FOOT & ANKLE Online Journal
OFFICIAL PUBLICATION OF International Foot & Ankle Foundation
FOR EDUCATION AND RESEARCH

Management of an open crush fracture to the foot from a lawnmower injury: A case report

by Rosario Saccomanno, DPM[1*], Matthew S. Kalmar, DPM[1]

The Foot and Ankle Online Journal 13 (4): 14

A 50-year-old male who reported to the emergency department (ED) with an open fracture to his right great toe sustained from a lawnmower injury is presented. The patient underwent emergent overnight podiatric surgery for treatment of the traumatic crush injury. Removal of all non-viable skin, soft tissue, and bone was performed intra-operatively which ultimately resulted in a partial right hallux amputation with primary closure. This case report aims to highlight the accepted treatment protocols set forth in the management of pedal open crush injuries. Open fractures are true podiatric emergencies and delay in treatment places the patient at increased risk for poorer prognosis.

Keywords: open fracture, trauma, crush, partial amputation

A pedal fracture is considered "open" when broken bone is immediately exposed to the atmosphere [1]. The mechanism of injury causing such injury is typically that of high velocity, crush-type trauma powerful enough to penetrate the layers of the integumentary system to cause said fracture. These injuries are true podiatric emergencies that are often accompanied by severe bone comminution and/or complex soft tissue degloving and may be constituted in polytrauma cases where primary, secondary, and tertiary surveys of the patient are imperative [2]. The essential goals in the management of open fractures revolve around prevention of infection, establishment of bony union, and restoration of function [1,3]. Treatment calls for non-excisional and/or excisional debridement, tetanus and antibiotic prophylaxis, and fracture stabilization, all of which have a synergistic role in attempting to prevent sepsis, minimize disability, and promote limb salvage [4].

Wound lavage acts as a form of non-excisional mechanical debridement to eradicate foreign debris from the wound site and to dilute the concentration of bacteria to a burden less than that of 10^5 in attempt to prevent infection [5]. Irrigation may be performed with low- or high-pressure modalities. Irrigation may be in the form of 0.9% sterile saline solution or agents such as povidone-iodine, chlorhexidine, and/or hydrogen peroxide which introduce antisepsis to the wound site [6,7]. Excisional debridement goes hand-in-hand with irrigation to further mechanically remove foreign material and nonviable tissue from the wound site [1]. Removal of devitalized tissue prepares the wound site for healthy tissue demarcation which will allow for wound closure to occur in the absence of bacterial bioburden [4].

Open fractures are particularly vulnerable to deep wound polymicrobial infection. Empiric antibiotic selection should be based on wound size, extent of soft tissue injury, and type of environment in which the injury was sustained [1,4]. Gustilo and Anderson devised a classification system with 3 types of open fractures which serves as a guide for recommended antibiotic coverage [8]. Type I open fractures are less than 1 cm in wound diameter with a simple fracture pattern and adequate soft tissue coverage. Type II open fractures have a wound diameter between 1 and

1 - Huntington Hospital at Northwell Health, Huntington, N.Y.
* - Corresponding author: saccoross@gmail.com

5 cm(s) with moderate soft tissue disruption yet intact periosteal and soft tissue coverage. Type III open fractures have extensive wound diameters greater than 5 cm(s) with comminution, extensive soft tissue damage, or traumatic amputation and can be further subdivided into those injuries with adequate soft tissue coverage (Type III-A), inadequate soft tissue coverage (Type III-B), or arterial compromise (Type III-C) [4,8].

Appropriate tetanus prophylaxis is imperative in cases of open fractures due to their inherently high risk of infection by *Clostridium tetani*, an obligate spore-forming anaerobe commonly found in farm environments that produces tetanospasmin. This is an exotoxin that causes spastic paralysis of voluntary muscles and can lead to fatal cases of respiratory arrest [1]. The Centers for Disease Control and Prevention (CDC) set forth recommendations in tetanus prophylaxis for wound management [9]. For those individuals sustaining an injury in a contaminated environment, both Tetanus-Diphtheria-Pertussis (TdaP) or Tetanus toxoid (Td) and Tetanus Immunoglobulin (TIG) are warranted for patients with an unknown vaccination history, those with fewer than 3 doses of Tetanus Toxoid (TT), or in cases where it has been more than 5 years since the patient's last dose of TT. For clean, minor wounds, TdaP or Td are indicated if the patient has an unknown vaccination history or has received less than 3 doses of TT. TdaP or Td is recommended for those patients who have had 3 or more doses of TT if more than 10 years has elapsed since receiving the last dose of TT [9].

Regarding fracture stabilization, reduction followed by immobilization may be necessary to perform in the acute ED setting for open crush injuries. In the operative setting, external fixators are often employed to hold fractured fragments out to anatomic longitudinal length while not interfering with open wound management in cases of contaminated or infected open fractures. Fixation using either open or percutaneous Kirschner (K) Wires are often employed to achieve internal splintage of fracture fragments [4]. It is recommended that the implementation of internal hardware such as that of plates and/or screws is reserved for use once the open fracture site is deemed clean and the site can be primarily closed, which may need to occur in a staged-procedure fashion [1].

Case Report

In the late evening of August 23, 2018, a 50-year-old male with a past medical history significant for alcoholism presented to the ED after his right foot was run over by a commercial lawnmower during farm and landscaping work earlier that afternoon. The patient reported 6 hours from the time of injury to presentation to the hospital. The patient reported wearing steel-toe boots during the incident and reported that he continued to work through his shift after sustaining the injury. The patient denied any trauma to the left foot or any constitutional symptoms upon presentation to the ED.

After thorough primary and secondary examinations were performed, a focused lower extremity physical examination noted a diffusely edematous and ecchymotic right foot with palpable peripheral pulses and soft and non-tender compartments. Delayed capillary refill time to the right first digit with absent protective and light touch sensation were noted. A traumatically amputated distal tuft of the right hallux revealed a Gustilo-Anderson Type III-A open fracture immediately exposing segmental comminution to the distal aspect of the distal phalanx along with gravel debris and active bleeding to the site. The right hallucal nail plate was found to be loose with subungual hematoma encompassing 100% of the underlying nail bed. The patient was unable to passively move the right first toe when prompted.

The nature, severity, and time sensitivity of the patient's injury called for immediate bedside management of his open crush fracture in the ED setting. Cefazolin, ciprofloxacin, and penicillin G potassium were administered and the patient was started on intravenous fluids. The patient was given an intramuscular (IM) dose of 0.5 mL TdaP for tetanus prophylaxis as he admitted it had been more than 10 years since his last tetanus booster. The open fracture was copiously irrigated using a total of 9 liters of 0.9% sterile saline solution. A right hallux anesthetic block was then administered. An excisional debridement of nonviable tissue as well as a total hallucal nail avulsion to evacuate subungual hematoma and to assess the true extent of the injury were performed (Figure 1). X-ray confirmed comminution of the distal phalanx with surrounding soft tissue swelling (Figure 2). The right hallux was immobilized by means of a basket-weave splint for fracture stabilization and the right foot was dressed with a bulky, compressive dressing. The patient was given pain medication for pain control.

Figure 1 Preoperative image demonstrating open fracture of the right foot with traumatic amputation of the hallucal distal tuft.

Figure 2 Plain dorsoplantar, oblique, and lateral radiographs of the foot revealing a comminuted fracture of the hallucal distal phalanx with surrounding soft tissue swelling.

At this time, the patient was prepped for emergency surgery and was instructed for his subsequent admission. The patient was booked for removal of nonviable skin, soft tissue, and bone from the right foot and instructed on the possible need for a staged procedure. The patient consented to the proposed operation and medical clearance was granted. The patient underwent the emergent operation overnight under monitored anesthesia care with local anesthetic.

Figure 3 Postoperative plain dorsoplantar, oblique, and lateral radiographs of the foot illustrating salvage of the proximal 1/3 base of the distal phalanx resulting in a partial hallux amputation.

Degloved, nonviable skin and soft tissue of the right hallux was excisionally debrided and all comminuted fragmentation of the exposed distal phalanx was excised and passed off for pathological analysis. The proximal 1/3 base of the hallucal distal phalanx was found to be viable and was salvaged intra-operatively (Figure 3). The surgical site was irrigated with 9 liters of 0.9% sterile saline solution. The remaining base of the distal phalanx was rasped to remove sharp edges and bone wax was applied over its surface. Primary closure was achieved using a flap from the plantar hallucal skin and soft tissue which ultimately resulted in a partial hallux amputation.

Surgical pathology revealed findings of hemorrhage and reactive changes without any evidence of bone or soft tissue infection. The patient was continued on IV antibiotics until the date of hospital discharge when he was transitioned to a 10-day course of cephalexin per the infectious disease specialist. The patient healed uneventfully on the outpatient basis with appropriate return to normal shoewear.

Discussion

In this case report, a farm injury caused by a commercial lawn mower resulted in an open fracture of the right hallux that required emergent overnight surgery. Immediate bedside irrigation was initiated using an initial 9 liters of 0.9% sterile saline solution

to remove gross debris and bacterial contamination followed by another 9 liters of the same solution used in the operating room. Anglen identified volume, pressure, and pulsation as three variables as part of a proposed irrigation protocol utilized for the treatment of open fractures, with his recommendation calling for 3 liters of irrigation used for Type I open fractures, 6 liters for Type II open fractures, and 9 liters for Type III open fractures [6]. Though antiseptic agents have been purported to have bactericidal properties, they have been reported to cause cytotoxicity, impaired osteoblast function, delayed wound healing, and chondrocyte damage; hence, 0.9% sterile saline solution is considered the standard of choice irrigant in cases of open fractures [1]. Regarding the pressure variable in the irrigation protocol, Anglen and colleagues in another study observed a 100-fold decrease in slime-producing *Staphylococcus* bacterial count in wounds treated with pulsatile lavage as compared with bulb irrigation when the same solutions and volumes were used in both delivery systems [7]. Anglen reported that even though pulsation may in theory remove surface debris by means of tissue elasticity, there is no established recommendation due to limited studies on this irrigation variable [6].

Another important consideration in the management of open fractures is timing from onset of injury to debridement. The American College of Surgeons Committee on Trauma (ACS-COT) deems debridement within 6 hours from time of injury to be the standard of care as a time lapse greater than this can result in 1 g of tissue inoculated with a single bacterium to duplicate 10^5 bacteria to convert a contaminated wound to an infected wound [4,5,10]. More recent clinical data in the literature lacks support of this postulation and concludes that early debridement is not an independent predictor of decreased risk of infection [11]. In this case, non-excisional and excisional debridement were performed at bedside within 6 hours from the onset of the patient's injury and shortly thereafter in the operative setting, which allowed for primary wound closure via a plantar hallucal skin and soft tissue flap.

Tetanus and antibiotic prophylaxis were initiated in this case due to the severity of the patient's open fracture as well as the farm environment where it occurred. The patient was given an IM dose of TdaP per the ED physician as more than 10 years had elapsed since the patient's last tetanus booster. The rate of bone and/or soft tissue infection following an open fracture is purported to be 3-25% with the most common pathogens being that of natural skin flora, namely coagulase-positive *Staphylococcus aureus* [1,8]. For the patient's Gustilo-Anderson Type III-A open fracture, the ED physician administered cefazolin, ciprofloxacin, and penicillin G potassium per recommendation of the podiatry service which provided appropriate gram-positive, gram-negative, and anaerobic coverage. With Type III-A open fractures occurring in a farm environment, penicillin G potassium is warranted for *Clostridium* spore coverage [1]. In a study of 1104 open fractures, Patzakis and Wilkins reported that early administration of antibiotics, deemed within 3 hours of onset of injury, was the single most important factor in reducing rate of infection (4.7% compared with 7.4% for those that received antibiotics after 3 hours from time of injury) [12]. Following surgical debridement and primary closure, it is recommended that antibiotics are continued for an additional 24 to 48 hours in the post-operative period [1]. In this case, bone and soft tissue of the right hallux that was passed off for pathological analysis came back negative for evidence of infection. The infectious disease specialist continued the patient on cefazolin in the immediate post-operative period and discharged him with a 10-day course of cephalexin due to the open and contaminated nature of the wound upon initial patient presentation.

The emergent nature of the patient's open fracture ultimately resulted in a partial hallux amputation. Due to the extensive amount of comminution to the distal aspect of the distal phalanx bone, these fragments could not be apposed in an improved position with internal or external fixation and were therefore deemed non-salvageable and excised altogether. Rasping of the salvaged 1/3 base of the hallucal distal phalanx and implementation of bone wax were used to smoothen osseous contour and deter spicule regrowth, respectively. Primary closure via use of a plantar hallucal skin and soft tissue flap was achieved as the site was deemed clean as a result of timely irrigation and debridement from onset of injury.

Conclusion

This article highlights a case of an open fracture to the great toe which resulted in a partial hallux amputation and outlines the accepted management of such traumatic injuries through a review of literature. Open fractures are true podiatric emergencies that can pose life-threatening changes to patients and their well-being. Traumatic great toe amputations may lead

to functional and psychological disability as well as decreased propulsive effort during the push-off phase of the gait cycle. Prognosis is highly dependent on both timing of patient presentation to seek medical attention as well as on prompt rendering of medical care by the practitioner. If treatment is delayed, the patient risks suffering from a greater likelihood of morbidity and poorer prognosis. By increasing the knowledge and awareness of these debilitating injuries and their treatment protocols, the patient will be best served and the practitioner will be best guided in the overall aim to prevent infection, minimize disability, and promote limb salvage.

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