Comparison of Early Versus Late Debridement Outcomes in the Management of Open Distal Radius Fractures

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Disclosures for this Article

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All authors of this journal-based CME activity have no relevant conflicts of interest to disclose. In the printed or PDF version of this article, author affiliations can be found at the bottom of the first page.

Planners

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Learning Objectives

Upon completion of this CME activity, the learner will understand:

- The classification of open distal radius fractures.
- The relative outcomes of early and late surgery for open distal radius fractures.
- The incidence of infection after operative treatment for open distal radius fractures.

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Purpose The optimal timing for surgical treatment of open distal radius fractures remains an area of debate. The purpose of this study was to examine the outcomes of open distal radius fractures treated surgically before or after 24 hours.

Methods A multicenter retrospective review was performed on all open distal radius fractures treated over 11 years. Patient demographics, injury mechanism, and initial treatment were

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recorded. Fracture severity was graded by the Gustilo-Anderson classification. Comparisons were made between those treated surgically within and after 24 hours. Outcomes examined included infection, revision surgery, osteomyelitis, and nonunion.

Results A total of 230 cases met the inclusion criteria. The cohorts of early and delayed surgical intervention were similar with regard to preoperative demographics. The most common mechanism of injury was motor vehicle accident. Approximately 40% of cases were graded as type I, 40% as type II, and 20% as type III. Mean time to debridement in the group treated after 24 hours was 5 days. A mean postoperative follow-up of greater than 6 months was obtained in both cohorts. Similar outcomes were found between cohorts with respect to postoperative infection, revision surgery, osteomyelitis, and nonunion.

Conclusions Similar outcomes with regards to infection, revision, osteomyelitis, and nonunion were found between open distal radius fractures treated emergently versus those managed in a delayed fashion. Patient- and injury-specific factors are important in dictating care.

Type of study/level of evidence Prognostic IIB.

Key words Complications, delayed debridement, distal radius, Gustilo-Anderson, open fracture, outcomes.

FRACTURES OF THE DISTAL RADIUS are common injuries occurring in approximately 643,000 people per year in the United States; estimates are that nearly 6% of those are classified as open fractures.[1] Traditional management of open fractures consists of immediate administration of antibiotics followed by surgical debridement and stabilization of the fracture within 6 hours of the injury. However, the optimal timing of surgery in the case of distal radius fractures—to prevent infection yet achieve the ideal anatomic reconstruction—is not known.

The impact of delayed surgical treatment of open fractures in the era of antibiotics, antiseptic protocols, and modern fixation techniques has previously been investigated.[2,3] Numerous retrospective studies have been unable to demonstrate that the risk of infection is decreased when debridement is performed in 6 hours versus 24 hours.[4–13] Of these studies, infections have been more closely correlated with greater severity of injury, increased time to antibiotic administration, lower quality debridement, and lower-extremity location.[4–27] In addition to the ethical considerations, a randomized controlled trial examining the effect of surgical timing on the development of infection is hindered by several variables such as surgeon availability, staffing and hospital resources, and patients' overall health condition.[2]

Several studies have also suggested that outcomes such as fracture alignment, surgery duration, patient mortality, readmission rate, and physician burnout may be poorer when surgery must be completed during nighttime hours with inexperienced staff or with cross-covering surgeons.[14,26,28–30] The window of time during which surgery can be safely delayed without compromising outcomes is not defined. The purpose of this study was to compare outcomes of open distal radius fractures treated before and after 24 hours. The authors hypothesized that outcomes of low-grade open distal radius fractures treated emergently would be similar to those treated in a delayed fashion.

METHODS

Study design

A multicenter retrospective review of all patients treated for open distal radius fracture was conducted between March 1, 2009, and March 1, 2020, at two US academic level-I trauma centers in two distinct geographic regions. Institutional review board approval was obtained for this study. Patients were identified by Current Procedural Terminology (CPT) code for distal radius open reduction and internal fixation (25607, 25608, and 25609) and cross-referenced with CPT code for open fracture debridement (11012) in both the hospital database and practice outpatient charts.

Patient selection

We separated the cases into two groups: those who underwent initial surgery within 24 hours of the injury and those who underwent initial surgery after

24 hours of the injury. Time of injury was defined as the time of day noted at the time of admission into the emergency department at the hospital. Charts were reviewed for basic demographics, fracture mechanism, and classification. Open fractures were classified based on the description of Gustilo and Anderson (Table 1) using patient history of mechanism, intraoperative description of the wound, and radiographs as criteria. Radiographs were obtained before surgery and at each postoperative visit. Cases were graded retrospectively by a hand surgery resident under the guidance and review of a fellowship-trained hand surgeon.

Outcomes such as infection, revision surgery, and nonunion were assessed. Major infection was defined as an abscess, draining wound, or erythematous wound requiring surgical debridement; we did not include cases of minor cellulitis or stitch abscess. Revision surgery was defined as an additional surgery for loss of reduction or failure of fixation; we did not include staged fixation (eg, external fixation converted to internal fixation) or removal of hardware as a revision. Osteomyelitis was diagnosed via positive bone culture. A fracture was considered a nonunion if it had not healed in 9 months or did not show any progress of healing within three consecutive months.

Open fracture management

Open fracture management policy across both institutions included gross debridement and irrigation at the bedside, fracture reduction, and provisional splinting. Additionally, in the setting of these injuries, antibiotics were given based on judgment of wound severity. Institutional guidelines recommended cefazolin 1 g intravenously (IV) every 8 hours for patients weighing less than 70 kg and 2 g for those weighing more than 70 kg; clindamycin 600 mg IV was recommended in patients with contraindications to cephalosporins. Furthermore, the addition of gentamycin (5 mg/kg) IV every 24 hours was recommended for type III open fractures. At the discretion of the surgeon, some low-grade injuries were treated on an outpatient basis and given oral cephalexin 500 mg PO every 6 hours. Antibiotics were recommended to be continued for 48 hours after the last debridement.

Exclusion criteria

We excluded patients with noncommunicating superficial wounds over the fracture, patients with open fractures that were treated nonoperatively, patients with open fractures that were treated surgically after fracture radiographic union, and patients who did not follow up with their surgeon after surgery. Furthermore, patients who underwent surgical debridement and/or stabilization prior to transfer to one of the participating institutions were excluded. Finally, patients who were operated on more than 2 weeks following initial injury were also excluded.

TABLE 1. Gustilo-Anderson Classification

Classification	Description
Type I	Low energy injury <1 cm, minimal soft tissue damage and contamination Minimal fracture comminution
Type II	Moderate energy injury 1−10 cm, moderate soft tissue damage and contamination. Moderate fracture comminution
Type III	High energy injury >10 cm, extensive soft tissue damage and contamination Severe fracture comminution
Type IIIA	Adequate soft tissue coverage despite injury, without vascular injury requiring repair
Type IIIB	Inadequate soft tissue coverage necessitating rotational vs free flap
Type IIIC	Vascular injury requiring vascular repair

Statistical analysis

Continuous data are presented as mean (95% confidence interval), whereas categorical data are presented as percent (95% confidence interval). Odds ratios were calculated to assess the strength of comparisons if the data were adequately powered.

RESULTS

A total of 259 patients were identified. Thirteen patients did not meet the inclusion criteria based on the time from injury to surgical intervention, leaving 246 patients for analysis. Of these 246, complete retrospective data were available for 230 patients. Basic demographics are listed in Table 2. We found 164 patients who underwent the initial surgery within 24 hours and 66 patients who were debrided after 24 hours. The mean follow-up time for those in the early debridement group was 6.7 months, and 8.1 months for those in the delayed debridement group. Preoperative demographics were similar between the two cohorts, with regard to age, body mass index, sex, hand dominance, laterality, diabetes, smoking, and workers' compensation status (Table 2).

TABLE 2. Preoperative Demographic Information

Demographics	Total Data (N = 230)	Debridement ≤ 1 d (N = 164)	Debridement > 1 d (N = 66)	Odds Ratio
Age (mean; SD)	40.9 (38.4; 43.5)	42.0 (39.1; 44.9)	37.7 (32.4; 43.0)	0.98 (0.96; 1.01)
BMI (mean; SD)	27.5 (26.6; 28.4)	27.4 (26.3; 28.4)	28.0 (26.0; 30.0)	1.01 (0.97; 1.06)
Sex				
F	79 (34.3%)	54 (32.9%)	25 (37.9%)	0.80 (0.44; 1.47)
M	151 (65.7%)	110 (67.1%)	41 (62.1%)	
Hand dominance				
Left	17 (7.4%)	15 (9.1%)	2 (3.0%)	2.47 (0.61; 18.1)
Right	213 (92.6%)	149 (90.2)	64 (97.0%)	
Affected side				
Left	117 (50.9%)	79 (48.2%)	38 (57.6%)	Reference
Right	103 (44.8%)	80 (48.8%)	23 (34.8%)	0.60 (0.32; 1.09)
Bilateral	10 (4.3%)	5 (3.0%)	5 (7.6%)	2.07 (0.53; 8.12)
Worker's compensation	18 (7.9%)	15 (9.2%)	3 (4.5%)	0.50 (0.11; 1.59)
Diabetes	25 (11.0%)	17 (10.4%)	8 (12.1%)	1.17 (0.45; 2.81)
Smokers	96 (41.7%)	70 (42.7%)	26 (39.4%)	0.85 (0.46; 1.53)

The most common mechanism of injury overall was motor vehicle/motorcycle accident (37.4% of all cases), which accounted for the largest proportion of cases both in the early (39.6%) and delayed (31.8%) patient cohorts. Most patients who experienced crush injuries in this study were taken to the operating room within 24 hours (10 of 12 cases).

Gustilo-Anderson wound classification was similar between the two cohorts (Table 3). When examining the data in totality, 39.6% of fractures were classified as grade I, 39.6% as grade II, and 20.9% as grade III (Table 3). Negative pressure wound therapy was used in the minority of cases overall (20.9%) and with similar frequency between early and delayed debridement cohorts.

Primary outcomes such as infection (major and minor), revision surgery, osteomyelitis, and nonunion were similar between groups (Table 4). Revision surgery was required in three cases overall, all belonging to the early debridement cohort. No cases of nonunion were encountered. Infection occurred in 11% of all cases, with similar frequency between early and delayed debridement cohorts. Bacterial species cultured from infected wounds mostly included methicillin-sensitive *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Enterobacter cloacae*. Less commonly cultured bacteria were methicillin-resistant *Staphylococcus aureus*, Aeromonas species, Acinetobacter, *Escherichia coli*, and *Stenotrophomonas maltophilia*.

Although grade III injuries only made up 20.9% of all cases, they accounted for 40.0% of cases complicated by infections (Table 5). Wound vacuum-assisted closure therapy was used in 21.2% of all cases yet was present in 40.0% of cases complicated by postoperative infection (Table 5).

DISCUSSION

The present study found similar outcomes between low-grade distal radius fractures treated emergently versus in a delayed fashion regarding infection, revision, nonunion, and osteomyelitis. However, this study also reinforced that case-specific factors and variables must be considered in the management of these injuries to optimize outcomes.

Multiple studies have been performed that appear to challenge the previous dogma of urgent open fracture management.[4–16] With the exception of Rozental et al, these have largely concluded that infections occurring after open distal radius fractures are relatively uncommon—and perhaps similar to closed fractures in low-grade injuries.[18,19] Rozental et al[20] reported on 18 open distal radius fractures citing an infection rate of 50%; although time to debridement was not specifically examined, all patients were treated with emergent debridement, and severe grade was associated with infection. Glueck et al[21] reported 42 open distal radius fractures and noted infection in 7%. All three infected fractures

TABLE 3. Mechanism of Injury and Injury Classification

Variable	Total Data (N = 230)	Debridement ≤ 1 d (N = 164)	Debridement > 1 d (N = 66)	Odds Ratio
Etiology				N/A
Fall	75 (32.6%)	53 (32.3%)	22 (28.9%)	
MVA/MCC	86 (37.4%)	65 (39.6%)	21 (31.8%)	
Penetrating	32 (14.0%)	16 (9.8%)	16 (24%)	
Crush	12 (5.2%)	10 (6%)	2 (3%)	
Other	25 (10.9%)	20 (12.2%)	5 (6.6%)	
Wound classification				
Grade I	91 (39.6%)	68 (41.5%)	23 (34.8%)	Reference
Grade II	91 (39.6%)	60 (36.6%)	31 (47.0%)	1.47 (0.76; 2.86)
Grade III	48 (20.9%)	36 (21.9%)	12 (18.2%)	0.95 (0.40; 2.16)
Negative pressure wound therapy	48 (20.8%)	35 (21.4%)	13 (20.0%)	0.86 (0.40; 1.77)

TABLE 4. Outcomes of Interest Between Cohorts

Variable	Total Data (N = 230)	Debridement ≤ 1 d (N = 164)	Debridement > 1 d (N = 66)	Odds Ratio
Follow-up (mo, mean; SD)	7.1 (5.9; 8.3)	6.7 (5.2; 8.2)	8.1 (6.1; 10.1)	1.02 (0.99; 1.05)
Infection	25 (11.0%)	20 (12.2%)	5 (7.7%)	0.60 (0.19; 1.58)
Major infection	15 (6.5%)	12 (7.3%)	3 (4.5%)	0.63 (0.13; 2.09)
Minor infection	9 (3.9%)	7 (4.3%)	2 (3.0%)	0.74 (0.10; 3.25)
Revision surgery	4 (1.7%)	4 (2.4%)	0 (0.0%)	N/A*
Osteomyelitis	1 (0.4%)	1 (0.6%)	0 (0.0%)	N/A*
Radiographic nonunion	0 (0.0%)	0 (0.0%)	0 (0.0%)	N/A*

*Odds ratios unable to be calculated because of the lack of quantifiable data in one or more of the subgroups.

were Gustilo type II or III and debrided within 8 hours. They concluded that preoperative contamination was the only clinically relevant risk factor.

Furthermore, several studies have demonstrated that delayed debridement of low-grade distal radius fractures results in similar outcomes when compared with closed injuries.[22–24] Kurylo et al[22] noted zero infections in 32 patients (30 patients were Gustilo type I or II); the mean time from arrival to the hospital to the operating room was 20 hours. Yang et al[23] reported an infection rate of zero in 91 Gustilo type I open fractures, with an average time to debridement of 5 days. However, all patients in the investigation performed by Yang et al[23] had 48 hours of intravenous antibiotics. Finally, Henry et al[24] noted zero infections in 24 open type I distal radius fractures. They examined urgently debrided patients (defined as debridement within 24 hours after injury) versus debridement-delayed patients (defined as debridement after 24 hours from the injury and on an outpatient basis) and found no clinically relevant differences in reoperation or radiographic alignment.[24]

Our study agrees with previous reports by demonstrating similar infection rates between urgent and delayed debridement groups with similar preoperative demographic and injury characteristics. Our overall infection rate was 11.0% of patients—all of whom required an operation for the infection. We believe this is similar to previous studies of open fractures but may be slightly higher than previous studies that focus on distal radius fractures.[18,19,21–24] However, our study had a higher proportion of type III injuries than other reports, which is a risk factor for infection. Likely, the higher risk of infection in those categories is a result of higher energy injuries and/or the presence of contamination, which we believe confirms the findings of smaller studies such

TABLE 5. Key Variables and Their Relationship to the Outcome of Postoperative Infection

Variable	Total Data (N = 226)	No Infection (N = 201)	Infection (N = 25)	Odds Ratio
Diabetes	25 (11.0%)	22 (11.0%)	3 (12.0%)	1.19 (0.25; 3.86)
Smoker	96 (42.5%)	82 (41.0%)	14 (56%)	1.68 (0.71; 4.06)
Workers compensation	18 (8.0%)	13 (6.5%)	5 (20.0%)	3.60 (1.04; 10.8)
Debridement > 1 d	65 (29.0%)	60 (29.9%)	5 (20.0%)	0.60 (0.19; 1.58)
Gustilo-Anderson classification				
Grade I	87 (38.5%)	82 (40.8%)	5 (20.0%)	Reference
Grade II	91 (40.3%)	81 (40.3%)	10 (40.0%)	1.99 (0.66; 6.80)
Grade III	48 (21.2%)	38 (18.9%)	10 (40.0%)	3.75 (1.19; 13.3)
Wound Vacuum-Assisted Closured (VAC) used	48 (21.2%)	38 (18.9%)	10 (40.0%)	3.10 (1.23; 7.58)

as Rozental et al,[20] Glueck et al,[21] and Harper et al,[31] who noted that high-grade fractures and contamination were independent risk factors, respectively.

Strengths of our study include a relatively large cohort from two geographically distinct areas. We had similar demographics and a similar proportion of Gustilo types I, II, and III in each group.

This study has limitations. First, because of its retrospective design, selection and indication bias may be inherent to the present study. The use of a single CPT to identify all open fractures may have led to incomplete data collection. Definition of the time of injury was inexact. This was compounded by the decision to use the time of admission in lieu of injury time, which may have underestimated the time to debridement. Therefore, by using this as a proxy, what differences seen in the data between cohorts may be overstated, as some patients in the urgent debridement group may, in fact, have been operated on over 24 hours postinjury. Additionally, because some patients with low-grade injuries were managed in the outpatient setting, data were unable to be collected, which may limit the generalizability of the present studies' findings.

Importantly, in this study, 12 of the 48 patients deemed to have type III open fractures were treated over 24 hours after injury, which conflicts with current guidelines. This delay in treatment arose secondary to patient transfers to appropriate trauma facilities as well as individual patient medical instability, which necessitated preoperative optimization. Three of these 12 patients went on to have postoperative courses complicated by infection. There is a risk of surveillance bias considering the mean follow-ups were 6.7 and 8.1 months for the early debridement versus delayed debridement groups, respectively. Furthermore, initial orthopedic management, antibiotics, and debridement protocols were not standardized in technique, which may have confounded results within and across institutions.

Clearly, at some point, a high-grade wound without treatment will become infected; however, with modern treatment advances, the inflection point at which the risk can be mitigated appears to depend on several factors. Time to debridement notwithstanding, antibiotic administration, quality of debridement, fracture severity, fracture mechanism, wound contamination, and anatomic location appear to correlate most strongly with infection.[2,26,27,32] Therefore, in patients with type III open fractures and crush injuries, we would still recommend early debridement for patients presenting with those risk factors.

CONFLICTS OF INTEREST

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

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