Initial Management of Open Hand Fractures in an Emergency Department

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Abstract

We retrospectively reviewed the cases of patients with open hand fractures and/or dislocations managed at our institution between 2001 and 2009. The management protocol consisted of irrigation and debridement, reduction (if necessary), splinting, and antibiotics administration in the emergency department. Patients with vascular compromise or severe mangling open wounds were taken to the operating room for treatment. Data regarding demographics, wound size and modified Gustilo–Anderson classification, and timing of interventions were recorded.

Included in the study were 145 cases (91 class III, 41 class II, and 13 class I injuries). In 102 cases, definitive and final management took place in the emergency department; in the other 43 cases, additional management took place in the operating room. Antibiotics were administered within 4 hours after injury, and irrigation and debridement were performed within 6 hours. Each of the 2 infections (1.4%) developed in a class III injury.

In open hand fractures, particularly type I and type II wounds, the protocol we followed can be appropriate when the injury is not the severe mangling type and does not require acute vascular repair.

An open fracture is identified by a soft-tissue disruption that allows the fracture site to be exposed to the outside environment. Open fractures are usually severe and prone to serious complications, such as infection.[1] The basic components of injury management are function restoration, bone union, and infection prevention.[2] Management traditionally consists of irrigation and debridement (I&D) and bone stabilization in the operating room (OR).[1-3] Irrigation should be performed with copious amounts of sterile saline, often combined with antibiotics, and debridement of nonviable tissue. Repeat I&D may be needed in severe open hand fractures.[2] Although all of these recommendations may have contributed to reducing infection rates, the management guidelines are based on studies of all fractures, usually not including hand fractures.

Current evidence indicates that infections that occur after open fracture management are often caused by nosocomial organisms, not the initial contaminating organisms.[4] Given the improvements in wound care,[4] the high costs of hospital care, and the excellent blood supply to the hand, it may be appropriate and desirable to manage a select group of open hand fractures with a standardized protocol of wound care, but in the emergency department (ED) setting. The fact that 12.5% of phalanx fractures are open[5] adds to the importance of defining the best management method for these fractures. In the study reported here, we retrospectively evaluated the effectiveness of such a protocol in terms of infection rates.

Materials and Methods

We retrospectively reviewed the cases of patients with open hand fractures and/or dislocations referred to the orthopedics service at our institution between 2001 and 2009. We obtained institutional review board approval before beginning this study. The patients in these cases included all those admitted with open hand fractures to the orthopedic hand service over this 9-year period. The orthopedic hand team at our institution has on-call responsibilities 50% of the time. We reviewed the records of these cases and recorded the data regarding sex, age, hand dominance, mechanism of injury, wound size, modified Gustilo–Anderson classification of wound (Table I),[6] timing of injury, ED arrival, antibiotics administration, and I&D. We also recorded type of antibiotic used and presence or absence of associated injuries, such as tendon and neurovascular injuries.

The management protocol consisted of local-field, digital or wrist block anesthesia combined with intravenous sedation; sterile draping of the extremity; irrigation with sterile saline (3 L), local wound debridement; reduction (if necessary), and splinting. These procedures were performed in the OR in the hospital ED by second-year or third-year orthopedic residents supervised by fellowship-trained attending orthopedic hand surgeons. Previously, these attendings had formally instructed the residents as to the specifics of the I&D procedure to ensure a consistent study protocol. Stable fractures with acceptable alignment and no need for soft-tissue coverage or tendon or nerve repair were managed with appropriate antibiotics and followed

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Am J Orthop. 2011;40(12):E243-E248.

Table I. Open Fracture Wound Classification (Modified Gustilo–Anderson)

Type I	Tidy laceration, <1 cm in length; no contamination, soft-tissue crush, loss, or fracture comminution
Type II	Tidy laceration, <2 cm in length; no contamination, soft-tissue crush, loss, or fracture comminution
Type III	Laceration, >2 cm; penetrating or puncturing projectile wound, soft-tissue crush, blast injury, periosteal stripping, or wound contamination

Table II. Wound Sizes for Gustilo Classification Groups in Our Patient Cohort

Gustilo Classification	Wound Size, cm			*P* Value for *t* Test
	Mean	SD	Range	
I	0.7	0.44	0.1-1	.003 (comparing I and II)
II	2.1	0.9	1.5-5	.1 (comparing II and III)
III	2.8	1.5	0.5-7	—

Table III. Mechanisms of Injury in Our Patient Cohort

Mechanism	No.	%
Work related	54	37%
Crush injury	36	25%
Gunshot	21	14%
Assault	10	7%
Fall	7	5%
Cut	6	4%
Other (motor vehicle accident, bite, etc)	11	8%
Total	145	

until fracture healing. Unstable fractures, fractures with unacceptable alignment, wounds that required skin graft, neurovascular injuries, and severe tendon injuries underwent initial I&D and splinting in the ED and then were taken to the OR for internal fixation or soft-tissue reconstruction procedures to be performed within the next 24 hours to 72 hours. Patients with vascular compromise or severe mangling open wounds were taken to the OR for appropriate treatment on the day of presentation.

One hundred forty-five cases matched our inclusion criteria. There were 119 men (82%) and 26 women (18%). Most patients (91.5%) were right-hand–dominant, and mean (SD) age was 39 (14) years. According to the modified Gustilo–Anderson classification, most wounds (91, 63%) were class III, followed by class II (41, 28%) and class I (13, 9%). Mean wound sizes were 0.7 cm (class I), 2.1 cm (class II), and 2.8 cm (class III) (Table II). The most common injuries (54, 37%) were work related, followed by crush injuries and gunshot wounds (Table III).

Twelve patients had concomitant injuries, such as femur, rib, mandible, cervical spine, and shoulder fractures. Other injuries included head concussion, pulmonary contusion, hemothorax, liver and renal lacerations, and median and ulnar nerve lacerations. Four patients had digital nerve injuries, and 16 had nail-bed injuries. Cefazolin (Ancef) was the first antibiotic used in the ED in the majority of cases (85%). Cephalexin (Keflex) was the oral antibiotic (7- to 10-day course) prescribed most often (87%) by the orthopedic team. Tables IV and V list the fracture locations: metacarpus or digits (4 cases had only open dislocations). There were 99 distal phalanx fractures, 17 proximal phalanx fractures, and 9 middle phalanx fractures. There were 23 metacarpus fractures and, in 5 cases, a concomitant finger fracture. In most cases, the injured tendon was the second extensor tendon (Table VI). The 12 hand joint dislocations occurred most often in the proximal interphalangeal joints—the thumb interphalangeal joint (4 cases), the third proximal interphalangeal joint (3), and the fifth proximal interphalangeal joint (3).

In 102 cases, I&D, fracture reduction, and wound closure constituted definitive management and were performed in the ED; in the other 43 cases, repeat I&D and open reduction and internal fixation (with pins or plates, and with or without nerve or tendon repair, nail-bed repair, or ablation) were performed in the OR after initial management in the ED. Of the 43 patients, 27 had a hospital stay of less than 1 day. The operations performed for hand fractures and concomitant injuries are summarized in Table VII.

Statistical analysis was performed with SPSS Version 16 (SPSS, Chicago, Illinois). χ^2 tests were used to compare the infection rates of the wound classes as

Table IV. Distribution of Metacarpal and Finger Fractures

Patients	No Finger Fracture		Finger Fracture	
	No.	%	No.	%
No metacarpus fracture	4	3.3%	119	96.7%
Metacarpus fracture	17	77.3%	5	22.7%

Table V. Distribution of Metacarpal and Phalanx Fractures

Fracture Type	No.
Metacarpus Fracture	
1st metacarpus	6
2nd metacarpus	6
3rd metacarpus	6
4th metacarpus	9
5th metacarpus	9
Total	**36**
Phalanx Fracture	**No.**
Thumb	21
Index finger	30
Middle finger	40
Ring finger	26
Small finger	21
Total	**138**

Table VI. Associated Tendon Injuries in Our Patient Cohort

Tendon Injury	No.
1st extensor tendon	1
2nd extensor tendon	3
3rd extensor tendon	1
3rd & 4th extensor tendons	1
4th extensor tendon	1
5th extensor tendon	1
2nd FDS tendon, FDP tendon	1
3rd FDP tendon	2
4th FDS tendon	1
Total	**12**

Abbreviations: FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis.

Table VII. Operations for Hand Injuries in Our Patient Cohort

Operation	No.
Nail-bed repair	8
Nail-bed ablation	5
Tendon repair	11
Open reduction and internal fixation with pins or in plates	20
Nerve repair	3
Skin graft	6
Median nerve repair	1
Ulnar nerve repair	2

well as the patients who underwent surgery and those who did not; *t* tests were used to compare the hospital stay lengths of patients with and without concomitant injuries as well as wound sizes of the wound classes. Analysis of variance (ANOVA) was used to evaluate the differences between hospital stay lengths of the patients in the different wound classes. Predictors of whether or not a patient needed to go to the OR were evaluated in a multiple regression model.

Results

Of the 36 patients who had more than 6 weeks (mean, 4 months) of complete follow-up, 35 maintained reduction, and 1 lost reduction at the dorsal base of the middle phalanx, which was originally fixed with Kirschner wires. In 3 patients, there was no callus formation after a mean follow-up of 9 weeks, but each patient appeared clinically healed on examination. Most of the 36 patients returned to good function: 27 had their usual daily function, 6 had mild limitation, and 3 reported severe limitations. Twenty-nine patients were pain-free or had minimal pain; the other 7 patients had moderate pain. Table VIII lists the functional outcomes for the 21 non–distal phalanx fractures (11 patients). Mean (range) follow-up for these fractures was 8.7 (2-46) months.

Each of the 2 infections (1.4%) developed in a class III injury at the distal interphalangeal joint and was successfully managed with a 5-day course of cephalexin. One of the 2 patients developed a second infection after a nail-bed ablation. Although he did not take antibiotics for the second infection, it resolved nevertheless. Class III open fractures had a 5.6% infection rate. Complications included extreme stiffness (4 cases), fixation failure (3), nerve damage (2), and Boutonnière deformity (1).

Wound size did not differ statistically (P = .21) between patients who underwent further operative management in the OR (mean, 2.8 cm; SD, 1.7 cm) and those who did not (mean, 2.2 cm; SD, 1.3 cm). Wounds in class II and class III injuries were significantly larger than wounds in class I injuries (Table II). Hospital stay lengths did not differ significantly among patients with different wound classes (ANOVA, P = .18). Mean delay from injury to first antibiotics administration was less than 4 hours, and mean delay from injury to I&D in the ED was less than 6 hours (Table IX). Delay from injury to first orthopedics visit in the ED was almost 10 hours (608 minutes) for class I injuries, 5.5 hours (322 minutes) for class II injuries, and 5 hours (294 minutes) for class III injuries. Patients with higher wound classes were seen earlier by the orthopedics team in the ED (P = .29). Patients with concomitant injuries had a longer mean hospital stay—3 days versus less than 1 day (*t* test, P = .028) No class I or class II wounds but 23% of class III wounds were caused by gunshots (P = .001). Patients with gunshot wounds had a higher rate of injuries to other body organs (P<.001). Twenty-six percent (15/57) of low-energy injuries, versus 36% (28/77) of high-energy injuries, were managed in the OR (P = .22).

Infection rates did not differ (P = .5) between patients who underwent surgery and those who did not. The infection rate for class I and class II injuries was 0%, compared with 5.6% for group III injuries (P = .35). Multiple regression model results showed that wound classification (P = .032) and associated injuries (P<.001) predicted which patients needed to go to the OR for further management.

Table VIII. Functional Results of the 21 Non–Distal Phalanx Open Hand Fractures (11 Cases)

	Functional Assessment			
	Excellent	Good	Fair	Poor
Total active range of motion (Duncan method) for all fractures	5	8	3	5

Table IX. Age; Wound Size; Time From Injury to Arrival at Hospital, to First Administration of Antibiotics, and to First Orthopedics Visit With Irrigation and Drainage (I&D); and Length of Hospital Stay and of Follow-Up

	Range	Mean	SD
Age, y	18-75	39	14
Wound size, cm	0.1-7	2.4	1.4
Time from injury to:			
Arrival at hospital, min	10-1440	102	274
First administration of antibiotics, min	10-1583	203	301
First orthopedics visit (I&D), min	36-2880	329	385
Length of:			
Hospital stay, d	0-28	1	5
Follow-up, d	0-2400	75	304

Discussion

As mentioned earlier, the most important part of open fracture management is meticulous debridement of the wound.[7] Our study results indicated that, for type I and type II open hand fractures that are stable and have no associated tendon or neurovascular injuries, ED management provides excellent infection prevention (class III open fractures may be more predisposed to infection). However, it is not clear if initial management of these wounds in the OR would have lowered the infection rate. The stable open hand fractures that can be managed with I&D and antibiotics entirely within the ED include the vast majority of finger fractures.[8] In addition, the class III fractures managed with our protocol had an infection rate similar to the rates for initial OR treatment in other published studies. Table X lists the studies that have reported infection rates (range, 0.3%-11%) for open hand fractures managed with different protocols; these protocols have had similar results.[7,9-17]

The Gustilo–Anderson classification (Table I) has proved to predict risk for infection in open fractures. In their classic 1987 study of 303 open fractures (none in the hand), Gustilo and colleagues[18] found infection rates of 0% (for type I injuries), 2.5% (type II), and 13.7% (type III). Their treatment protocol consisted of immediate and repeat debridement within 24 hours to 48 hours; cefazolin for type I and type II injuries; and cephalosporin, with or without aminoglycosides, for type III injuries. Since then, many authors have reported an association between soft-tissue wound severity and infection.[19-21] Our study results show that open hand fractures, particularly class I and class II fractures, are less prone to infection when they are managed with early antibiotics therapy and I&D—possibly because of use of more effective antibiotics, improved debridement methods, more timely wound care and antibiotics administration after injury, and excellent blood supply to the hand. In addition, the young age and relative good health of our patients may have contributed to the low infection rate.

Patzakis and colleagues[20] conducted a prospective randomized study of open fractures and found a significantly lower infection rate for patients who were administered cephalothin (2.3%, 2/84 fractures) than for patients who did not receive antibiotics (13.9%, 11/79 fractures). In addition, early administration of antibiotics is a major factor in decreasing infection rates in open fractures. With antibiotics being administered within 4 hours after injury and I&D being performed within 6 hours, the present study showed an infection rate of only 1.4% during a mean follow-up of 75 days. Which antibiotics therapy to use has varied among authors. O'Meara[2] used first- or second-generation cephalosporin for type I fractures and recommended additional treatment for Gram-negative organisms in type II and type III fractures. As most infections are caused by staphylococci and aerobic gram-negative bacilli, antibiotics should primarily cover these organisms. Whereas results from a study of 1104 open fractures (50% tibia fractures) suggested administering antibiotics within the first 3 hours after injury to prevent infection (Patzakis and Wilkins[22]), our study showed that, for hand infections, the time limit might be 4 hours.

Debridement should be started as soon as the patient is resuscitated and stabilized. When antibiotics are administered early, however, delayed surgical management is not associated with a higher infection rate. In a retrospective study of 227 patients' open fractures (241 open long bone fractures, 78 upper limb fractures), debridement delay of up to 13 hours did not increase the rate of infection as long as prophylactic antibiotics were administered early.[3]

Table X. Studies That Have Reported Infection Rate After Open Hand Fractures

Year	Author	Patients/Injuries	Follow-Up	Antibiotics	Management	I&D Setting	Functional Assessment	Function Rating	Infection Rate
1987	Sloan et al[9]	85 distal interphalangeal joint fractures —10 cases, antibiotics not administered —73 cases, antibiotics administered	5 d (mean)	Cephradine —24 cases, oral for 5 d —24 cases, 1 injection & oral for 5 d —25 cases, 1 injection & 1 oral dose	—I&D, all cases —Closed reduction or ORIF, not reported	OR	Not reported	Not reported	—Antibiotics, 1.3% (1/73) —No antibiotics, 0.3% (3/10)
1990	Suprock et al[10]	91 phalanx fractures —46 cases, antibiotics not administered —45 cases, antibiotics administered	Not reported	1st-generation antibiotic for 3 d —Cephalosporin —DiCloxacillin —Erythromycin	—I&D, all cases —Closed reduction or ORIF, not reported	Not reported	Not reported	Not reported	—Antibiotics, 8.9% (4/45) —No antibiotics, 8.7% (4/46)
1991	McLain et al[7]	143 cases (146 hands) —Type I, 11% —Type II, 29% —Type III, 60%	Not reported	Antibiotics used but not specifically reported	—I&D, all cases —ORIF, all cases	OR	Not reported	Normal or functional outcome —Type I, 88% —Type II, 93% —Type III,80%	11% (16/143) —Type I, 0% —Type II, 9% —Type III, 14%
1991	Chow et al[11]	201 patients —245 open digital fractures (Metacarpals and proximal & middle phalanges)	2 mo (mean) after return to daily activity	Ampicillin & cloxacillin, or cephradine	—I&D, all cases —Closed reduction, 82 cases; ORIF, 163 cases	Not reported	Total active finger ROM	Good (total active ROM >210°), 29% —Closed reduction, 36.6% —ORIF, 25.2%	2.04%
1993	Duncan et al[12]	75 cases —125 fingers	17 mo (mean), 6 mo–7 y (range)	Antibiotics used but not specifically reported	—I&D, all cases —ORIF, all cases	OR Internal fixation —53 patients (94 fingers), <24 h —22 patients (31 fingers), >24 h	Total active digital ROM	Good or excellent —Metacarpus, 63% —Phalanx, 32% —Types I, II, IIIA, 63% —Types IIIB & C, 0%	4.8% (6/125)
1996	Ip et al[14]	765 patients —924 fractures (342 open)	2 mo (mean) after return to daily activity	Not reported	—I&D, all cases —Closed reduction, 480 cases; ORIF, 444 cases	Not reported	—Thumbs, Buck-Gramcko point system —Fingers, total active ROM & Strickland system	Good or excellent —Thumb, 90% —Fingers, 58.7%-76.5%	7.7% (19/248)
1998	Drenth & Klasen[13]	33 patients —36 fractures (27 open)	4.4 y (mean), 2.3-8.2 y (range)	Not reported	—I&D, all cases —ORIF, all cases (external fixation with mini-Hoffmann device)	OR	Total active ROM (Duncan et al[12])	Good or excellent —25 cases	0%
2001	Van Oosterom et al[16]	350 cases —666 fractures	1 y (minimum)	Not reported	—I&D, all cases —ORIF, all 573 cases; closed reduction, 93 of concomitant fractures	OR	Not reported	Not reported	2% (8/490)
2003	Stevenson et al[15]	193 distal phalanx fractures	8 wk (mean)	Flucloxacillin —95 cases, antibiotics not administered —98 cases, antibiotics administered	—I&D, all cases —Closed reduction, all cases	ED	Not reported	Not reported	—Antibiotics, 3% —No antibiotics, 4%
2007	Ali et al[17]	120 patients —226 fractures (68 open; Metacarpels & proximal & middle phalanges [56.7%], 41 distal interphalangeal joints [34%])	Not reported	Antibiotics used but not specifically reported	—I&D, all cases —Closed reduction, 26 cases (21.7%); ORIF, 94 cases (78.3%)	OR, 94 cases ED, 26 cases	Not reported	Not reported	2.2% (5/226)

Abbreviations: ED, emergency department; I&D, irrigation and debridement; OR, operating room; ORIF, open reduction and internal fixation; ROM, range of motion.

Our study was limited by its retrospective design and lack of thorough functional and radiographic evaluation of our entire patient population. As patients in this study were relatively young (mean age, 39 years), such a treatment protocol may not be justified for open hand fractures in elderly patients. Another limitation of this study is a selection bias—lesser injuries were managed in the ED, and more severe fractures required management in the OR. Third, only a small percentage of the original study population was followed up. However, because our urban patients often have limited financial resources, they typically return to the ED or our clinic when they have complications, such as an infection. Further prospective randomized studies are needed to evaluate the effect of antibiotics or debridement delay on incidence of infection in open hand fractures.

Early antibiotics administration (<4 hours after injury) and I&D (<6 hours after injury) are effective in preventing infections in open hand fractures and may be the only management needed in these cases, as long as the patient does not require surgery for associated injuries, particularly type I and type II injuries. This approach also shortens hospital stays, which in turn reduces exposure to nosocomial organisms and lowers overall treatment costs.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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