Timing of Operative Debridement in Open Fractures

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KEYWORDS

• Open fracture • Debridement • Surgical timing • Antibiotics

KEY POINTS

- Patients with open fractures are at high risk of infection if not treated expediently.
- The historic 6-hour time limit for debridement of open fractures has been challenged in contemporary publications.
- In the context of early antibiotic administration, debridement within 6 hours has not been shown to be an independent risk factor for infection after open fracture.
- Delayed versus primary wound closure is determined based on the clinical experience of the surgeon, but may not have an effect on infection rates.

BACKGROUND

An open fracture is defined as a fracture that involves a violation of the soft tissue envelope with communication through to the fracture fragments, the associated fracture hematoma, or both.[1] Although Gustilo and Anderson[2] espoused universal agreement that open fractures require emergent treatment to include adequate irrigation and surgical debridement of the open wound, few issues in orthopedics today are debated more than the appropriate timing and management of open fractures.[3–11] However, there is consensus that these low- or high-energy injuries result in wound contamination, devitalized tissue, local edema, and surrounding ischemia that interfere with the body's natural immune defense mechanisms to resist infection.[12] As a result of thorough surgical techniques, antibiotic options and administration, and advanced techniques for soft tissue coverage, the ability to manage open fractures has improved. The treating orthopedic surgeon must be able to address these injuries appropriately to limit the risk of infection and promote adequate healing.

This article addresses the evaluation of a patient with an open fracture and analyzes the evidentiary support regarding the historic "6-hour rule" in the timing of operative management.

HISTORICAL PERSPECTIVE

The use of excisional debridement to prevent wound infection dates back to the time of Hippocrates.[13] In 1898, a German military surgeon and bacteriologist, Paul Leopold Friedrich, conducted an experiment using guinea pigs whereby he created open wounds in the triceps region and contaminated them with mud and house dust. Wounds were cleaned in intervals of 30 minutes. He found that when wounds were debrided within 6 hours of inoculation, the guinea pigs survived. All of the guinea pigs whose wounds were debrided after 8.5 hours died. Thus, Friedrich showed that the early phases of bacterial growth within contaminated

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wounds terminated within 6 to 8 hours after inoculation and that extensive debridement to viable tissue within this time period could decrease the risk of infection.[14–16] Of note, Friedrich's work did not involve administration of local or systemic antibiotics. Before World War II, open injuries were left to heal by secondary intention.[17,18] Military surgeon Joseph Trueta aptly described treatment of an open wound (ie, soft tissue injury) as the principal part of the treatment of an open fracture. He believed that the greatest danger of infection lay not in the infection of the bone, but rather the muscle. By the end of the war, Friedrich's study was adopted to reflect the time required to close open wounds.[14] This "6-hour rule," although based primarily on historical opinion and limited clinical evidence,[11] has since been extrapolated to open fractures and was adopted as a treatment guideline in the orthopedic community for many years.[9,19,20] Not until recently have many studies started to challenge the 6-hour rule, shifting away from the previous doctrine of emergently operating on open fractures.[21]

EPIDEMIOLOGY

The tibia is the most common location for an open fracture.[1] Its proximity to the skin and limited soft tissue envelope enable even low-energy fractures to violate the soft tissue envelope.[6,22] Most open fractures occur in the fifth decade of life, commonly as a result traffic accidents, crush injuries, or falls.[23,24] As with most fracture patterns, there is a bimodal distribution: lower energy injuries occur in the elderly most commonly from falls, whereas higher energy injuries occur in younger patients.[24] In a recent review, Court-Brown and colleagues[25] evaluated the epidemiology of open fractures over a 15-year period. They reported 30.7 open fractures per 100,000 person-years, a steady increase as compared with previous reports of 11.5 per 100,000 person-years.[15,24] In their cohort, 69.1% occurred in males and 30.9% occurred in females.

As a result of the disruption of the protective skin barrier, injuries with exposed bone and soft tissue are more prone to infection. For open tibia fractures, an infection rate of 13% to 25% has been reported.[10] Further studies have elucidated the differences in infection rate based on the Gustilo-Anderson classification system[2,26] and the timing of operative debridement.[6,11,27,28] In a retrospective review by Templeman and colleagues,[29] none of 29 type I fractures, 1 of 36 (3%) type II fractures, and 14 of 68 (21%) type III fractures became infected. Early administration of antibiotics has been shown to be an extremely important factor in the prevention of infection following open fractures. Although antibiotic administration has been deemed "prophylactic," work by several authors has shown that antibiotic use is actually therapeutic.[30,31] Most current recommendations suggest that antibiotics should be administered for 24 to 48 hours after the last debridement.[5,11,18,21,32]

CLASSIFICATION

The Gustilo-Anderson classification of open fractures is the most commonly used system in current practice.[33] This system takes into consideration the energy of the fracture, soft tissue damage, and the degree of contamination.[34] In their retrospective (n = 673) and prospective (n = 352) reviews of 1052 open fractures,[2] a type I injury was defined as a low-energy injury with minimum soft tissue damage and a small (<1 cm) wound. These were typically inside-out puncture injuries with minimal comminution. A type II injury described a low- to moderate-energy injury with moderate soft tissue damage and an open wound up to 10 cm, but without periosteal stripping. Originally, a type III injury was an umbrella category for either an open, segmental fracture with extensive soft tissue damage, or a traumatic amputation. This description was found to be too inclusive, so Gustilo and colleagues[26] modified their type III classification several years later. A type IIIA injury has adequate soft tissue coverage despite the high-energy comminution and segmental nature, irrespective of the wound size. However, an injury with a wound greater than 10 cm was also characterized as IIIA. A type IIIB open fracture necessitates local or distant flap coverage of areas of exposed bone (not including skin grafting). In addition, these fractures are commonly associated with extensive periosteal stripping (**Fig. 1**). Finally, a type IIIC injury results in a vascular injury that requires repair to preserve limb survival. Isolated injuries to the anterior or posterior tibial artery are not included in this description (**Table 1**). Importantly, the final classification of the injury is determined in the operating room.[34] To test the reliability of this system, 245 surgeons were given clinical histories, physical examinations, radiographs, and video footage of the operative debridement of 12 open fractures. The overall interobserver agreement was a moderate 60% (range, 42%–94%).[35]

More recently, the Orthopedic Trauma Association developed a more comprehensive