

Association of Timing With Postoperative Complications in the Management of Open Distal Radius Fractures

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Abstract

Background: This study investigates whether open distal radius fractures (ODRFs) treated after 24 hours from time of injury have an increased risk of infection or overall complication profile compared with those treated within 24 hours. **Methods:** Retrospective review was performed of all patients treated for ODRF over a 6-year period at a single large academic institution. Postoperative complications included surgical site infections, need for revision irrigation and debridement, delayed soft tissue healing, loss of reduction, nonunion, and malunion. **Results:** One-hundred twenty patients were treated for ODRF. Mean (SD) age at time of injury was 59.92 (17.68) years. Twenty patients (16.7%) had postoperative complications. Regarding mechanism of injury, 78 (65.0%) had a low-energy and 42 (35.0%) had a high-energy injury. Age and fracture grade were not significant factors. Mean (SD) open wound size was 1.18 (1.57) cm. Mean (SD) time from injury presentation to the emergency department (ED) and first dose of intravenous antibiotics was 3.07 (4.05) hours and mean (SD) time from presentation to the ED and operative treatment was 11.90 (6.59) hours, which did not show a significant association with postoperative complications. Twenty-four patients (20.0%) were treated greater than 24 hours after presentation to the ED, which was not significantly distinct from those treated within 24 hours. **Conclusion:** Patients with ODRFs treated after 24 hours were not associated with a greater risk of postoperative complications. Factors including age, energy and mechanism of injury, and fracture grade did not alter outcome in any statistically significant manner.

Level of Evidence: Level IV

Keywords: open distal radius fractures, fracture management, hand surgery, wrist surgery, orthopedic surgery trauma

Introduction

Although distal radius fractures are very common with more than 643 000 occurring annually in the United States, the incidence of open distal radius fractures (ODRFs) is unknown.^{1–3} In fact, the incidence of ODRFs has been estimated to be 6% of all distal radius fractures with the majority being low-grade, Gustilo I injuries.^{3–6} Interestingly, Gustilo type I ODRFs have been demonstrated to have similar outcomes compared with closed distal radius injuries, albeit with a concern for higher risk of postoperative infection compared with closed fractures.^{4,7,8}

The standard of care of ODRFs is urgent irrigation and debridement along with operative fixation.^{3,9} There is evidence indicating that treatment of Gustilo type I ODRFs in a delayed fashion is an acceptable approach.⁹ However, there remains a paucity of data investigating the historical surgical dogma regarding timing for treatment of ODRF management.

Furthermore, the overall treatment of ODRFs remains controversial with the largest study to date including 90 patients published in 2020, and this specific study investigated complication rates between patients treated with single-stage debridement and open reduction internal fixation (ORIF) versus patients undergoing staged treatment (initial external fixation with wound care followed by definitive ORIF).¹⁰

Here, we examine whether ODRFs treated after 24 hours from time of injury have an increased risk of infection or

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overall complication profile compared with those treated within 24 hours. We hypothesize that there is no significant difference in complications in ODRFs treated after 24 hours compared with those treated within 24 hours from injury.

Materials and Methods

Institutional review board approval was obtained. A retrospective chart review was performed of all patients treated for ODRF over a 9-year period from 2015 to 2023. Patients were seen at an academic institution in a large metropolitan city, including level I trauma centers. A total of 120 patients were identified by the International Classification of Disease, Tenth Revision codes for distal radius fractures, and Current Procedural Terminology (CPT) codes for irrigation and debridement (Supplemental Table S1). Inclusion criteria included all patients older than 18 years of age with an open fracture of the distal radius. Patients were excluded if they were treated at an outside institution, if their medical record had insufficient documentation, or if they were lost to follow-up. All patients underwent irrigation, debridement, and operative fixation of the ODRFs, all performed within the same operative period. Patient demographic data were collected, including age, sex, race/ethnicity, mechanism and energy of injury, smoking history, relevant comorbidities, time of injury, time of presentation to the emergency department (ED), preoperative antibiotics administered, any allergies to antibiotics, time to surgery, Gustilo classification of the ODRF, Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) fracture and dislocation classification, characteristics of the fracture patterns, operative treatment, open wound location, open wound size, time to reoperation, and follow-up time. Gustilo classification was confirmed and documented by the treating physician. Our primary outcomes were postoperative surgical complications. The postoperative surgical complications reviewed included surgical site infections, need for reoperation for repeat irrigation and debridement, delayed soft tissue healing or wound complications, loss of reduction, nonunion, and malunion of the distal radius fractures.

Statistical Methodology

Regarding statistical methodology, cohort data were summarized using frequencies and percentages for categorical data and means and SDs for numeric data. Treatment characteristics were similarly summarized with statistical testing performed to compare characteristics of those who experienced a complication to those who did not. Nominal data were compared for distributional equality between complication dichotomy via Pearson chi-square or Fisher's exact test depending on cell sample size distribution. Ordinal data were tested for ordinal association via exact Kendall's tau test. Rank equivalency between complication dichotomy was determined for nonparametric numeric data

Table 1. Patient Demographics and Fracture Characteristics.

Variable	Patient cohort (N = 120)
Demographics	
Age, y	
Mean (SD)	59.92 (17.68)
Gender	
Female	74 (61.7%)
Male	46 (38.3%)
Smoking history—current or former	37 (31.4%)
Fracture characteristics	
AO/OTA classification	
A1	3 (2.5%)
A2	18 (15.3%)
A3	30 (25.4%)
B3	1 (0.8%)
C1	8 (6.8%)
C2	42 (35.6%)
C3	16 (13.6%)
Not available	2
Fracture type	
Intraarticular	68 (57.6%)
Extraarticular	50 (42.4%)
Not available	2
Follow-up	
Time to final follow-up, mo	
Mean (SD)	6.93 (6.51)
Time to reoperation, d	
Mean (SD)	32.45 (28.42)

Note. AO/OTA = Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association.

via Mann-Whitney *U* tests. All statistical tests were two-sided with *P* less than .05 considered statistically significant. All analyses were done using RStudio for Windows.

Results

One-hundred twenty patients were treated for ODRF with 74 (61.7%) female and 46 (38.3%) male patients included in the cohort. The mean (SD) age at time of injury was 59.92 (17.68) years. Notably, 37 patients (31.4%) had a history of smoking. Fifteen patients (12.5%) were polytrauma patients and had other injuries. Regarding comorbidities, 6 patients (5.0%) had osteopenia, 11 (9.2%) had osteoporosis, and 6 (5.0%) had a history of substance or opioid abuse. Average time to reoperation was 32 days (12 reoperations). Average follow-up time was 6.93 months (Table 1). In total, 34 surgeons performed the 120 ODRF procedures that were analyzed in this study.

Overall, there were 31 postoperative complications across 20 patients (16.7%). The complications included 2 infections, 12 reoperations, 4 wound healing complications, 3 loss of reductions, 7 nonunions, and 3 malunion (Tables 2

Table 2. Open Distal Radius Postoperative Complications.

Variable	Patients without complications	Patients with complications	P-value
	n = 100	n = 20	
Age, y			
<65	58 (58.0%)	11 (55.0%)	1.000
≥65	42 (42.0%)	9 (45.0%)	
Gustilo classification			.144
I	78 (78.0%)	12 (63.2%)	
II	15 (15.0%)	3 (15.8%)	
III	7 (7.0%)	4 (21.1%)	
Missing/unavailable		1	
Intraarticular fractures			1.000
Intra	56 (57.1%)	12 (60.0%)	
Extra	42 (42.9%)	8 (40.0%)	
AO/OTA classification			.150
A1	2 (2.0%)	1 (5.0%)	
A2	17 (17.3%)	1 (5.0%)	
A3	24 (24.5%)	6 (30.0%)	
B3	1 (1.0%)	0 (0.0%)	
C1	6 (6.1%)	2 (10.0%)	
C2	38 (38.8%)	4 (20.0%)	
C3	10 (10.2%)	6 (30.0%)	
Wound size, cm			.096
Mean (SD)	1.05 (1.45)	1.75 (1.96)	
Time from ED to surgery, h			
Mean (SD)	12.32 (6.48)	9.61 (6.89)	.108
Time >24 h	18 (18.0)	6 (30.0)	.358
Time from ED to antibiotics, h			.910
Mean (SD)	3.09 (4.05)	2.98 (4.17)	
Mechanism of injury			.797
Low energy	66 (66.0%)	12 (60.0%)	
High energy	34 (34.0%)	8 (40.0%)	
Smoking status			
Current or former	26 (26.5%)	11 (55.0%)	.025

Note. ED = emergency department. AO/OTA = Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association. Bolded values are statistically significant ($p < 0.05$).

and 3). A total of 50 patients (42.4%) had an intraarticular fracture. For AO/OTA classification grade, 3 (2.5%) had a type A1 fracture, 18 (15.3%) had a type A2 fracture, 30 (25.4%) had a type A3 fracture, 1 (0.8%) had a type B3 fracture, 8 (6.8%) had a type C1 fracture, 42 (35.6%) had a type C2 fracture, and 16 (13.6%) had a type C3 fracture (Table 1). One patient's radiographs were not available to be assessed for fracture characteristics. For Gustilo classification fracture grade, 90 (75.6%) had a type I distal radius fracture, 18 (15.1%) had a type II fracture, and 11 (9.2%) had a type III fracture (Table 2). There were no significant associations between Gustilo classification and postoperative complications ($P = .144$) or between AO classification

and postoperative complications ($P = .150$). Regarding mechanism of injury, 78 (65.0%) had a low-energy and 42 (35.0%) had a high-energy injury, and did not show a statistically significant association with any postoperative complications ($P = 1.000$). Likewise, age ($P = 1.000$) was not a statistically significant factor for any surgical complications. The overwhelming majority of patients were definitively treated with irrigation, debridement, and ORIF with volar locking plates 99 (82.5%). The mean (SD) open wound size was 1.18 (1.57) cm and most wounds were ulnar sided. Wound size was not associated with any postoperative complications ($P = .096$; Table 2).

The mean (SD) time from injury presentation to the ED to the first dose of intravenous antibiotics was 3.07 (4.05) hours and was not statistically significant for any postoperative complication ($P = .910$). The mean (SD) time from presentation to the ED to operative treatment was 11.90 (6.59) hours and did not show a statistically significant association with any postoperative complications ($P = .108$; Table 2). Specifically, the mean (SD) time from presentation to the ED to surgical treatment of patients in the less than 24-hour time period group was 13.19 (6.28) hours in 96 patients. The mean (SD) time from presentation to the ED to surgery in the greater than 24-hour time period group was 53.89 (66.85) hours in 24 patients. There were 24 patients (20.0%) treated greater than 24 hours after presentation to the ED, which was not significantly distinct from those treated prior to 24 hours ($P = .358$). In contrast, smoking (defined as being a current or former smoker) was found to be associated with postoperative complications ($P = .025$; Table 2).

Discussion

This study demonstrated that patients with ODRFs treated after 24 hours did not have a greater risk of postoperative complications, including surgical site infections, wound healing complications, loss of reduction, nonunion, or malunion. Regarding factors that may influence urgent treatment, age, energy and mechanism of injury, and fracture grade were similarly not statistically significant for any postoperative complications in ODRF management. The only variable that was associated with postoperative complications after an ODRF was smoking. Thus, these results challenge the orthodoxy of all open fractures meriting urgent treatment within 24 hours. To the authors' knowledge, this is the largest documented series to date of patients with ODRFs with a cohort of 120 patients specifically looking at the outcomes and timing of treatment for ODRFs. This study seeks to add to the paucity of literature available on the postoperative outcomes of ODRFs.

Previously, Harper et al¹⁰ investigated postoperative complications following ODRF repair in the largest cohort at the time of publication in 2020 (90 patients) and found 37% complication rate. Furthermore, Harper et al¹⁰ reported that mechanism of injury and type of treatment were the

Table 3. Demographics of Open Distal Radius Patients With Postoperative Complications.

Patient no	Age, y	Sex	Mechanism of injury	Energy of injury	Time from ED to OR, h	Gustilo classification	Postoperative complications experienced	Time to reoperation/ I&D	Reason for reoperation/I&D
1	87	Female	Trip and fall	Low	More than 24	I	Nonunion	NA	NA
2	51	Male	Motorcyclist struck by motor vehicle	High	Less than 24	II	Nonunion	NA	NA
3	59	Female	FOOSH	Low	Less than 24	I	Infection, reoperation/I&D, nonunion	27 d	Loss of reduction
4	86	Female	FOOSH	Low	More than 24	I	Loss of reduction	NA	NA
5	39	Female	Motorcyclist struck by motor vehicle	High	Less than 24	I	Nonunion	NA	NA
6	36	Male	Trip and fall	Low	Less than 24	I	Reoperation/I&D, wound healing problems	10 d	Repeat I&D
7	39	Male	Electric scooter accident	High	Less than 24	II	Wound healing problems	NA	NA
8	64	Female	Dog bite	Low	Less than 24	III	Nonunion	NA	NA
9	62	Male	Trip and fall	Low	Less than 24	III	Reoperation/I&D, nonunion	2 d	Delayed closure
10	55	Female	Trip and fall	Low	Less than 24	III	Infection	NA	NA
11	32	Male	Motorcycle accident	High	Less than 24	I	Reoperation/I&D, malunion	45 d	Instability
12	26	Male	Motorcyclist struck by motor vehicle	High	Less than 24	I	Reoperation/I&D	27 d	Instability
13	27	Male	Firework injury	High	Less than 24	III	Reoperation/I&D, loss of reduction	90 d	Loss of reduction
14	58	Male	Assault/fall	Low	Less than 24	II	Reoperation/I&D, wound healing problems	18 d	Repeat I&D
15	72	Male	FOOSH	Low	Less than 24	I	Wound healing problems, nonunion	NA	NA
16	69	Female	Trip and fall	Low	Less than 24	I	Reoperation/I&D	22 d	Instability
17	100	Male	Trip and fall	Low	Less than 24	NA	Malunion	NA	NA
18	83	Male	Trip and fall	Low	More than 24	I	Reoperation/I&D, malunion	61 d	Malunion
19	80	Female	Trip and fall	Low	More than 24	I	Backed out screw/hardware issue	NA	NA
20	75	Female	Trip and fall	Low	More than 24	I	Pain and protrusion due to hardware	429	Pain

Note. ED = emergency department; OR = operating room; I&D = irrigation and debridement; FOOSH = fall on outstretched hand.

only variables shown to correlate with an increased rate of postoperative surgical complications. Moreover, Glueck et al⁶ demonstrated no association between complication or infection rate and Gustilo classification in one of the larger published series of ODRFs featuring a cohort of 42 patients.

Recently, there has been evidence in the literature to support that ODRFs treated with ORIF at the time of index irrigation and debridement are safe and efficacious with infection rates equivalent to treatment of closed distal radius fractures in matched cohorts.^{6,11,12} As Harper et al¹⁰ astutely comment in their publication, with adequate debridement of the soft tissues in a single-stage procedure, modern volar locking plates or dorsal spanning plates enable orthopedic and plastic surgeons with the ability to achieve appropriate skeletal stability. Our experience with the vast majority of patients in our cohort of patients with ODRFs receiving single-stage irrigation, debridement, and fixation with volar locking plates with a correspondingly low complication rate bolsters this commentary.

Regarding delineating urgent timing of operative repair of ODRFs as significant or not, Henry et al¹³ recently examined a cohort of Gustilo type I ODRFs that underwent volar plating, stratifying the patients by those treated within 24 hours and those scheduled for delayed outpatient surgery. Henry et al¹³ reported that in a cohort of 24 patients with open type I distal radius fractures with 17 treated urgently and 7 treated in delayed fashion, there were no infections in either group and only a single reoperation in each respective group. In the treatment algorithm by Henry et al¹³, all patients received preoperative antibiotics with urgently treated patients receiving intravenous antibiotics, and those in the delayed treatment group receiving oral antibiotics in the interim to surgical intervention.

Optimal timing for treatment of open fractures has been extensively debated. Historically, open fractures were managed with emergent debridement within 6 hours of injury, yet the precise origin of this “6-hour rule” is unclear, but is reported by both Friedrich in 1898 in animal models and by Gustilo and Anderson in 1976 in humans.^{14,15} However, multiple studies demonstrated no advantage for the 6-hour rule if antibiotics were administered early (preoperatively or intraoperatively), and studies have demonstrated no advantage to antibiotics beyond 24 hours after initial administration.¹⁶⁻²² In a meta-analysis of 3539 open fractures, Schenker et al²³ reported no increased association with rates of infection with delayed debridement beyond this historical “6-hour rule.” In a retrospective, multicenter study of 554 pediatric open fractures, Skaggs et al²⁴ demonstrated no difference in infection in patients who had surgery within 6 hours compared with those delayed up to 72 hours. Furthermore, the management of open fractures within this emergent window has been advocated for and perpetuated since Gustilo’s initial reports.^{14,25,26} Historically, in the lower extremity orthopedic trauma literature, there is evidence to

support favorable outcomes associated with early intramedullary nailing of open femoral shaft fractures within 24 hours.²⁷⁻³⁰ Yet, more recently, within the field of lower extremity orthopedic trauma, staged treatment protocols are advocated encompassing initial urgent irrigation, debridement, and external fixation with definitive internal fixation following adequate debridement.³¹⁻³⁵ A detailed critical analysis of the management of open fractures in orthopedic surgery is provided by Okike and Bhattacharyya.³⁶

Comparatively, there are limited studies on open fracture management in the upper extremity. Our study challenged the current surgical dogma of all open orthopedic fractures needing urgent treatment within 24 hours and adds to the current paucity of data on the timing of management of upper extremity open fractures, namely distal radius fractures. In contrast to the few studies with small sample sizes and concordantly widely varied outcomes, a recent study by Tareen et al³⁷ aimed to characterize surgical and functional outcomes of open fractures of the distal radius in patients younger than 65 years of age with a cohort of 92 patients. Notable findings included the following: Reoperation was required for 33% of ODRFs that underwent immediate definitive fixation, and for 50% that underwent staged treatment.³⁷ Second, Tareen et al³⁷ reported an overall 15% infection rate with no statistically significant difference in the immediate definitive fixation group and the staged treatment group; moreover, the authors concluded deep surgical site infections associated with open fractures of the distal radius were driven by the extent of soft tissue injury. Ultimately, open fractures cannot be viewed as one category nor compartmentalized under one treatment algorithm and merit a more nuanced approach to delineating identifying which open fractures need urgent treatment.

Although our cohort is the largest single series to our knowledge, our study is severely underpowered, thus causing significant statistical limitations. According to the post hoc power analysis, a study would require tens of thousands of patients to detect a difference between the two groups (>24 hours and <24 hours) to power the study at 80%. With only 24 patients in the greater than 24-hour group, dividing the cohorts into two groups would not be sufficient to address the sample size issue. Furthermore, a multivariate regression is not possible due to overparameterization. Similarly, inputting additional variables into a model and dividing the data into two strata (>24 hours and <24 hours) are also not possible, as it would only point out differences that are not able to be adjusted in a multivariable model. Further analysis in larger populations of patients with ODRFs may explicate additional differences between the two cohorts not captured because of these limitations. Of note, this study included all ODRFs, with no exclusion by Gustilo classification status. This study, which is retrospective in nature, would benefit from prospective analysis as well as long-term follow-up. Treating fractures in a delayed

fashion is not standard of care, so it was difficult to increase our numbers in this group with the retrospective study design considering this method would be challenging a widely accepted dogma. This study was specifically focused on examining the factors associated with postoperative surgical complications in ODRF management, and whether such management within 24-hour time interval was significant. Ultimately, given the low incidence of ODRFs nationally, a multi-institutional study would likely facilitate the most informative study with a larger cohort of patients.

In conclusion, timing of the treatment of ODRFs remains controversial. Based on the results of this study, we believe that fixation at the time of debridement of open fractures of the distal radius can provide satisfactory surgical outcomes regardless of whether within the strict 24-hour time interval. We demonstrate that patients with ODRFs treated after 24 hours did not have a greater risk of postoperative complications such as surgical site infections and nonunion. Regarding factors that may influence urgent treatment, age, energy and mechanism of injury, and fracture grade were all not statistically significant for any postoperative complications in ODRF management.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

Ethical approval for this study involving human participants was obtained from the institutional review board. Animal subjects were not used in this study.

Statement of Informed Consent

Informed consent was not sought for this article because this is a retrospective review study. A waiver of consent was granted by the institutional review board.

Declaration of Conflicting Interests

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