

Open fractures with soft-tissue loss

Coverage options and timing of surgery

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Abstract

Open fractures with soft-tissue loss remain challenging injuries to treat. These often high-energy fractures are at a higher risk of delayed healing and at much higher risk of infection than open fractures with less significant soft-tissue injury. The initial management of the open wound, flap coverage options, and the timing of definitive coverage all remain areas of controversy, which will be discussed in this article.

Keywords: open fracture, bead pouch, negative pressure wound therapy, soft-tissue coverage, orthoplastic

1. Introduction

Open fractures with soft-tissue loss remain challenging injuries to treat. These often high-energy fractures are at a higher risk of delayed healing and at much higher risk of infection than open fractures with less significant soft-tissue injury. Much of the literature on this topic focuses on the treatment of open tibia fractures, as these are the most common open fracture with soft-tissue loss; however, the same challenges and principles apply to other open fractures as well. The initial management of the open wound, flap coverage options, and the timing of definitive coverage all remain areas of controversy, which will be discussed in this article.

1.1. Initial wound management

The initial priority in the management of these open fractures is the early administration of appropriate antibiotics (which is covered elsewhere in this special issue) and ensuring that tetanus prophylaxis is updated. The importance of thorough surgical debridement cannot be over-emphasized.

This debridement should be followed by copious irrigation with normal saline, as demonstrated in the FLOW study.^[1]

Once fracture debridement and stabilization has been performed, the optimal management of the open fracture wound becomes the first question to be addressed. Over time, a number of topical treatments have been used; however, conventionally sterile gauze dressings moistened with saline have been used most consistently. Unfortunately, we have seen very high rates of infection with open fractures with severe soft-tissue loss. In their classic 1976 paper, Gustilo and Anderson^[2] reported a 44% infection rate with open tibia fractures with severe soft-tissue injury. Cierny et al^[3] reported on a small series of 36 open tibial fractures with 33% either resulting in infection or amputation.

In the early 1990s, Henry, Ostermann, and Seligson published 2 studies describing the use of an antibiotic bead pouch to cover open fracture wounds.^[4,5] They described the initial use of Tobramycin-impregnated polymethyl methacrylate (PMMA) beads sealed with an occlusive dressing to cover 335 open fractures, reporting a significant decrease in the incidence of infection to less than 10%.^[5] This has become a popular means of managing open fracture wounds over the past 25 years.

More recently, interest shifted to the use of negative-pressure wound therapy (NPWT) following the results of several studies in the 2000s demonstrating decreased infection rates with the use of this technology for severe open wounds.^[6-8] Stannard et al^[7] in 2009 reported only a 5.4% infection rate in 35 patients with high-energy open fractures, and in 2012, Blum et al^[8] reported a reduction in infection rates to 8.4% in 166 open tibia fractures. This was a significant improvement over the reported 28% and 20.6% infection rates observed in their patients managed with conventional moist gauze dressings in these 2 studies.^[7,8]

While it might seem intuitive that combining both antibiotic beads and negative-pressure wound therapy would be even more beneficial, this is unfortunately not the case. Animal studies have shown decreased effectiveness of the antibiotic delivery in the presence of NPWT.^[9]

Two recent systematic reviews and meta-analyses have continued to support the benefit of NPWT showing decreased infection and decreased nonunion rates.^[10,11] However, the recent WOLFF study out of the United Kingdom, a large randomized controlled trial including 460 patients, failed to show

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any benefit to NPWT over conventional dressings in reducing infection rates in severe open lower limb fractures.^[12] The most recent Cochrane review in 2018 also showed no clear advantage of NPWT over conventional dressings.^[13]

While there may be some controversy over the benefit of NPWT, it is clear that this is not a substitute for timely soft-tissue coverage, and does not permit any additional delay, as will be discussed further in the surgical timing section.^[14,15]

1.2. Soft-tissue coverage options

Historically, the reconstructive approach to soft-tissue defects involved a step-wise process starting with simple, local measures or skin grafting prior to progressing to more involved procedures such as free-tissue transfer. This “reconstructive ladder” approach has been replaced by the so-called “reconstructive elevator,” bypassing potentially less-effective local procedures and proceeding directly to flap coverage of soft-tissue defects.^[16]

Current coverage options include either fasciocutaneous or muscle flaps. These may be rotational flaps, rotated around a vascular pedicle within the local region, or free-flaps from remote donor sites, requiring vascular anastomosis. Condition and availability of local rotational options needs to be weighed against the potential donor site morbidity and need for microvascular anastomosis associated with free-transfer.

While very large defects may mandate a large muscle flap such as the latissimus dorsi, most defects can be managed with either a fasciocutaneous or smaller muscle flap. While 1 small study of 39 patients suggested slightly better fracture healing at 6 months with muscle flap coverage, no difference was seen at 1 year.^[17] Fasciocutaneous flaps are becoming used with increasing frequency. Paro et al^[18] in 2016 showed no difference in bone healing or infection rates with the use of either fasciocutaneous or muscle flaps. Similarly, Cho et al reported on over 500 muscle or fasciocutaneous flaps showing equivalent rates of limb salvage as well as functional outcome with both options.^[19] Without the need for muscle transfer, there is potentially less concern of functional deficit using fasciocutaneous flaps, and without the need for split-thickness skin grafting, the cosmetic results may be better as well.

1.3. Timing of coverage

In 1976, Godina^[19] published his landmark study looking at the results of 532 patients showing lower rates of flap failure, infection, and nonunion if coverage was performed within 72 hours. Not much has changed since then! While negative pressure wound therapy may decrease infection risk and decrease flap complications, it does not permit delay of soft-tissue coverage beyond 7 days.^[14,15] A large North American retrospective cohort study, including 672 patients from 140 centers, similarly showed a significantly increased risk of complications if coverage was delayed beyond 7 days.^[20] These findings are consistent with the current guidelines from the American College of Surgeons recommending that soft-tissue coverage be achieved within 7 days.^[21]

Despite the body of evidence and best-practice guidelines, there remain challenges in meeting this goal of achieving coverage within 7 days. Pincus et al in their large multicentered retrospective study showed that in over 60% of the cases, this goal was not met. Time required for transfer to specialty centers with soft-tissue coverage capabilities may contribute to the delay in coverage.^[22] These system delays can lead to significant

regional variations in the length of delay to soft-tissue coverage.^[23] Certain socioeconomic and demographic factors may contribute to increased delay in soft-tissue coverage as well.^[24]

In an effort to improve the management of complex open extremity injuries, the United Kingdom has widely adopted an “orthopaedic” team approach. Patients with complex open extremity injuries are transported directly to these centers, where they are treated by a team comprised of both orthopaedic and plastic surgeons. This type of team approach has demonstrated success in achieving early coverage, as well as improved outcomes.^[25]

2. Conclusions

Optimal management of open fractures includes timely administration of systemic antibiotics and thorough surgical debridement and irrigation. If primary closure is not possible, management of the open wound with either a bead pouch or negative pressure wound therapy may help decrease infection. Timely soft-tissue coverage within 7 days is required to reduce the risk of infection and other complications. A coordinated team approach involving both orthopaedic and plastic surgery may help improve the timely care and outcomes of these complex injuries.

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