

Factors Associated with Infection Following Open Distal Radius Fractures

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Abstract Open fractures are often classified according to a system described by Gustilo and Anderson. However, this system was applied to open long bone fractures, which may not predict the incidence of infection in open metaphyseal fractures of the upper extremity. Other studies have found that wound contamination and systemic illness were the best predictors of infections in open hand fractures. Our study assessed infection in open distal radius fractures and identifies factors that are associated with these infections. We hypothesize that contamination, rather than absolute wound size, is the best predictor of infection associated with open distal radius fractures. A review by CPT code yielded 42 patients with open distal radius fractures between 1997 and 2002 treated at a level one trauma center. Medical records and radiographic follow-up were reviewed to assess the time to irrigation and debridement, the number of debridements in initial treatment period, the method of operative stabilization, the Gustilo and Anderson type of fracture, the Swanson type of fracture, and description of wound contamination. Forty-two patients were followed up for an average of 15 months (range 4 to 68 months). Twenty-four fractures were classified as Gustilo and Anderson type I,

ten were type II, and eight were type III, 30 were Swanson type I, and 12 were Swanson type II. Five of the 42 fractures were considered contaminated. Two were exposed to fecal contamination. The others were contaminated with tar, dirt/grass, and gravel, respectively. Three of 42 (7%) fractures developed infections. All three infected cases received a single irrigation and debridement. Two of five contaminated fractures (40%) developed a polymicrobial infection. Both were exposed to fecal contamination and, therefore, considered Swanson type II fractures. They were classified as Gustilo and Anderson type II and IIIB based solely upon the size of the wound. Both required multiple debridements and eventually wrist fusions. The third infection occurred in a Gustilo and Anderson type II and Swanson type I open fracture treated with one debridement and plate fixation. Hardware removal, debridement, and antibiotics resolved the infection. Three contaminated fractures that healed uneventfully received two debridements. Statistical analysis revealed a correlation with infection and contamination ($p=0.0331$). The number of initial debridements played a role in infection, but was not statistically significant. No relationship between infection and time to initial irrigation and debridement, method of fixation, Gustilo and Anderson type, or Swanson type was found. We propose that open distal radius fractures behave differently than open long bone fractures. Infection developed in 7% of the distal radius fractures in our study and was significantly associated with wound contamination. We recommend that contamination be included as factor for prognosis in open distal radius fractures. Contaminated fractures should be treated with multiple debridements as part of the initial plan not based upon subsequent development of an infection.

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Introduction

Gustilo and Anderson's classification (Table 1) of open long bone fractures is often generalized to include all fractures [5, 6]. However, we postulate that it is not easy to use this classification to correlate the severity of fracture with the incidence of contamination associated with open distal radius fractures. Few studies exist concerning the prognosis of open distal radius fractures with variable infection rates reported [9, 10]. In general, open fractures of the distal upper extremity have been thought to have relatively low infection rates, which may require a less aggressive approach than other open long bone fractures [1–4, 8, 10–12]. This may be due to the relatively greater blood supply to this region compared to the lower extremity [1, 12]. Two studies addressing open fractures of the hand found a more direct correlation of infection with wound contamination than wound size or extent of soft tissue injury [7, 11]. Swanson et al. proposed a new classification incorporating contamination, duration, and systemic illness (Table 2) to predict infection [11]. A recent article by Rozental et al. found a significant correlation with the Gustilo and Anderson classification of open distal radius fractures in terms of both initial complications and long-term outcomes [10]. Given the conflicted nature contained in available literature, our goal was to evaluate factors associated with infection in open distal radius fractures.

Materials and Methods

A retrospective review by CPT code yielded 42 patients who received treatment for open distal radius fractures between 1997 and 2002 at a level one trauma center. We considered fractures of the distal radius to include the metaphyseal region and excluded both bone forearm fractures and radial fractures of the diaphyseal region (Fig. 1a–c). In- and outpatient records and radiographic follow-up were reviewed to assess the following factors: type of fracture as determined by the treating surgeon according to Gustilo and Anderson, type of fracture including medical co-morbidities (retrospectively reviewed for this study but not employed in patient management) according to Swanson, time from injury to initial irrigation

and debridement, number of initial debridement(s) (i.e. not later procedures to treat infection), method of stabilization, and the attending surgeon's estimate of the degree of contamination [5, 6, 11]. Criteria for contamination included debris or foreign material in the wound or exposure to contaminants, including river, lake, or sewage water runoff. The diagnosis of infection was determined by the attending surgeon caring for the patient.

The average age of the patients was 35 years (range 9–80). There were 27 males and 15 females in the study. Average follow-up was 15 months (range 4–68).

All patients were treated with confirmation of tetanus status, intravenous antibiotics, and emergent operative irrigation and debridement. In several cases, definitive skeletal fixation was delayed due to the length of time preceding irrigation and debridement. Surgical incisions were closed, while traumatic wounds were loosely approximated or left open for later closure. All patients received post-operative intravenous antibiotics. Repeat irrigation and debridement(s) were performed based on the initial and intraoperative assessments of the wound. In all cases of infection, intraoperative wound cultures were obtained at the time of repeat surgery. Data analysis was performed with Fisher's exact test.

Results

Of the 42 fractures evaluated according to Gustilo and Anderson's classification, 24 were type I, ten were type II, and eight were type III. Retrospective application of Swanson's classification produced 30 type I and 12 type II fractures. While not employed in patient management, Swanson's criteria evaluated contamination, medical co-morbidities, and time to debridement. The average time to initial irrigation and debridement was 7.7 h (range 3–17.5). Fifteen of the open fractures were treated with repeat irrigation and debridement in 48–72 h. Thirty-one fractures were treated with external fixation. Of these, six were revised with open reduction internal fixation (ORIF), and one was treated with ORIF at the time of external fixation. Six were treated with ORIF initially. Two were treated with percutaneous pinning, and three were stabilized only with cast immobilization.

Table 1 Gustilo and Anderson [5, 6].

Type	Wound	Soft tissue injury	Bone injury
I	<1 cm long	Minimal	Minimal comminution
II	>1 cm long	Moderate, some muscle damage	Moderate comminution
IIIA	>10 cm long	Severe with crushing	Comminuted, soft tissue coverage possible
IIIB	>10 cm long	Very severe loss of coverage, possible massive contamination	Poor bone coverage; moderate to severe comminution
IIIC	>10 cm long	Very severe loss of coverage plus vascular injury requiring repair	Poor bone coverage; moderate to severe comminution

Table 2 Swanson criteria.

Type I	Type II
Clean	Contaminated
Treatment <24 h	Treatment >24 h
No systemic illness	Systemic illness

Infection developed in three of the 42 (7.1%) fractures. Significantly, two were exposed to fecal contamination. Upon taking a more thorough history, it was learned that one patient's motorcycle accident came to rest in a drainage ditch, and the other patient was trapped under a trailer home bathroom following a motor vehicle collision. These were classified as Gustilo and Anderson types II and III. Both were considered Swanson type II injuries. Both were treated with a single irrigation and debridement and external fixator placement. Infection became apparent at 4 and 10 days post-injury, respectively. A polymicrobial flora consistent with enteric organisms was cultured from each wound. Multiple debridements and intravenous antibiotics were required to

control these infections. In one patient, debridement necessary to control the infection resulted in performance of median nerve grafting and soft tissue coverage with a rectus free-flap. Given the excessive bony debridement necessary to eradicate the infection, both ultimately required wrist fusion as part of their reconstruction. At 17.5 and 9 months from injury, respectively, both were free of infection with clinical and radiographic evidence of solid fusions.

The third infection presented 4 months after the injury with purulent drainage from the incision site. The mechanism was an all-terrain vehicle accident in the woods. It was classified as a Gustilo and Anderson type II and Swanson type I open fracture. No gross contamination was noted. One initial irrigation and debridement was performed with ORIF and percutaneous pinning at that time. Debridement, plate removal (radiographically and clinically healed fracture), and intravenous/oral antibiotics resolved the infection. *Staphylococcus aureus* was cultured. The patient was without evidence of infection at the final 12 month follow-up.

Data analysis with Fisher's exact test was performed on each of the previously mentioned variables (Table 3). Swanson type I fractures were compared with Gustilo and Anderson type I and II fractures, while Swanson type II fractures were compared with Gustilo and Anderson type III fractures. No statistically significant correlation between infection and either Gustilo and Anderson or Swanson's classification was found. Although not statistically significant, there was a trend toward significance with the Swanson criteria. Notably, zero of 24 Gustilo and Anderson type I fractures and one of 30 Swanson type I fractures became infected.

The single variable of contamination was found to be a significant predictor of infection ($p=0.0331$) with two of five (40%) of grossly contaminated cases developing infection. Three other cases that did not become infected had gross contamination at presentation. These included tar (roofer who fell 25 feet), dirt from a motorcycle accident, and gravel from a car accident (rollover with arm out of

**Figure 1** a Open distal radius fracture. b and c Open distal radius fracture radiographs.**Table 3** Data analysis.

Variable	Percent Infection	Statistical Correlation
Gustilo and Anderson		
I and II	2/34	$p=0.479$
III	1/8	
Swanson		
I	1/30	$p=0.192$
II	2/12	
Contamination	2/5	$p=0.0331$
Number of I's and D's	I—3/27	$p=0.541$
	II—0/15	

window). In contrast to the two infections, each of these received a second irrigation and debridement.

Time to debridement was not a significant predictor of infection in this study. In the three infected cases, time to debridement averaged 6 h (range 4 to 7 h)—all less than the average time to debridement of all patients in this study of 7.7 h.

The number of initial debridements played a role in infection. Each of the three infected cases was treated with a single initial irrigation and debridement. Twenty-four of 27 cases that were treated with a single debridement did not become infected, however. No infections developed in the 15 cases treated with two initial debridements.

The type of fixation was not found to be a significant predictor of infection ($p < 0.05$). Two of the 31 (6.5%) fractures treated with external fixation and one of six (16.7%) treated with initial ORIF became infected. No infections developed in the six patients treated initially with external fixation who were later revised to ORIF. No infections occurred in the two patients treated with percutaneous pinning or in the three treated with cast immobilization. A synopsis comparing various fracture specifics to infection can be seen in Table 4.

Discussion

To our knowledge, only two studies have specifically addressed open distal radius fractures. Nyquist and Stern described ten open radiocarpal fracture dislocations [9]. No infections were reported, and no specific mention of wound size or contamination was made. A high incidence of nerve contusions and diminished ranges of motion and chronic wrist pain resulted in a guarded prognosis with these significant injuries.

More recently, Rozental et al. reviewed 18 patients with open distal radius fractures [10]. A strong correlation with wound severity, as assessed by Gustilo and Anderson's classification, was found [5]. A higher type was associated with the following outcomes: increased complications,

increased rate of infection, greater number of procedures, decreased range of motion, and increased fair and poor results. Seven of the 18 open distal radius fractures were treated with a second debridement within 2 days of the initial treatment. External fixation was used in 15 patients, while two were treated with ORIF and one was stabilized with kirschner wires. Wound severity classification resulted in nine type I fractures, three type II fractures, and six type III fractures. Nine of the 18 (50%) fractures became infected. Of these, two of nine type I fractures, two of three of the type II fractures, and five of six of the type III fractures became infected. Although a similar trend finding infection correlating with higher Gustilo and Anderson classification, as noted in our study, contamination was not mentioned as a contributing factor.

Embarking upon a relevant review of literature concerning open distal radius fractures, we found a paucity of studies. More literature has been written regarding open hand fractures as compared to distal radius fractures. Although slightly off the focus of the current study, analysis of this literature may prove enlightening. Several studies have assessed the prognosis of open hand fractures. McLain et al. found an 11% overall incidence in 146 cases [7]. There were no infections in type I fractures, while infection rates of 9% and 14% were seen in types II and III, respectively. Grossly contaminated fractures resulted in a 20.5% incidence of infection. They concluded that initial wound contamination was the most important predictor of infection. However, wound severity was also correlated with infection. Forty-seven percent of the infected cases had enteric pathogens, a polymicrobial infection, or both. Duncan et al., using a modified Gustilo and Anderson classification, found four of 125 deep infections in open hand fractures [4]. These were all considered type IIIB or IIIC fractures. They noted a relationship with wound severity and degree of contamination.

Swanson et al. also addressed open hand fractures and proposed a new classification for open hand fractures with an emphasis upon contamination [11]. Their study found a distinct difference between the prognosis and treatment of open hand fractures and open long bone fractures. A 6% infection rate, all considered relatively minor infections, was reported. Increased infection was found with a greater degrees of wound contamination, delay in treatment greater than 24 h, and in patients with a systemic illness. In contrast, infection was not increased by the presence of internal fixation, immediate wound closure, large wound size, tendon/nerve/vascular injury, or a high-energy mechanism. The infection rate in contaminated fractures was 20% compared to 1.2% in non-contaminated fractures. Given these findings, a classification scheme was proposed as seen in Table 1. Of the seven infections, six (86%) were type II injuries.

Table 4 Infected fracture synopsis.

Fracture specifics	Infection
Fecal contamination	2/3
Ex fix	2/3
Plate	1/3
>8 h	0/3
Type I	0/3
Type II	2/3
Type II	1/3
One I and D	3/3

Left column—number infected/fracture specific

In contrast to Rozental et al., we report a relatively low incidence of infection (7%) in 42 open distal radius fractures [10]. The greatest contributing factor to infection was contamination—specifically, the type of contamination. Wound severity, as assessed by the Gustilo and Anderson classification, played a lesser role in the incidence of infection. The study by Rozental et al. found a more significant correlation with Gustilo and Anderson type and open distal radius fracture prognosis, including propensity for infection [10]. Their study may be limited by the relatively low number of fractures (18) studied. We do not propose an explanation for our incidence of infection being substantially lower than their clinical experience. Analysis of our infections were actually more comparable to Swanson and McLain's studies of open hand fractures, which emphasized contamination over wound severity as a predictor of infection [7, 11]. Therefore, we similarly recommend a classification of open distal radius fractures (such as that of Swanson et al.) that emphasizes contamination over the extent of soft tissue injury [11].

Additionally, we found no correlation with time to irrigation and debridement and infection. In contrast to Swanson et al., no fracture had delayed irrigation and debridement beyond 24 h [11].

Finally, in this study, the number of initial debridements played a significant role in preventing infection. The more easily visible contamination of debris (dirt, gravel, tar etc.) prompted a more aggressive approach with a repeat irrigation and debridement. However, in contrast, when there was a small wound with no contamination, the incidence of infection, regardless of the number of debridements, was very low. In some instances such as the patient whose vehicle came to rest under a trailer, the contamination may

be more subtle yet quite severe. This emphasizes the importance of assessing the circumstances of the injury and recognizing less obvious wound contamination in an effort to prevent infection.

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