Factors Influencing Infection Rates After Open Fractures of the Radius and/or Ulna

Justin W. Zumsteg, MD, Cesar S. Molina, MD, Donald H. Lee, MD, Nick D. Pappas, MD

Purpose To investigate factors associated with the development of deep infection in patients with open fractures of the radius and/or ulna.

Methods We retrospectively reviewed 296 open fractures of the radius and/or ulna. Of these patients, 200 had at least 6-month follow-up and were included in this study. The following variables were examined for each patient: time from injury to antibiotic administration, time from injury to operative debridement, Gustilo−Anderson classification, type of antibiotic received, and host characteristics such as age, diabetes, and tobacco use. Outcome parameters included the presence of deep infection and fracture union.

Results The overall rate of deep infection was 5% (10 of 200). No type 1 fractures (of 41) developed deep infection. In contrast, 4% (2 of 48) of type 2 and 7% (8 of 110) of type 3 fractures developed infection. Of 200 patients, 28 received antibiotics in less than 3 hours and underwent debridement in less than 6 hours from the time of injury; however, they did not have lower rates of infection. Similar findings were noted when nonunion was used as the outcome, and the association between Gustilo−Anderson classification and the development of nonunion was statistically significant.

Conclusions Factors such as time to antibiotics and time to operative debridement were not predictors for either rate of deep infection or nonunion in open fractures of the radius and/or ulna. The type of fracture as outlined by the Gustilo−Anderson classification was the factor most strongly associated with the development of deep infection and nonunion in these fractures. *(J Hand Surg Am. 2014;39(5):956−961. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic III.

Key words Complications, forearm fractures, infection, nonunion, open fractures.

Open fractures of the extremities can be difficult to treat. They are often fraught with complications that may severely limit the function of the involved limb. One of the chief concerns after these injuries is the development of infection. Infection not only impedes fracture healing but can also lead to sepsis if inadequately treated. Much of the orthopedic literature on open fractures has focused on the lower extremity, particularly tibia fractures.[1,2] There are few data, however, regarding the proper management of open fractures in the upper extremity.

Multiple studies have attempted to define the appropriate time frame in which open fractures should undergo operative debridement and antibiotic administration. Some authors have argued that operative treatment should be performed within 6 hours

From the Department of Orthopedics, Vanderbilt University Medical Center, Nashville, TN; and the Greenville Health System/Steadman-Hawkins Clinic of the Carolinas, Greenville, SC.

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Corresponding author: Justin Zumsteg, MD, Department of Orthopedics, Vanderbilt University Medical Center, 1215 21st Avenue South, Medical Center East, South Tower, Suite 4200, Nashville, TN 37232; e-mail: Justin.Zumsteg@Vanderbilt.edu.

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from the time of injury. The genesis of the 6-hour rule is believed to be derived from a study by Freidrich in 1898,[3] who found that open fractures in guinea pigs had a reduced infection rate if debrided within 6 hours, compared with those debrided after greater than 6 hours. This concept of the 6-hour rule garnered further support by Robson et al,[4] who found that 5.2 hours was the time required for bacteria to reach 10^5 colonies per gram of tissue, a value previously shown to correlate with the development of wound infection. In contrast, several recent studies have shown no correlation between operative debridement in less than 6 hours and reduced incidence of infection.[1,2,5]

A similar unofficial rule for antibiotic delivery within 3 hours of the time of injury was developed after Patzakis and Wilkins[6] analyzed over 1,100 open fractures and found a higher infection rate in patients who did not receive antibiotics in less than 3 hours. Although the authors noted that almost half of the infections occurred in open tibia fractures, no further subgroup analysis was presented for infection rate by fracture location.

The purpose of this study was to evaluate which factors influence the rate of infection after open fractures of the forearm, including the time to antibiotic administration and time to debridement. A secondary aim was to evaluate factors associated with the development of nonunion. Our hypothesis was that earlier administration of antibiotics and earlier time to debridement would be associated with lower infection rates.

MATERIALS AND METHODS

We identified 296 patients with open fractures of the forearm from January 1, 2006 to December 31, 2011, through a search of International Classification of Diseases−9 codes for open forearm fractures. Based on the Gustilo−Anderson classification, 71 of the injuries were type 1 (24%), 70 were type 2 (24%), and 155 were type 3 injuries (52%). Two hundred of these 296 patients had at least 6-month follow-up and were included in the analysis of the primary outcome of the study of deep infection. Inclusion criteria were patients 18 years of age and older, presence of an open fracture of the radius and/or ulna, and availability of accurate information regarding time of injury and clinical care within the medical record. Patients with ballistic injuries or traumatic amputations and those with inadequate information in the medical record were excluded. Institutional review board approval was obtained before the start of the study. No external source of funding was used in conducting this study.

We extracted data from the institutional electronic medical records. Several patient variables were recorded, including age, chronic medical conditions (eg, diabetes mellitus, human immunodeficiency virus, hepatitis B, or hepatitis C), tobacco use, Gustilo−Anderson classification, time to operative debridement, and time to administration of antibiotics. Outcome measures were development of deep infection requiring surgical debridement and fracture union. The Gustilo−Anderson classification was determined by review of the available medical record documents and radiographic review. Definitions for Gustilo−Anderson classification were taken from the work of Gustilo and Anderson[7] in 1976, and are as follows: type 1 is an open fracture with a wound less than 1 cm long and clean; type 2 is an open fracture with a laceration more than 1 cm long without extensive soft tissue damage, flaps, or avulsion; and type 3 is an open segmental fracture, an open fracture with extensive soft tissue damage, or a traumatic amputation.

For the purposes of this study, type 3 fractures were considered to be those with major soft tissue damage, laceration greater than 10 cm, major comminution, or gross contamination. No distinction was made among A, B, and C subtypes for type 3 fractures.

Deep infection was defined as one requiring operative debridement and was determined through a review of patients' medical records. To be included in the analysis for deep infection, a minimum of 6 months' follow-up was required; this resulted in 149 patients. Patients with less than 6 months of clinical follow-up were contacted by telephone ($n = 142$) and provided a standardized questionnaire regarding the development of any complications related to their injury, which included specific questions as to whether they had undergone surgery or been prescribed an antibiotic for an infection at the fracture site since the most recent follow-up. We made efforts to contact patients by telephone up to 3 times on different days, in order to maximize data accrual. This resulted in the inclusion of an additional 51 patients in the final analysis of risk factors for deep infection.

A subanalysis of risk factors for nonunion was performed in 169 of 200 fractures (85%) included in the deep infection analysis. Patients with radiographic evidence of union at final follow-up, as well as those with a minimum of 6 months of clinical and radiographic follow-up, were included, which resulted in 169 patients. Nonunion was defined as the absence of radiographic union at 6 months or surgery to treat a clinically diagnosed nonunion. The primary author (J.W.Z.) independently reviewed all images