Impact of Infection on Fracture Fixation

Michael Willey, MD*, Matthew Karam, MD

KEYWORDS

• Musculoskeletal trauma • Fracture fixation • Surgical site infection
• Surgical management of infection • Clinical outcomes

KEY POINTS

- Rates of infection are higher in patients undergoing operative fixation of fractures compared with other orthopedic procedures.
- Patients with open fractures are at the highest risk of infection, especially in cases with severe soft tissue injury.
- Re-evaluation of current antibiotic infection prophylaxis in patients with open fracture is warranted.
- A diagnosis of surgical site infection after fracture fixation requires a comprehensive evaluation of clinical examination, serum laboratory values, and imaging studies.
- Surgical site infection can have devastating consequences for patients in orthopedic trauma surgery and innovative methods to prevent these complications must continue to be sought.

INTRODUCTION

The human body is composed of 10^{13} native cells and a surprising 10^{14} symbiotic microbes that coexist to allow a functional, healthy lifestyle.[1] Despite being outnumbered 10 to 1 by microbes, the body is protected by physical barriers, including skin, mucous membranes, and the immune system. Trauma and surgery disrupt these barriers and can disturb the balance, leading to surgical site infection and significant disability. This article discusses the prevention of surgical site infection in patients who undergo operative fixation of fractures and the management of this well-described complication.

Throughout history, surgical site infection has consistently been a barrier to performing operations to treat pathology. Effective anesthesia and antisepsis are justly given credit for allowing advances in surgical treatments. Anesthesia made surgery physically tolerable but especially important to surgical site infection is antisepsis. Well-known individuals in the history of medicine, including Semmelweis, Pasteur, and Lister, are credited with the development of modern asepsis. Ignaz Semmelweis in 1847, before understanding of the germ theory, deduced that unwashed hands of physicians were contaminating women during childbirth. After implementing a policy requiring physicians and medical students to wash their hands in chlorinated lime after leaving the autopsy suite to examine patients on the ward, the mortality mostly due to puerperal fever dropped from 18.3% to 2.2%.[2]

Lister, 20 years later, applied theories developed by Pasteur identifying that microbes causing fermentation could be killed by heat and chemical solutions.[3] He theorized that chemicals could kill microbes on the skin and surgical instruments, preventing inoculation of surgical wounds. Prior to his work, purulence was thought a normal component of the wound

Disclosure Statement: The authors have nothing to disclose related to this article.
Department of Orthopaedic Surgery and Rehabilitation, University of Iowa Hospitals and Clinics, 200 Hawkins Drive, Iowa City, IA 52242, USA
* Corresponding author.
E-mail address: michael-willey@uiowa.edu

Orthop Clin N Am 47 (2016) 357–364
http://dx.doi.org/10.1016/j.ocl.2015.09.004
0030-5898/16/$ – see front matter Published by Elsevier Inc.

healing process. In the American Civil War (1861–1865), gunshot injuries to the extremities with fracture resulted in a 50% rate of amputation and a 26% mortality rate.[4] Exsanguination and infection were the most common complications after amputation.[5] Erysipelas (streptococcal soft tissues infection) was associated with an 87% mortality.[4] During this time, Lister noted that more than half of patients with open fractures developed septicemia and died at the University of Glasgow.[3] Applying theories developed by Pasteur, he treated the wounds of 11 patients who suffered open fractures with carbolic acid, intending to kill infecting microbes. Nine patients healed without infection, which was a drastic improvement from previously reported results.[3] He published his work in 1867, 2 years after the Civil War, and although acceptance of his methods was slow, it led to significant progress in the field of surgery.

By the 1960s, advances in antiseptic technique drove down the rates of surgical site infections enough to allow for development of relatively safe operations. Stevens[6] published a series from this time that reports rates of deep infection as low as 4.35% for all orthopedic operations. Recent published rates of return to the operating room for surgical site infection are 1.18% after primary total hip arthroplasty and 0.90% after primary total knee arthroplasty.[7] These impressive numbers might suggest that this is a minor issue, but rates of surgical site infection have consistently been higher in patients who undergo operative fixation of acute fractures. The procedures with the highest rates of deep surgical site infection in the series published by Stevens in 1964 were "Open reduction with a plate" (13.0%) and "Débridement of open fractures" (12.1%), much higher than the overall average of 4.35%.[6] Recent published series of operative fixation of bicondylar tibial plateau fractures with dual approaches report rates of deep infection requiring operative débridement from 17.6% to 23.6%.[8,9] In patients with compartment syndrome, the rate was 36.4%[8] and with open fracture the rate of deep infection was 43.8%.[9] Two patients with infection in 1 series ultimately required an above-the-knee amputation.[8] Despite advances since the 1960s in minimally invasive techniques for fracture reduction and fixation, surgical site infection rates remain a common complication in the operative treatment of fractures. The rates continue to be significant, and innovative interventions to reduce surgical site infection in this patient population would have significant impact on the field of orthopedic fracture surgery.

TYPE AND TIMING OF PROPHYLACTIC ANTIBIOTICS IN FRACTURE SURGERY

Published series reporting outcomes and antibiotic recommendations for infection prophylaxis in patients with open and closed fractures were developed in the 1970s and early 1980s with little recent change. Since that time, there has been significant increase in the incidence of infection with resistant organisms. In a study that established cephalosporins as the preferred antibiotic to use for prophylaxis in patients with open fracture, Patzakis and colleagues[10] reported that 50% (11/22) patients with infection were culture positive for *Staphylococcus aureus*. In the entire series, infection was seen in 7.1% of all open fractures. They randomized patients with open fractures to no antibiotic prophylaxis, penicillin/streptomycin, and cephalothin. The rate of deep infection was 13.9% in the no antibiotic group, 9.7% in the penicillin and streptomycin group, and 2.3% in the cephalothin group. This study established cephalosporins as the antibiotic of choice for the next 40 years.

Around the same time, Gustilo and Anderson[11] reported results of implementing a débridement, fixation, and intravenous antibiotic protocol for open tibia fractures. They reported that 68.4% of organisms cultured from wound infections were *S aureus*. None of the isolated bacteria in either series was identified as methicillin-resistant *S aureus* (MRSA). *S aureus* first became resistant to penicillins in the 1950s, and, after widespread use of methicillin, MRSA was first isolated in the United Kingdom in 1961.[12] By the mid-1980s, MRSA became a frequently encountered hospital-acquired infecting organism. A recent published series reported a 2.5% rate of MRSA infection in patients with open fractures and 25% of patients with infections were culture positive for MRSA.[13] Another article reporting outcomes of adding intravenous vancomycin as a prophylactic antibiotic identified MRSA as the infecting organism in 18% of cases of open fracture. This trend of increasing rates of MRSA infection over the past 20 years is mirrored in cardiothoracic surgery and hospital-acquired infections.[14,15]

Re-evaluation of the current standard for appropriate prophylactic antibiotics in open and closed injuries is an interesting topic in orthopedic trauma surgery. The previously discussed study by Morris and colleagues[8] reported that 46.5% of wound infections after fixation of bicondylar tibial plateau fractures had cultures positive for MRSA. They discussed the possibility of giving vancomycin as procedural prophylaxis as a standard protocol. Torbert and colleagues[16] published the most