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Original Research

Postoperative Complications After Operative Treatment of Open Versus Closed Distal Radius Fractures: A Propensity Score Matched Analysis

R. Cole Schmidt, MD, [*] Conor N. O'Neill, MD, [†] Zakkary J. Walterscheid, MD, [‡] James R. Satalich, MD, [*] Jonathan Isaacs, MD [*]

[*] Department of Orthopaedic Surgery, Virginia Commonwealth University, Richmond, VA
[†] Department of Orthopaedic Surgery, Duke University, Durham, NC
[‡] Curtis National Hand Center, MedStar Union Memorial Hospital, Baltimore, MD

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Purpose: The primary objective was to use a large sample size to compare 30-day infection rates and other perioperative outcomes between operatively treated open and closed distal radius fractures.
Methods: Patients in the American College of Surgeons National Surgical Quality Improvement Program database who underwent open reduction and internal fixation of a distal radius fracture between 2008 and 2018 were identified using Current Procedural Terminology codes and stratified into open (OF) and closed fractures (CF). A 10:1 (CF:OF) nearest neighbor propensity score matching was used to address demographic differences. Infection rate and other outcomes were compared between groups.
Results: A total 17,536 CF and 401 OF were treated by open reduction and internal fixation. After matching, baseline demographics were not statistically different ($P > .05$). There was a statistically significant increase in deep surgical site infections between OF and CF (0.2% vs 0.02%, $P < .05$). The OF cohort had a higher rate of significant adverse events (7.2% vs 1.6%, $P < .05$), return to the operating room (3.5% vs 0.9%, $P < .05$), mean length of stay (1.8 vs 0.7 days, $P < .05$), and operative time (90.8 vs 73.7 minutes, $P < .05$), but no difference in time from admission to the operating room (0.4 vs 0.3 days).
Conclusions: There was a statistically but probably not clinically impactful increase in 30-day deep surgical site infections in OF compared to CF. Patients with OF had significantly longer operative times and length of stay, and more often returned to the OR. This suggests that many OF patients do not carry a clinically increased short-term risk of infection when compared to CF patients.
Type of study/level of evidence: Prognostic, Level III.

Distal radius fractures are the most common injury facing the hand surgeon. However, open distal radius fractures (OF) are much rarer than their closed (CF) counterparts.[1,2] Open distal radius fractures only comprise 6% of such fractures, limiting the availability of high-quality complications data.[2]

Several small-cohort studies (under 60 patients) have reported outcomes following operative fixation of OF.[3–8] The data from these studies are not precise, as to be expected from small series, with infection rates ranging between 0%–44% and overall complication rates from 25%–61%. Kim et al[6] found that a cohort of 20 low-grade (Gustilo and Anderson type I or II) open distal radius fractures did not differ in infection rate or other complications and demonstrated no difference in Disabilities of the Arm, Shoulder and Hand (DASH) scores at 1 year when compared to a 40-patient cohort of CF. Several of the previously cited studies did not include a CF group for comparison purposes. In contrast, Schick et al[9] created a much larger cohort using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database to evaluate CF treated operatively and found an early complication rate of 3%. The literature on OF is comprised mainly of small patient cohorts with no large studies comparing complications following operative fixation.

The primary objective of this study was to compare the infection rate between OF and CF within the first 30 days after surgery. The

Corresponding author: R. Cole Schmidt, 1200 East Broad Street P.O. Box 980153, Richmond, VA 23219.
E-mail address: robert.schmidt@vcuhealth.org (R.C. Schmidt).

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secondary objective was to compare other perioperative data, such as return to the OR, operative time, outpatient status, and overall adverse event rates. We hypothesized that OF would have an increased rate of infections when compared to CF.

Materials and Methods

This is a retrospective cohort study of prospectively collected data as part of the NSQIP database. This registry contains demographics, comorbidities, and laboratory values with corresponding readmission and complication rates within 30 days of the indexed procedure. Patients are identified through Current Procedural Terminology (CPT), and International Classification of Diseases Ninth and Tenth Revision (ICD-9 and ICD-10) codes.[10] The NSQIP hospitals each employ trained nurse surgical clinical reviewers to oversee data collection, adding an additional quality measure. All patients are monitored for 30 days after surgery for any adverse events, readmissions, and reoperations. No outcome differences exist between institutions participating in the NSQIP program with nonparticipants.[11] The NSQIP database is comprised of a network of hospitals that are required to employ nurse surgical clinical reviewers to collect 274 variables from surgical procedures. The database implements several quality assurance measures, such as biweekly random internal audits, which have reported <1.8% interrater disagreement.[12,13] Informed consent was obtained from all individual participants included in the study.

Patients in the database who had undergone open reduction and internal fixation of a distal radius fracture from 2008 to 2018 were identified using CPT codes. These cases were stratified into OF versus CF based on respective ICD-9 and ICD-10 codes. Patient demographics, including age, smoking status, body mass index (BMI), male versus female, and American Society of Anesthesiologists physical status classification score were collected, along with complications data for each. Patients in each group underwent a 10:1 nearest neighbor propensity match for age, sex, BMI, and American Society of Anesthesiologists status, diabetes mellitus, hypertension requiring medication, congestive heart failure, chronic obstructive pulmonary disease, and bleeding disorders.

For each patient, length of stay (LOS), readmission rate, and 30-day complications were collected. In addition, all-cause mortality, and patients who required unplanned reoperation were recorded. The LOS was defined as the number of days from procedure to postoperative discharge. The NSQIP database stratifies 30-day complications into minor and significant categories. Minor adverse events as defined in the NSQIP database are superficial surgical site infections (SSI), urinary tract infection, pneumonia, acute kidney injury, or wound dehiscence. Significant adverse events (SAE) as defined in NSQIP are death, coma, placement on ventilator, unplanned intubation, cerebrovascular accident, deep venous thrombosis, pulmonary embolism, cardiac arrest, myocardial infarction, acute renal failure, sepsis, septic shock, or return to the operating room. Whether NSQIP classified return to the operating room as being related to the original wrist operation or unrelated also was recorded.

Statistical analysis was performed using R-studio software version 1.0.143 (R Foundation for Statistical Computing, Vienna, Austria). Patient demographics, comorbidities, and complications were compared between the two cohorts using the two-tailed *t* test for continuous variables and χ^2 analysis for categorical variables. Propensity score matching was performed using the nearest neighbor method to reduce treatment assignment bias and simulate randomization between the cohorts. Throughout these analyses, statistical significance was set at $P < 0.05$.

Table 1
Demographic and Comorbidity Characteristics for Open versus Closed Distal Radius Fractures

	Open Distal Radius Fractures (%)	Closed Distal Radius Fractures (%)	*P* Value
Patients, N (%)	401	4010	
Age (y, mean ± SD)	65.0 ± 17.6	65.0 ± 17.5	.50
BMI (kg/m^2, mean ± SD)	27.1 ± 7.3	27.2 ± 6.7	.46
Sex, M	92 (23.0)	953 (23.8)	.71
Modified Charleson Comorbidity Index (mean)	0.28 ± 0.70	0.64 ± 0.80	.32
Diabetes	33 (8.2)	425 (10.5)	.14
Smoking	75 (18.7)	570 (14.2)	.02*

* Indicates statistical significance.

Table 2
Thirty-day Outcomes for Patients With Operatively Treated Open and Closed Distal Radius Fractures

	Open Distal Radius Fractures	Closed Distal Radius Fractures	*P* Value
Patients, N	401	4010	
Time from admission to operating room (d)	0.4 ± 0.8	0.26 ± 5.6	0.32
Operative time (min)	90.8 ± 45.5	73.7 ± 46.2	<.001*
LOS (d)	1.8 ± 5.6	0.7 ± 4.4	<.001*
Outpatient status	145 (36.1%)	3,386 (84.4%)	<.001*
Return to the operating room for any reason	14 (3.5%)	35 (0.9%)	<.001*
Return to the operating room related to operative wrist	14 (3.0%)	26 (0.6%)	<.001*
Minor adverse events†	5 (1.2%)	29 (0.7%)	.25
Superficial SSI	1 (0.2%)	6 (0.1%)	.63
Wound dehiscence	0	1 (0.02%)	–
SAE‡	29 (7.2%)	66 (1.6%)	<.001*
Deep SSI	1 (0.2%)	1 (0.02%)	.04*

* Indicates statistical significance.
† Minor adverse event includes superficial surgical site infection, wound dehiscence, urinary tract infection) acute kidney injury.
‡ Significant adverse event includes return to the operating room, deep surgical site infection, organ space infection, renal failure, intubation issues (fail to wean or reintubation), postoperative transfusion, pneumonia, deep venous thrombosis, pulmonary embolism, shock.

Results

A total of 20,436 patients was identified who underwent operative fixation of a distal radius fracture. Patients without demographic or complications data were excluded, leaving 17,937 patients, of which 17,536 (97.8%) had CF and 401 (2.2%) had OF. After propensity score matching, the CF group included 4010 patients and the OF group included 401 patients for a total of 4,411 patients included in the matched analysis.

After matching, the CF cohort (N = 4,010) had a mean age of 65.0 ± 17.5 years, with 23.8% (n = 95) men, and a mean BMI of 27.2 ± 6.7 kg/m^2. The OF cohort (N = 401) had a mean age of 65.0 ± 17.6 years, with 22.9% (n = 92) men and a mean BMI of 27.1 ± 7.3 kg/m^2. A significant difference in current smoking status remained between the two groups following matching (18.7% in OF vs 14.2% in CF, $P < 0.05$). Including smoking in the propensity match substantially limited the precision of nearest neighbor matching, giving less well-matched pairings in the rest of the demographics and decreasing the amount of usable data. There were no significant differences in individual comorbidities or in modified Charleston Comorbidity Index (Table 1).

Postmatching outcome data were included in Table 2. There was a significantly higher rate of deep SSI in the OF cohort (0.2% vs 0.02%, $P < .05$). However, the absolute number of deep infections

remained quite low with only one case reported in the OF group. There was no difference in superficial SSI between OF and CF (0.2% vs 0.1 %). The rate of overall SAE differed significantly between the OF (7.23%) and CF (1.65%) cohorts ($P < 0.05$). The OF group had a higher rate of return to the operating room for any reason of 3.5% compared to 0.9% for CF ($P < 0.05$). Of these, 3% of total OF and 0.5% of CF patients returned specifically for additional surgery on their wrist ($P < 0.05$). More patients in the CF group were classified as outpatient level of care (36.1% vs 84.4%, $P < 0.05$). The OF group had a significantly higher total hospital LOS (1.9 vs 0.7 days, $P < .05$). Operative time was longer in OF patients (90.8 vs 73.7 minutes, $P < 0.05$). Of note, there was no significant difference in minor adverse events or in time from admission to the operating room (OF 0.4 days, CF 0.3 days).

Discussion

Although open distal radius fractures are rare, comprising 2.2% of operatively treated distal radius fractures in the NSQIP database from 2008–2018, differences in early complication risk would be useful information. Intuitively, the potential for fracture site contamination with OF should increase infection rates. Based on our data, however, there is no clinically important difference in infection rate between OF and CF.

Superficial SSI were not statistically different between OF and CF groups and, while rates of deep SSI in the OF group were higher, this finding only represented one case reported in each cohort, meaning the absolute numbers were quite low. Based on this, infection does not seem to be different in a clinically meaningful way between the two cohorts. The rate of infection detailed in this study is considerably lower compared to previously reported rates between 0%–44%.[3–8] This could be for several reasons. Firstly, infections outside of the 30-day window were not included. Secondly, levels of contamination or severity of soft tissue damage are not quantified in the NSQIP database. Studies emphasizing more dramatic wounds will have higher infection rates than this data set. Tar, gravel, dirt, or feces contamination was observed in 40% of infected OF patients in one series.[4]

The higher rate of significant adverse events ($P < .01$) observed in the OF cohort in these data were chiefly because of the need for return to the operating room, which comprised approximately half of the SAE for each cohort. However, OF were nearly four times more likely to return to the operating room for any reason. Many of the other SAE recorded in NSQIP are more likely related to the higher degree of systemic trauma experienced in parallel to the wrist injury. Although not all CPT codes for reoperations were listed, the database does demonstrate that some of the differences in operating room return rates between OF and CF were related to the wrist injury itself. As a whole, the complication rates for OF from these data are significantly lower than the previously cited 25%–61%, likely explained by many complications in other cohorts occurring outside of the 30-day window.[3–8]

The two cohorts did not differ in the time from admission to operating room (mean 0.40 vs 0.26 days, $P = 0.32$). Previous studies have established that time to operating room does not affect infection rates following distal radius or hand fractures.[14–16] Not surprisingly and probably reflective of lower levels of associated trauma, CF were treated much more often outpatient. Inpatient stays have been associated with higher rates of major adverse events in this setting.[17] Low-grade OF can be treated most likely on an outpatient basis as long as the wound is not contaminated and appropriate antibiotics are given.[18] The longer operating room times reported for OFs, possibly related to increased complexity or the added time necessary for debridement, also can increase complications.[19]

While providing large volumes of high-quality data, NSQIP database studies have notable limitations. Outcomes data are confined to 30 days after surgery, so longer term complications, such as late infection, malunion, nonunion, implant failure, and functional outcomes, are not captured. Though not related to the NSQIP database, in this series, we were not able to control for smoking status, as this would have significantly limited our propensity match to smaller cohorts, defeating the purpose of the large sample sizes available in the database. That said, the large cohorts conferred significance to a fairly small difference in proportion (18.7% of OF patients were smokers compared to 14.2% of those with CF). Smoking does correlate with increased infection and reoperation risk following distal radius fractures, likely leading to a small overestimation of the increased reoperation rates found in our data.[20,21] The groups otherwise were not different in terms of age, BMI, sex, and other comorbidities. The BMI has been associated particularly with longer operative times and complications.[22] Specialty of the treating surgeon was not stratified, as this has been shown not to have an impact on complications.[23] Lastly, there was no available information on detailed reasoning for return trips to the operating room beyond CPT and ICD codes—these could represent deliberate staging by the operating surgeon or need for revision fixation because of implant failure. Whether these trips were planned or unplanned, infection risk between OF and CF was not impactful clinically regardless of whether the treatment ultimately required multiple trips to the operating room.

In conclusion, there was a statistically but probably not clinically impactful increase in 30-day deep SSI in OF compared to CF and no difference in superficial SSI. The OF patients had significantly longer operative times and LOS, and more often returned to the operating room. This suggests that many OF do not carry a clinically increased short-term risk of infection when compared to CF.

Conflicts of Interest

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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