Human Subjects, institutional review board approval was not needed for our analysis because data were deidentified and collected as part of a quality assurance activity.

### Patient Selection

Data from 2008 through 2019 were queried to identify patients who underwent ankle fracture surgery using the *Current Procedural Terminology* codes 27766 (medial malleolus), 27769 (posterior malleolus), 27792 (lateral malleolus), 27814 (bimalleolar), 27822 (trimalleolar without posterior lip fixation), and 27823 (trimalleolar with posterior lip fixation). An initial 38 958 patients were identified. None had missing data of smoker status. NSQIP variables were used to exclude patients who had preoperative sepsis (n = 1147), open wound / wound infection prior to surgery (n = 981), or other concurrent/concomitant procedures (n = 3089).

Patient demographics, comorbidities, and selected laboratory values were obtained as baseline characteristics (Table 1). These included age, gender, race, American Society of Anesthesiology (ASA) classification, operative time, functional status, body mass index (BMI), diabetes mellitus, hypertension, steroid use, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), dyspnea, renal failure on dialysis, anesthesia type, bleeding disorders, international normalized ratio (INR), and hematocrit (Hct). The BMI classification was adapted from the World Health Organization global database.[47] Anemia was defined using the World Health Organization sex-based criteria.[48]

Thirty-day mortality and morbidity, including cardiac, wound, respiratory, urinary tract, central nervous system, sepsis, venous thromboembolism, bleeding, mortality, related return to the operating room, and related readmission were recorded as adverse events. NSQIP classifies wound infection as deep when an infection appears to be related to the operation and involves the deep soft tissues of the incision.

### Statistical Analysis

Statistical analyses were done using IBM SPSS Statistics software (version 28; Norman H. Nie, Dale H. Bent, C. Hadlai Hull; Armonk, NY). Categorical variables were

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**Table 1.** Patient Characteristics.

| Patient Characteristics (N = 33741) | Nonsmokers, Mean ± SD or n (%) (n = 25642; 76.0%) | Smokers, n (%) (n = 8099; 24.0%) | *P* Value |
|---|---|---|---|
| **Age, y** | 50.61 ± 18.46 | 43.63 ± 14.78 | <.001 |
| ≤39 | 7890 (31.10) | 3451 (42.60) | <.001 |
| 40-49 | 3643 (14.40) | 1620 (20.00) | |
| 50-59 | 4727 (18.60) | 1727 (21.30) | |
| 60-69 | 4793 (18.90) | 994 (12.30) | |
| ≥70 | 4328 (17.10) | 302 (3.70) | |
| **Gender** | | | |
| Male | 9873 (38.50) | 4054 (50.10) | <.001 |
| Female | 15769 (61.50) | 4045 (49.90) | |
| **Race/ethnicity** | | | |
| White | 16435 (64.10) | 4893 (60.40) | <.001 |
| Black | 2220 (8.70) | 1150 (14.20) | |
| Asian | 541 (2.10) | 81 (1.00) | |
| Other | 6430 (25.10) | 1972 (24.40) | |
| **ASA class** | | | |
| I-II | 18474 (72.20) | 5892 (72.90) | .209 |
| III-V | 7116 (27.80) | 2189 (27.10) | |
| **Mean total operation time, min** | 76.57 ± 42.35 | 76.14 ± 45.51 | <.001 |
| <60 min | 10064 (39.26) | 3335 (41.18) | .005 |
| 60-90 min | 8111 (31.60) | 2420 (29.90) | |
| 90-120 min | 4219 (16.50) | 1300 (16.10) | |
| >120 min | 3243 (12.60) | 1043 (12.90) | |
| **Functional status prior to surgery** | | | |
| Independent | 24497 (96.70) | 7838 (98.10) | |
| Partially dependent/dependent | 848 (3.30) | 150 (1.90) | |
| **BMI**[a] | 30.92 ± 7.07 | 30.03 ± 6.89 | <.001 |
| <18.5 | 109 (0.40) | 51 (0.60) | <.001 |
| 18.5-24.9 | 4276 (16.70) | 1744 (21.50) | |
| 25-29.9 | 8155 (31.80) | 2582 (31.90) | |
| 30-34.9 | 7608 (29.70) | 2210 (27.30) | |
| 35-39.9 | 3096 (12.10) | 905 (11.20) | |
| ≥40 | 2398 (9.40) | 607 (7.50) | |
| **Diabetes on oral drugs or insulin** | | | |
| No diabetes | 22523 (87.80) | 7464 (92.20) | <.001 |
| Diabetes on oral drugs | 1330 (5.20) | 280 (3.50) | |
| Diabetes on insulin | 1789 (7.00) | 355 (4.40) | |
| **Hypertension requiring medication** | 8355 (32.60) | 1967 (24.30) | <.001 |
| **Steroid use for chronic condition** | 451 (1.80) | 94 (1.20) | <.001 |
| **Severe COPD** | 557 (2.20) | 406 (5.00) | <.001 |
| **Dyspnea** | 626 (2.40) | 273 (3.40) | <.001 |
| **CHF (within 30 d)** | 133 (0.50) | 24 (0.30) | .010 |
| **Anesthesia technique** | – | – | |
| General | 22503 (87.80) | 7348 (90.80) | <.001 |
| Spinal/epidural | 2080 (8.10) | 466 (5.80) | |
| Others | 1048 (4.10) | 282 (3.50) | |
| **Acute renal failure** | 46 (0.20) | 6 (0.10) | .040 |
| **Currently on dialysis** | 163 (0.60) | 19 (0.20) | <.001 |
| **Preoperative serum creatinine** | 0.96 ± .0.76 | 0.88 ± 0.54 | <.001 |
| <1.2 mg/dL | 13656 (87.30) | 4307 (92.10) | <.001 |
| ≥1.2 mg/dL | 1983 (12.70) | 371 (7.90) | |
| **>10% loss body weight in last 6 mo** | 19 (0.10) | 8 (0.10) | .500 |
| **Bleeding disorders** | 786 (3.10) | 173 (2.10) | <.001 |

*(continued)*

**Table 1. (continued)**

| Patient Characteristics (N = 33741) | Nonsmokers, Mean ± SD or n (%) (n = 25642; 76.0%) | Smokers, n (%) (n = 8099; 24.0%) | *P* Value |
|---|---|---|---|
| **Preoperative INR** | 1.06 ± 0.26 | 1.04 ± 0.28 | <.001 |
| ≤1.2 | 8011 (93.80) | 2386 (95.80) | <.001 |
| >1.2 | 528 (6.20) | 105 (4.20) | |
| **Hematocrit, %**[b] | 38.89 ± 4.72 | 40.17 ± 4.68 | <.001 |
| No anemia | 11489 (70.30) | 3752 (76.60) | <.001 |
| Mild anemia | 3219 (19.70) | 835 (17.10) | |
| Moderate-severe anemia | 1631 (10.00) | 309 (6.30) | |
| **Albumin** | 3.87 ± 0.53 | 3.91 ± 0.53 | <.001 |
| ≥3.5 g/dL | 5503 (80.00) | 1737 (82.50) | .009 |
| <3.5 g/dL | 1380 (20.00) | 368 (17.50) | |
| ***CPT* code** | | | |
| ***CPT* code 27766** | 1395 (5.40) | 532 (6.60) | <.001 |
| ***CPT* code 27769** | 226 (0.90) | 66 (0.80) | |
| ***CPT* code 27792** | 8156 (31.80) | 2694 (33.30) | |
| ***CPT* code 27814** | 9381 (36.60) | 2857 (35.30) | |
| ***CPT* code 27822** | 4927 (19.20) | 1524 (18.80) | |
| ***CPT* code 27823** | 1557 (6.10) | 426 (5.30) | |

Abbreviations: ASA, American Society of Anesthesiology; BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; *CPT*, *Current Procedural Terminology*; INR, international normalized ratio.
[a]BMI classification was adapted from the World Health organization (WHO) global database.
[b]Anemia was defined using the WHO sex-based criteria.

presented as number and percentage and continuous ones as mean and SD. Continuous variables were compared using the independent *t* test and categorical variables using the $\chi^2$ test. Odds ratios (ORs) for complications were calculated, using logistic regression with 95% CIs. After an initial univariate analysis, relevant confounders for specific complications were controlled for, and a multivariate logistic regression analysis was performed to detect the independent effect of smoking on complications (Table 2). When smoking was found to be an independent risk factor for a specific complication, that adverse event was further analyzed by subgroup stratification to identify specific subgroup of patients who might be at an even higher risk for that specific complication. Total and postoperative length of stay were analyzed using linear regression and reported using β value with its 95% CI. The level of significance for *P* value was <.05.

## Results

A total of 33741 patients were identified, of which 25642 (76.0%) were nonsmokers and 8099 (24.0%) were smokers. Table 1 shows the baseline characteristics of each group. Demographic data showed that a higher proportion of smokers were younger in age (43.63 ± 14.78 years vs 50.61 ± 18.46 years, $P < .001$), male (50.10% vs 38.50%, $P < .001$), Black (14.20% vs 8.70%, $P < .001$), nonobese (21.50% vs 16.70%, $P < .001$), functionally independent (98.10% vs 96.70%, $P < .001$), nondiabetic (92.20% vs 87.80%, $P < .001$), nonanemic (76.60% vs 70.30%, $P < .001$) and underwent general anesthesia more frequently (90.80% vs 87.80, $P < .001$). Several characteristics were less prevalent in the smoker cohort; these included hypertension (24.30% vs 32.60%, $P < .001$), CHF (0.30% vs 0.50%, $P < .001$), bleeding disorders (2.10% vs 3.10%, $P < .001$), acute renal failure (0.10% vs 0.20%, $P < .001$), dialysis (0.20% vs 0.60%, $P < .001$), and steroid use (1.20% vs 1.80%, $P < .001$).

Regarding the 30-day outcomes, multivariate logistic regression analysis found smokers to be at a higher risk for developing wound dehiscence (OR 2.43, 95% CI 1.56-3.77, $P < .001$) and deep surgical site infection (OR 2.34, 95% CI 1.48-3.69, $P < .001$) compared to nonsmokers. Smokers were also at a higher risk for return to operating room related to the index procedure (OR 1.69, 95% CI 1.36-2.11, $P < .001$) and related readmissions (OR 1.67, 95% CI 1.32-2.09, $P < .001$). No statistically significant differences were found between the 2 groups in terms of mortality, cardiac complications, pneumonia, intubation, renal complication, cerebrovascular accidents, thromboembolism, bleeding, and total or postoperative length of stay (Table 2).

Upon stratification of different baseline characteristics in patients who developed deep wound infections (n = 79), several subgroups of smokers were at a risk higher than the baseline adjusted OR of 2.34 (95% CI 1.48-3.69, $P < .001$) for developing deep wound infection. These included patients who were between 40 and 49 years (OR 3.46, 95% CI 1.08-11.09, $P = .037$), between 50 and 59 years (OR 5.75, 95% CI 1.78-18.58, $P = .003$), those who were Black (OR 4.24, 95% CI 1.04-17.23, $P = .044$), had race other

**Table 2.** Postoperative Outcomes.

| Postoperative Complications | Nonsmokers, n (%) or Mean ± SD | Smokers, n (%) or Mean ± SD | Unadjusted OR | | Adjusted OR | |
|---|---|---|---|---|---|---|
| | | | OR (95% CI) | *P* Value | OR (95% CI) | *P* Value |
| **Mortality** | 58 (0.20) | 14 (0.20) | 0.76 (0.43, 1.37) | .366 | 1.30 (0.67, 2.54) | .443 |
| **Bleeding** | 121 (0.50) | 22 (0.30) | 0.57 (0.37, 0.91) | .017 | 1.03 (0.64, 1.68) | .896 |
| **Return to** operating **room (related)** | 247 (1.00) | 125 (1.50) | 1.61 (1.30, 2.00) | <.001 | 1.69 (1.36, 2.11) | <.001 |
| **Thromboembolism**[a] | 143 (0.60) | 34 (0.40) | 0.75 (0.52, 1.09) | .136 | 0.86 (0.58, 1.26) | .433 |
| **DVT** | 89 (0.30) | 22 (0.30) | 0.78 (0.49, 1.25) | .302 | 0.87 (0.54, 1.41) | .575 |
| **Pulmonary embolism** | 66 (0.30) | 13 (0.20) | 0.62 (0.34, 1.13) | .119 | 0.72 (0.39, 1.32) | .290 |
| **Cardiac complications**[b] | 28 (0.10) | 9 (0.10) | 1.02 (0.48, 2.16) | .964 | 1.15 (0.54, 2.49) | .715 |
| **Cardiac arrest** | 10 (0.00) | 5 (0.10) | 1.58 (0.54, 4.63) | .402 | 2.27 (0.73, 7.01) | .155 |
| **MI** | 20 (0.10) | 4 (0.00) | 0.63 (0.22, 1.85) | .404 | 0.68 (0.23, 2.00) | .479 |
| **Pneumonia** | 70 (0.30) | 12 (0.10) | 0.54 (0.29, 1.00) | .050 | 0.86 (0.44, 1.68) | .656 |
| **Intubation**[c] | 32 (0.10) | 13 (0.20) | 1.29 (0.68, 2.45) | .444 | 1.09 (0.55, 2.19) | .801 |
| **Urinary tract infection** | 193 (0.80) | 30 (0.40) | 0.49 (0.33, 0.72) | <.001 | 1.09 (0.73, 1.63) | .683 |
| **Renal complications**[d] | 23 (0.10) | 5 (0.10) | 0.69 (0.26, 1.81) | .449 | 1.26 (0.46, 3.42) | .650 |
| **CVA** | 10 (0.00) | 4 (0.00) | 1.27 (0.40, 4.04) | .690 | 3.37 (0.85, 13.39) | .084 |
| **Sepsis** | 48 (0.20) | 17 (0.20) | 1.12 (0.65, 1.95) | .685 | 1.49 (0.82, 2.72) | .194 |
| **Superficial surgical site infection** | 188 (0.70) | 67 (0.80) | 1.13 (0.85, 1.49) | .394 | 1.27 (0.94, 1.70) | .116 |
| **Wound dehiscence** | 49 (0.20) | 35 (0.40) | 2.27 (1.47, 3.50) | <.001 | 2.43 (1.56, 3.77) | <.001 |
| **Deep wound infection** | 47 (0.20) | 32 (0.40) | 2.16 (1.38, 3.39) | <.001 | 2.34 (1.48, 3.69) | <.001 |
| **LOS (total stay)**[e] | 1.68 ± 3.66 | 1.33 ± 3.68 | –0.35 (–0.44, –0.26) | <.001 | –0.01 (–0.10, –0.08) | .830 |
| **LOS (postoperative stay)**[e] | 1.22 ± 2.98 | 0.94 ± 2.91 | –0.29 (–0.36, –0.21) | <.001 | –0.01 (–0.09, –0.06) | .687 |
| **Readmission (related)** | 287 (1.10) | 119 (1.50) | 1.32 (1.06, 1.63) | .012 | 1.67 (1.32, 2.09) | <.001 |
| **Related readmission reason** | | | *P* Value | | | |
| Superficial incisional SSI | 18 (0.10) | 19 (0.20) | <.001 | | | |
| Deep incisional SSI | 26 (0.10) | 17 (0.20) | .017 | | | |
| Wound disruption | 12 (0.00) | 9 (0.10) | .043 | | | |
| Pneumonia | 13(0.10) | 3 (0.00) | .776 | | | |
| Intubation[c] | 0 (0.00) | 1 (0.00) | .240 | | | |
| Urinary tract infection | 14 (0.10) | 3 (0.00) | .777 | | | |
| CVA | 2 (0.00) | 1 (0.00) | .561 | | | |
| Cardiac complications[b] | 7 (0.00) | 2 (0.00) | 1.0 | | | |
| Sepsis | 13 (0.10) | 2 (0.00) | .545 | | | |
| Pulmonary embolism | 28 (0.10) | 7 (0.10) | .579 | | | |
| Vein thrombosis requiring therapy | 10 (0.00) | 3 (0.00) | 1.0 | | | |
| Thromboembolism[a] | 36 (0.10) | 10 (0.10) | .719 | | | |
| Renal complications[d] | 4 (0.00) | 0 (0.00) | .579 | | | |

Abbreviations: CVA, cerebrovascular accident; DVT, deep vein thromboembolism; LOS, length of stay; MI, myocardial infarction; OR, odds ratio; SSI, surgical site infection.

[a]Includes DVT and/or pulmonary embolism.

[b]Includes cardiac arrest and/or MI.

[c]Includes unplanned intubation and/or intubation >48 hours.

[d]Includes acute renal failure and/or progressive renal insufficiency.

[e]Linear regression reported as β and its 95% CI.

than White, Black, or Asian (OR 4.77, 95% CI 1.67-13.63, $P = .004$), had BMI between 30 and 34.9 (OR 2.83, 95% CI 1.29-6.21, $P = .010$) and 35 and 39.9 (OR 3.73, 95% CI 1.46-9.50, $P = .006$), had mild anemia (OR 3.80, 95% CI 1.33-10.85, $P = .013$) or operative times between 60 and 90 minutes (OR 3.64, 95% CI 1.79-7.39, $P < .001$). Stratification for wound dehiscence (n = 84) also showed certain subgroups of smokers to be at a risk greater than the baseline OR of 2.43 (95% CI 1.56-3.77, $P < .001$) compared with nonsmokers (Table 3). These included patients

**Table 3.** Stratification of Patients With Deep Wound Infection and Wound Dehiscence.

| | Deep Infection (n = 79) | | | | Wound Dehiscence (n = 84) | | | |
|---|---|---|---|---|---|---|---|---|
| | Nonsmokers, n (%) | Smokers, n (%) | Adjusted OR (95% CI) | *P* Value | Nonsmokers, n (%) | Smokers, n (%) | Adjusted OR (95% CI) | *P* Value |
| **Overall** | 47 (0.20) | 32 (0.40) | 2.34 (1.48-3.69) | <.001 | 49 (0.20) | 35 (0.40) | 2.43 (1.56-3.77) | <.001 |
| **Age, y** | | | | | | | | |
| ≤39 | 11 (0.14) | 8 (0.23) | 1.78 (0.71-4.45) | .221 | 4 (0.05) | 7 (0.20) | 4.14 (1.24-14.37) | .025 |
| 40-49 | 5 (0.14) | 7 (0.43) | 3.46 (1.08-11.09) | .037 | 4 (0.11) | 7 (0.43) | 4.49 (1.27-15.87) | .020 |
| 50-59 | 4 (0.08) | 10 (0.58) | 5.75 (1.78-18.58) | .003 | 4 (0.08) | 18 (1.04) | 9.86 (3.29-29.53) | <.001 |
| 60-69 | 11 (0.23) | 5 (0.50) | 2.01 (0.68-5.91) | .207 | 15 (0.31) | 3 (0.30) | 0.56 (1.16-1.99) | .371 |
| ≥70 | 15 (0.35) | 2 (0.66) | 1.95 (0.44-8.60) | .377 | 19 (0.44) | 0 (0.00) | N/A | N/A |
| **Gender** | | | | | | | | |
| Female | 31 (0.20) | 16 (0.40) | 2.29 (1.24-4.22) | .008 | 34 (0.22) | 17 (0.42) | 2.15 (1.19-3.89) | .012 |
| Male | 16 (0.16) | 16 (0.39) | 2.42 (1.21-4.84) | .013 | 15 (0.15) | 18 (0.44) | 3.33 (1.61-6.92) | .001 |
| **Race/ethnicity** | | | | | | | | |
| White | 34 (0.21) | 18 (0.37) | 1.85 (1.04-3.29) | .037 | 37 (0.23) | 20 (0.41) | 1.95 (1.13-3.39) | .017 |
| Black | 3 (0.14) | 6 (0.52) | 4.24 (1.04-17.23) | .044 | 4 (0.18) | 5 (0.43) | 2.26 (2.58-8.80) | .239 |
| Asian | 2 (0.37) | 0 (0.00) | N/A | N/A | 1 (0.18) | 0 (0.00) | N/A | N/A |
| Other | 8 (0.12) | 8 (0.41) | 4.77 (1.67-13.63) | .004 | 7 (0.11) | 10 (0.51) | 5.64 (2.72-15.81) | .001 |
| **ASA class** | | | | | | | | |
| I, II | 22 (0.12) | 17 (0.29) | 2.73 (1.44-5.16) | .002 | 13 (0.07) | 17 (0.29) | 4.52 (2.18-9.39) | <.001 |
| III-V | 25 (0.35) | 15 (0.69) | 2.11 (1.10-4.05) | .024 | 36 (0.51) | 18 (0.82) | 1.73 (8.98-3.09) | .060 |
| **Operative time** | | | | | | | | |
| <60 min | 13 (0.13) | 8 (0.24) | 1.99 (0.82-4.85) | .130 | 13 (0.13) | 10 (0.30) | 2.47 (1.77-5.74) | .034 |
| 60-90 min | 17 (0.21) | 16 (0.66) | 3.64 (1.79-7.39) | <.001 | 15 (0.18) | 9 (0.37) | 2.40 (1.63-5.61) | .042 |
| 90-120 min | 11 (0.26) | 5 (0.38) | 2.39 (0.76-7.51) | .135 | 11 (0.26) | 10 (0.77) | 4.88 (1.89-12.58) | .001 |
| >120 min | 6 (0.19) | 3 (0.29) | 1.69 (0.42-6.88) | .461 | 10 (0.31) | 6 (0.58) | 2.05 (5.73-5.79) | .173 |
| **BMI** | | | | | | | | |
| 18.5-24.9 | 7 (0.16) | 3 (0.17) | 1.14 (0.28-4.56) | .858 | 10 (0.23) | 5 (0.29) | 1.33 (2.44-4.01) | .610 |
| 25-29.9 | 11 (0.13) | 8 (0.31) | 2.48 (0.99-6.21) | .052 | 14 (0.17) | 11 (0.43) | 2.57 (1.15-5.76) | .022 |
| 30-34.9 | 15 (0.20) | 11 (0.50) | 2.83 (1.29-6.21) | .010 | 16 (0.21) | 13 (0.59) | 3.06 (1.45-6.45) | .003 |
| 35-39.9 | 10 (0.32) | 9 (0.99) | 3.73 (1.46-9.50) | .006 | 5 (0.16) | 5 (0.55) | 3.32 (6.96-11.53) | .058 |
| ≥40 | 3 (0.13) | 1 (0.16) | 1.32 (0.14-12.73) | .809 | 4 (0.17) | 0 (0.00) | N/A | N/A |
| **Diabetes** | | | | | | | | |
| Diabetes on insulin | 10 (0.75) | 2 (0.71) | 0.75 (0.16-3.55) | .715 | 8 (0.60) | 5 (1.79) | 0.83 (1.10-6.93) | .864 |
| Diabetes on oral drugs | 7 (0.39) | 2 (0.56) | 1.43 (0.30-6.91) | .657 | 6 (0.34) | 1 (0.28) | 0.71 (7.09-6.00) | .759 |
| **Anesthesia technique** | | | | | | | | |
| General | 42 (0.19) | 30 (0.41) | 2.36 (1.47-3.80) | <.001 | 42 (0.19) | 29 (0.39) | 2.49 (1.51-4.11) | <.001 |
| Spinal/epidural | 3 (0.14) | 2 (0.43) | 3.09 (0.51-18.68) | .220 | 4 (0.19) | 6 (1.29) | 9.31 (2.31-37.58) | .002 |
| **Hematocrit (%)** | | | | | | | | |
| Mild anemia | 8 (0.25) | 7 (0.84) | 3.80 (1.33-10.85) | .013 | 9 (0.28) | 8 (0.96) | 3.81 (1.43-10.18) | .008 |
| Moderate-severe anemia | 9 (0.55) | 2 (0.65) | 1.17 (0.25-5.46) | .838 | 11 (0.67) | 5 (1.62) | 2.81 (8.94-8.42) | .064 |
| ***CPT* code** | | | | | | | | |
| ***CPT* code 27766** | 2 (0.14) | 3 (0.56) | 3.92 (0.65-23.51) | .135 | 1 (0.07) | 0 (0.00) | N/A | N/A |
| ***CPT* code 27769** | 1 (0.44) | 0 (0.00) | N/A | N/A | (0.00) | (0.00) | N/A | N/A |
| ***CPT* code 27792** | 11 (0.13) | 7 (0.26) | 2.15 (0.83-5.57) | .117 | 10 (0.12) | 10 (0.37) | 2.98 (1.23-7.19) | .015 |
| ***CPT* code 27814** | 20 (0.21) | 14 (0.49) | 2.61 (1.30-5.24) | .007 | 21 (0.22) | 12 (0.42) | 1.92 (6.93-3.99) | .078 |
| ***CPT* code 27822** | 10 (0.20) | 7 (0.46) | 2.65 (0.99-7.13) | .053 | 13 (0.26) | 11 (0.72) | 3.28 (1.42-7.59) | .005 |
| ***CPT* code 27823** | 3 (0.19) | 1 (0.23) | 1.20 (0.13-11.59) | .873 | 4 (0.26) | 2 (0.47) | 2.03 (0.37-11.24) | .417 |

Abbreviations: ASA, American Society of Anesthesiology; BMI, body mass index; *CPT*, *Current Procedural Terminology*; N/A, not applicable; OR, odds ratio.

between 40 and 49 years (OR 4.49, 95% CI 1.27-15.87, $P = .020$), between 50 and 59 years (OR 9.86, 95% CI 3.29-29.53, $P < .001$), patients with operative times between 90 and 120 minutes (OR 4.88, 95% CI 1.89-12.58, $P < .001$), BMI between 30 and 34.9 (OR 3.06, 95% CI 1.45-6.45, $P = .003$), and those who underwent spinal or epidural anesthesia (OR 9.31, 95% CI 2.31-37.58, $P = .002$) or had mild anemia (OR 3.81, 95% CI 1.43-10.18, $P = .008$).

Subgroups of patients with increased risk of related readmissions (n = 406) included those between 40 and 49 years (OR 2.66, 95% CI 1.54-4.58, $P < .001$) and 50 and 59 years (OR 1.78, 95% CI 1.09-2.91, $P = .021$), who were Black (OR 2.18, 95% CI 1.11-4.27, $P = .0230$), had BMI between 30 and 34.9 (OR 1.91, 95% CI 1.28-2.85, $P < .001$), had mild anemia (OR 2.14, 95% CI 1.28-3.56, $P = .004$) or operative times between 60 and 90 minutes (OR 2.48, 95% CI 1.65-3.73, $P < .001$). Characteristics that increased the risk of return to operating room (n = 372) included male gender (OR 2.32, 95% CI 1.64-3.27, $P < .001$), age 40-49 years (OR 2.19, 95% CI 1.25-3.85, $P = .007$) or >70 years (OR 2.08, 95% CI 1.02-4.25, $P = .043$), BMI 25 to 29.9 (OR 2.10, 95% CI 1.41-3.15, $P < .001$), Black ethnicity (OR 2.60, 95% CI 1.26-5.34, $P = .010$), operative times 60-90 minutes (OR 2.56, 95% CI 1.75-3.73, $P < .001$), anemia (OR 3.45, 95% CI 1.92-6.19, $P < .001$), and neuraxial anesthesia (OR 3.16, 95% CI 1.54-6.48, $P < .002$).

## Discussion

The aim of our study was to evaluate the differences in complications between smokers and nonsmokers undergoing ORIF for ankle fractures and to further analyze whether there are certain subgroups of smokers who are at even higher risks for those complications. Smokers were found to have a higher risk of deep wound infection, wound dehiscence, related return to the operating room and related readmissions. Certain characteristics conferred a higher increase in the risk for these complications.

Our study has the largest number of patients analyzing the impact of smoking in ankle fracture fixation, with a total of 33 741 patients. Prior studies were limited to single institution case series[30,32,34] where the limited number of patients might not allow an in-depth analysis of risk factors. SooHoo et al[41] have used California's discharge database and analyzed 57 183 patients who had undergone ORIF for ankle fractures. Smoking was not analyzed in this large population study as the variable was not available.[41]

The findings in our study are in contradistinction to other NSQIP studies that have not found any association between smoking and postoperative complications.[4,9] These studies have grouped adverse events into aggregates, like severe adverse events, and major or minor local and systemic complications.[4,7,9] This grouping of complications makes clinical interpretation of the results difficult as mentioned by Basques et al.[4] Our study aimed to analyze the effect of smoking on individual outcomes that can help surgeons incorporate rigorous measures to avert those complications. Miller et al[30] did not find smoking to be a risk factor for wound complications in a cohort of 478 patients undergoing ankle fracture surgery. They attributed this to extensive counseling of smokers and potentially less cigarette smoking during the healing period.[30] Nåsell et al[31] have found that a 6-week smoking-cessation program started immediately after emergency fracture surgery significantly reduced the postoperative complication rate ($P = .048$).

Although the rates of deep wound infection and wound dehiscence were low, 0.2% in nonsmokers and 0.4% in smokers, multivariate analysis showed a 2-fold increased risk for developing these complications in smokers, with OR 2.34 ($P < .001$) and 2.43 ($P < .001$), respectively. A significant finding in our study was the higher risk of wound complication in certain subgroups. Smokers of Black origin were at a much higher risk for deep wound infections with an OR of 4.24 ($P = .044$). A recent NSQIP study analyzing patients undergoing orthopaedic trauma surgery has found higher frequencies of deep wound infection (0.5% vs 0.3%, $P = .002$) among Black patients, although with decreased mortality and postoperative transfusion.[44] Prior studies evaluating complications after ankle fracture surgery have not examined the effect of ethnicity on adverse outcomes.[4,7,9,28,30,32,34,41]

Smokers in certain age groups were at a higher risk of developing deep wound infections and wound dehiscence than the baseline OR of 2.34 and 2.43 for those complications respectively. Patients between 40 and 49 years had an OR of 3.46 ($P = .037$) for deep infection and 4.49 ($P = .020$) for wound dehiscence. The increased risk was even more prominent in the 50-59 years age group with an OR of 5.75 ($P = .003$) for deep infection and 9.86 ($P < .001$) for dehiscence. Cornelius et al[11] have reported the highest rate of smoking in adults aged 45-64 years (17.0%) vs 8.2% for 65 years and older. This might also be true for the smoking habits and number of cigarettes consumed per day, with patients in the older age group smoking less. The NSQIP does not record the heaviness of smoking or smokeless tobacco. Although several studies have not found age to be a risk factor for wound complications in ankle fracture surgery,[7,30,38] others have found older patients to be at an increased risk of infectious complications.[4,41] More pronounced effect of risk factors on certain age groups is not uncommon. Gil et al[17] have found the negative effect of obesity on perioperative complications and hospital costs of open ankle fractures to be primarily manifested in patients with obesity who are younger than 60 years.

Stratification by operative time also showed differences in the risk of wound complications above the baseline for deep wound infection and for wound dehiscence. Smokers with operative times between 60 and 90 minutes had an OR of 3.64 ($P < .001$) for deep compared to the baseline OR of 2.34. Similarly, smokers with operative times between 90 and 120 minutes had a 2-fold increased risk of wound dehiscence (OR 4.88, $P < .001$) compared to the baseline risk of 2.43. Ovaska et al[34] have found increased risk of wound infections (OR 2.07, $P < .001$) in patients with operative times more than 90 minutes. The effect of operative time has been studied in several elective orthopaedic procedures like total hip and knee arthroplasty.[10,45] However, in ankle fracture surgery, operative time might be dictated by the complexity of the fracture, which the ACS-NSQIP does not report; thus, its independent effect on outcomes is difficult to assess.

The same trend of increased risk for wound infection and dehiscence above the baseline was seen in smokers with BMI between 30 and 34.9 (obese) and 35 and 39.9 (severely obese). This finding is expectable given the high risk obesity has on postoperative wound and other complications.[33] Several studies have found that obesity does not increase the rate of complications after ankle fracture fixation[8,42]; however, obese patients tend to have higher number of medical comorbidities and sustain more complex fracture types than nonobese patients.[24,42]

A significant finding in our study was the highly increased risk of wound dehiscence in the subgroup of smokers undergoing spinal/epidural anesthesia (OR 9.31, $P < .002$). None of the prior studies have assessed the impact of anesthesia type on complications after ORIF of ankle fractures.[4,7,9,28,38,41] This finding can be due to selection bias, where the sicker patients with more comorbidities were given neuraxial anesthesia.

Mild anemia too conferred an increased risk for deep wound infection and wound dehiscence above the baseline. Although the negative effects of anemia on postoperative outcomes have been studied in hip and knee arthroplasty[18,46] and hip fracture surgery,[19,20] only 1 study has found anemia to be a risk factor for "any adverse event" in ankle fracture surgery.[9]

Stratification by fracture type showed that trimalleolar fractures posed a 3-fold increased risk of wound dehiscence in smokers compared with nonsmokers treated for the same fracture type (OR 3.28, $P = .005$). Sato et al[38] have found both smoking and trimalleolar fractures to be independent risk factors for infection after surgical fixation of ankle fractures.

Our study is the first to address related return to the operating room and related readmissions. Basques et al[4] found only ASA more than 3 to be a risk factor for any readmission after ORIF of ankle fractures. Although smokers in our study were the healthier cohort, they had a higher risk for reoperations and readmission related to the index surgery. A recent study comparing union rates in midfoot and hindfoot arthrodesis has also found smokers to be younger in age and with less comorbidities, although with increased rates of nonunion and infection.[1] Our stratification analyses identified subgroups of smokers at even a higher risk for related readmissions and related reoperations (Table 4). This is important for patient counseling and for hospitals as this might incur additional costs that might not be covered if a bundled payment gets implemented for ankle fracture surgery.[3] This is in addition to the indirect costs that can occur because of time away from work or loss of productivity due to the readmissions. Belatti and Phisitkul[6] have shown that in 2011, treatments for ankle fractures and dislocation had contributed the most (31.0% of $11 billion) to the overall economic burden of foot and ankle surgery in the Medicare population, with more than 80% of the cost from indirect costs, like temporary work loss.[6]

There are several limitations in this study. The ACS-NSQIP collects information up to 30 days postoperatively; as such, complications occurring past that time cannot be captured. Similarly, functional outcomes cannot be assessed due to the short followup period. Other shortcomings of the database include inability to gather data concerning surgical techniques, postoperative protocols, surgeon experience, venous thromboembolism prophylaxis, use of tourniquet or drains. These limitations, however, should affect both study groups similarly.

## Conclusion

Although the 30-day complication rates were low, smokers undergoing ORIF for ankle fractures were at an increased risk of deep wound infection, wound dehiscence, related return to operating room, and related readmissions. Specific patient characteristics that pose further increased risk of these complications include age (40-59 years), Black ethnicity, elevated BMI, anemia, prolonged operative times, and spinal/epidural anesthesia. With a high prevalence of smoking in society, research should focus on identifying those predisposed patients and tailoring specific perioperative measures to reduce the risk of complications. Large-database studies with longer follow-up periods are needed to better validate these findings.

**Table 4.** Stratification of Patients With Readmission and Reoperation.

| | Readmission (n = 406) | | | | Return to Operating Room (n = 372) | | | |
|---|---|---|---|---|---|---|---|---|
| | Nonsmokers, n (%) | Smokers, n (%) | Adjusted OR (95% CI) | *P* Value | Nonsmokers, n (%) | Smokers, n (%) | Adjusted OR (95% CI) | *P* Value |
| **Overall** | 287 (1.10) | 119 (1.50) | 1.67 (1.32-2.09) | <.001 | 247 (1.00) | 125 (1.50) | 1.69 (1.36-2.11) | <.001 |
| **Age, y** | | | | | | | | |
| ≤39 | 42 (0.50) | 29 (0.80) | 1.57 (0.97-2.53) | .066 | 55 (0.70) | 42 (1.22) | 1.67 (1.12-2.51) | .013 |
| 40-49 | 24 (0.70) | 30 (1.90) | 2.66 (1.54-4.58) | <.001 | 26 (0.71) | 24 (1.48) | 2.19 (1.25-3.85) | .007 |
| 50-59 | 39 (0.80) | 29 (1.70) | 1.78 (1.09-2.91) | .021 | 38 (0.80) | 30 (1.74) | 1.76 (1.07-2.90) | .026 |
| 60-69 | 66 (1.40) | 22 (2.20) | 1.45 (0.89-2.37) | .138 | 60 (1.25) | 20 (2.01) | 1.38 (0.82-2.32) | .226 |
| ≥70 | 109 (2.50) | 8 (2.60) | 0.99 (0.48-2.06) | .986 | 61 (1.41) | 9 (2.98) | 2.08 (1.02-4.25) | .043 |
| **Gender** | | | | | | | | |
| Female | 188 (1.19) | 69 (1.71) | 1.77 (1.31-2.38) | <.001 | 163 (1.03) | 61 (1.51) | 1.50 (1.11-2.03) | .008 |
| Male | 99 (1.00) | 50 (1.23) | 1.53 (1.07-2.19) | .020 | 84 (0.85) | 64 (1.58) | 2.32 (1.64-3.27) | <.001 |
| **Race/ethnicity** | | | | | | | | |
| White | 214 (1.30) | 70 (1.43) | 1.48 (1.11-1.98) | .008 | 183 (1.11) | 75 (1.53) | 1.43 (1.09-1.89) | .010 |
| Black | 18 (0.81) | 19 (1.65) | 2.18 (1.11-4.27) | .023 | 13 (0.59) | 18 (1.57) | 2.60 (1.26-5.34) | .010 |
| Asian | 5 (0.92) | 0 (0.00) | N/A | N/A | 3 (0.55) | 0 (0.00) | N/A | N/A |
| Other | 50 (0.78) | 30 (1.52) | 2.06 (1.30-3.27) | .002 | 48 (0.75) | 32 (1.62) | 2.37 (1.50-3.76) | <.001 |
| **ASA class** | | | | | | | | |
| I, II | 117 (0.63) | 64 (1.09) | 2.01 (1.47-2.77) | <.001 | 117 (0.63) | 70 (1.19) | 1.92 (1.43-2.59) | <.001 |
| III, V | 169 (2.37) | 55 (2.51) | 1.38 (0.99-1.92) | .060 | 129 (1.81) | 55 (2.51) | 1.46 (1.06-2.03) | .021 |
| **Operative time** | | | | | | | | |
| <60 min | 94 (0.93) | 36 (1.08) | 1.24 (0.84-1.84) | .281 | 82 (0.81) | 44 (1.32) | 1.68 (1.16-2.45) | .007 |
| 60-90 min | 84 (1.04) | 41 (1.69) | 2.48 (1.65-3.73) | <.001 | 71 (0.88) | 47 (1.94) | 2.56 (1.75-3.73) | <.001 |
| 90-120 min | 62 (1.47) | 23 (1.77) | 1.50 (0.90-2.52) | .123 | 53 (1.26) | 14 (1.08) | 0.89 (0.49-1.62) | .701 |
| >120 min | 47 (1.45) | 19 (1.82) | 1.27 (0.74-2.17) | .392 | 41 (1.26) | 20 (1.92) | 1.52 (0.89-2.62) | .128 |
| **BMI** | | | | | | | | |
| 18.5-24.9 | 44 (1.03) | 15 (0.86) | 1.11 (0.59-2.08) | .753 | 33 (0.77) | 16 (0.92) | 1.22 (0.67-2.24) | .519 |
| 25-29.9 | 63 (0.77) | 38 (1.47) | 3.40 (2.26-5.10) | <.001 | 60 (0.74) | 41 (1.59) | 2.10 (1.41-3.15) | <.001 |
| 30-34.9 | 94 (1.24) | 41 (1.86) | 1.91 (1.28-2.85) | .001 | 81 (1.06) | 38 (1.72) | 1.75 (1.18-2.60) | .005 |
| 35-39.9 | 54 (1.74) | 12 (1.33) | 0.98 (0.51-1.88) | .957 | 42 (1.36) | 20 (2.21) | 1.66 (0.97-2.86) | .066 |
| ≥40 | 32 (1.33) | 12 (1.98) | 2.07 (1.03-4.18) | .042 | 30 (1.25) | 9 (1.48) | 1.25 (0.59-2.65) | .569 |
| **Diabetes** | | | | | | | | |
| Diabetes on insulin | 51 (3.83) | 14 (5.00) | 1.37 (0.75-2.54) | .309 | 38 (2.86) | 10 (3.57) | 1.20 (0.59-2.44) | .621 |
| Diabetes on oral drugs | 25 (1.40) | 8 (2.25) | 1.60 (0.71-3.60) | .255 | 21 (1.17) | 9 (2.54) | 2.39 (1.07-5.33) | .033 |
| **Anesthesia technique** | | | | | | | | |
| General | 240 (1.07) | 107 (1.46) | 1.73 (1.36-2.21) | <.001 | 202 (0.90) | 109 (1.48) | 1.71 (1.35-2.17) | <.001 |
| Spinal/epidural | 26 (1.25) | 7 (1.50) | 1.21 (0.52-2.83) | .653 | 23 (1.11) | 13 (2.79) | 3.16 (1.54-6.48) | .002 |
| **Hematocrit (%)** | | | | | | | | |
| Mild anemia | 65 (2.02) | 25 (2.99) | 2.14 (1.28-3.56) | .004 | 45 (1.40) | 23 (2.75) | 2.27 (1.34-3.82) | .002 |
| Moderate-severe anemia | 48 (2.94) | 13 (4.21) | 1.58 (0.84-2.97) | .159 | 35 (2.15) | 19 (6.15) | 3.45 (1.92-6.19) | <.001 |
| ***CPT* code** | | | | | | | | |
| ***CPT*** code 27766 | 15 (1.08) | 6 (1.13) | 1.11 (0.43-2.90) | .826 | 8 (0.57) | 8 (1.50) | 2.49 (0.93-6.71) | .071 |
| ***CPT*** code 27769 | (0.00) | (0.00) | N/A | N/A | 2 (0.88) | 1 (1.52) | 2.36 (0.19-29.55) | .506 |
| ***CPT*** code 27792 | 57 (0.70) | 33 (1.22) | 1.69 (1.10-2.60) | .017 | 54 (0.66) | 41 (1.52) | 2.22 (1.47-3.35) | <.001 |
| ***CPT*** code 27814 | 115 (1.23) | 45 (1.58) | 1.67 (1.15-2.43) | .007 | 115 (1.23) | 46 (1.61) | 1.39 (0.98-1.97) | .065 |
| ***CPT*** code 27822 | 72 (1.46) | 29 (1.90) | 1.76 (1.10-2.80) | .018 | 50 (1.01) | 25 (1.64) | 1.72 (1.06-2.81) | .030 |
| ***CPT*** code 27823 | 28 (1.80) | 6 (1.41) | 0.76 (0.31-1.84) | .540 | 18 (1.16) | 4 (0.94) | 1.11 (0.36-3.37) | .860 |

Abbreviations: ASA, American Society of Anesthesiology; BMI, body mass index; *CPT*, *Current Procedural Terminology*; N/A, not applicable; OR, odds ratio.

## Ethical Approval

In accordance with our institutional guidelines, which follow the US Code of Federal Regulations for the Protection of Human Subjects, institutional review board approval was not needed for our analysis because data were deidentified and collected as part of a quality assurance activity

## Declaration of Conflicting Interests

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