The Northern Ohio Foot and Ankle Journal *Official Publication of the NOFA Foundation*

Primary vs. Secondary Closure of Open Fractures

by Jenna Mackay, DPM[1]

The Northern Ohio Foot and Ankle Journal 4(18):1-4

Abstract: Traditionally, the management of open fractures has included delayed or secondary closure. This method has been utilized to manage infection, and was first described by war-time physicians before the advent of modern antibiotics. While there is no one correct way to manage the soft tissues of an open fracture, primary closure should not be discounted as a viable treatment option. Based on a literature review, this article concludes that if proper debridement and antibiotic coverage can be obtained, primary closure of open fractures does not result in more instances of infection.

Key words: Open fractures, primary closure, delayed primary closure, secondary closure, and Gustilo Anderson

Accepted: December, 2017 **Published:** January, 2018

INTRODUCTION

The management of open fractures is an important topic with initial concepts originating from war-time surgeons[1]. Due to a lack of antibiotics in those times, open fractures were most frequently left to heal by secondary intention. With the advent of modern antibiotics, improvements in debridement and lavage techniques, the decision between primary and secondary closure has become less clear. This article will aim to present recent literature demonstrating that it is reasonable to close open fractures primarily so long as appropriate antibiotics has been administered and proper debridement performed.

EARLY MANAGEMENT AND CLASSIFICATIONS

Open fracture treatment varies subtly from institution to institution, but follows the same general protocol universally. The hallmarks of open fracture management include: initial lavage, closed reduction and temporary fixation, systemic antibiotic administration, operating room within 24 hours of the injury for debridement, lavage, fracture stabilization and wound management[2]. In an attempt to further unify the management of open fractures, there are various classification systems used. The most commonly used open fracture classification system is the Gustilo Anderson classification (Figure 1). The Gustilo Anderson classification system not only organizes open fractures into groupings based on severity of open fracture but also provides recommendations for antibiotic administration. For fractures which fit into types I and II, a cephalosporin, clindamycin, or vancomycin is recommended. Fractures which fit into the category of type III receive the same initial antibiotic as would a fracture in group I or II, but with the addition of an aminoglycoside. Gustilo and Anderson further suggested the addition of Penicillin G for those fractures occurring in a barnyard or battle field. For those injuries in brackish water, an area in which fresh and salt water meet, the addition of a quinolone or 3rd generation cephalosporin is recommended[1]. Another useful classification system is the Mangled Extremity Severity Score (MESS). This classification system differentiates between extremity injuries which are salvageable and unsalvageable. The four criteria within the MESS are skeletal/soft-tissue injury, limb ischemia, shock, and age[4]. According to a combined retrospective and prospective study by Johansen et al, a MESS value of greater than or equal to 7 had a 100% positive predictive value for amputation. The results of this

study were reflected in a prospective study done by McNamara et al., in which Gustilo Anderson type IIIB and IIIC fractures of the tibia were reviewed. McNamara et al. also retrospectively applied the NISSSA score, which adds the criteria of nerve injury to the MESS and found it to be more sensitive and specific in predicting limb salvage versus amputation[3].

Classification	Description
Type 1	Puncture wound of less than or equal to 1 cm with minimal soft tissue injury Minimal wound contamination or muscle crushing
Type 2	Wound is greater than 1 cm in length Moderate soft-tissue injury Soft tissue coverage of the bone is adequate Comminution is minimal
Type 3a	Extensive soft tissue damage Includes massively contaminated, severely comminuted, or segmental fractures Soft tissue coverage of the bone is adequate
Type 3b	Extensive soft tissue damage with periosteal stripping and bone exposure Usually severely contaminated and comminuted Flap coverage is required to provide soft tissue coverage
Type 3c	Associated with an arterial injury requiring repair for limb salvage

Figure 1: Gustilo-Anderson Classification system.

INFECTION

The most common pathogens encountered in open fractures are gram negative rods and *Staphylococcus*. Injuries occurring on a battlefield or farm have an increased risk of acquiring *Clostridium perfringes*, while those in brackish water have a higher risk of contracting *Pseudomonas*[2]. Due to the concerns of infection, open fractures have classically been stabilized and left open for repeat debridement and assurance of eradication of infection before closure. However, a study by Patzakis et al., in 2000, stated that only 18% of infections in open fractures are caused by the same organism which was isolated perioperatively[5]. The increasing emergence of nosocomial infections suggests a need for earlier wound coverage. Provided that thorough debridement and irrigation is performed in the operating room, it stands to reason that the soft tissue is at its cleanest point before exiting the operating room.

SECONDARY CLOSURE

Secondary wound closure involves the applications of regular dressings to facilitate gradual healing of a wound on its own, in these instances skin edges are left unsutured[6]. Secondary closure is commonly utilized in wounds which require repeat debridements, small wounds, and second-degree burns. Classically wounds that are greater than 6 hours old should be closed secondarily due to increased infection risk. Disadvantages to this method include the need for wound care management and difficulty to the patient. This method of closure is contraindicated where there is exposure of vital structures, and where a tight scar would be undesirable[6]. Delayed primary closure is considered a compromise between primary and secondary closure. Delayed primary closure most often involves a short period of local wound care with eventual closure of the defect with the aid of sutures. Secondary or delayed closure of wounds following open fracture has long been a standard of practice, particularly in the case of fractures with gross contamination. In a 2007 article, by Zalavras et al., it was stated that primarily closed fracture sites are at a greater risk for developing gas gangrene than those closed secondarily[7]. This finding was first published by Brown and Kinman, in 1974, in which 27 patients, between 1963 and 1973, underwent primary closure of open fractures. Of the included fractures, 13 involved contaminated water and 2 presented with fecal contamination. In all, there were 19 cases of gas gangrene and 8 cases of anaerobic cellulitis following primary closure[1]. The study published by Brown and Kinman was later reviewed by Weitz et al. in 2002. In this review, it was found that all wounds were severely contaminated, only 5 patients received antibiotics that covered anaerobic organisms and 4 patients did not receive any antibiotics at all. Based on these findings, the cause of gas gangrene and anaerobic cellulitis was more likely due to improper debridement and irrigation, as well as lack of antibiotic coverage, as opposed to primary closure. Further support for delayed closure of open fractures has previously been supplied by Russell et al., who published a retrospective review in 1990. This reviewed looked at 110 patients, between 1981 and 1986, with open tibial fractures. These fractures were classified with the Gustilo-Anderson classification system, with 41% being type I, 39% being type II, and 20% being type III. The review found 4 cases of deep infection in 30 patients treated with primary wound closure. This was compared to 22 patients whom underwent delayed closure and whom had no instances of deep infection. Of the 18 type III injuries, there was a 50% infection

rate in those treated with primary closure, and a 17% infection rate in those treated with delayed closure. Russell therefore concluded that the optimum treatment for open fractures included delayed primary closure[8].

PRIMARY CLOSURE

Primary wound closure is achieved when skin edges of a wound are sutured together to directly close a defect. The advantages to primary closure included simplification of wound care, faster healing, better cosmetic outcome, and protection of vital underlying structures. Contraindications to this method include infection or an acute wound greater than 6 hours old, presence of foreign debris, active oozing of blood, presence of a large dead space, or instances in which closure with sutures would place a large amount of tension on skin edges[6]. One of the many reasons for a push toward primary closure, is that delayed healing of fractures is seen when soft tissue coverage cannot be adequately achieved[9].

Delayed closure can be advocated for when a free muscle flap is applied within 72 hours of the initial injury. Sinclair et al. retrospectively reviewed 17 patients with Type IIIB open tibial fractures. Of these 17 cases, there were no instances of deep infection and a 100% flap survival rate. The mean time to fracture healing was 10 months. Through this study, Sinclair et al. concluded that a delay in cover for Type IIIB and IIIC tibial fractures leads to an increased risk of flap failure[10]. Looking further into flap application, for type IIIB and IIIC injuries, Gopal et al. reviewed 84 severe open tibial fractures from 1990 to 1998. In this study, each patient was treated with what was considered a radical protocol and included early soft-tissue coverage with a muscle flap by an orthopedist and plastic surgeon. 33 of the 84 patients received debridement, stabilization and soft-tissue reconstruction in a single procedure. 30 patients received soft-tissue reconstruction within 72 hours of their injury. 21 patients had a delay in their soft-tissue reconstruction by more than 72 hours. The soft-tissue reconstruction consisted of 9 pedicle flaps and 75 free-muscle flaps. The authors found a 6% rate of superficial infection in their single stage application of a flap, and a statistically insignificantly higher rate of infection with delayed flap application. It was concluded that for best results a single stage procedure with internal fixation and soft-tissue reconstruction should be performed in cases of type IIIB and IIIC open tibial fractures. The authors further stated that "delay is not necessary if healthy soft tissue can be imported reliably into the zone of injury."[11]

More recently, a 2014 retrospective review performed by Moola et al. looked at a Level 1 trauma center over a 5-year period. A total of 297 patients with open fracture were reviewed, 255 of which underwent definitive immediate primary closure. Within the 255 patients receiving immediate primary closure were 45 Type III fractures. The study looked at the rates of post-operative infection and delayed/non-union rates between primary and delayed closure groups. Superficial infection rates were found to be 10.9% in the primary closure group and 11.9% in the delayed closure group. Deep infection rates in the primary closure group were 4.7% compared to an 11.9% rate in the delayed group. Delayed and non-unions were also found to be at a higher rate in the delayed closure group at 19.6%, while the primary closure groups had a 14.5% rate. The authors therefore concluded that immediate primary closure was not significantly associated with development of deep wound infections. The article also offered a suggested protocol for management of open fractures, which included: immediate antibiotic prophylaxis and tetanus prophylaxis, irrigation of the wound in the trauma bay, application of sterile dressing and immobilization of the extremity, surgical management to include systematic debridement, wound irrigation, and an attempt at wound closure. If the wound can be closed they recommend a further 24 hours of antibiotics. If wound closure cannot be accomplished, a second look at 24-48 hours is recommended with continued IV antibiotics and a consult to Plastics for possible wound closure options[12].

CONCLUSION

While it is impossible to reasonably state that all open fractures should be primarily closed, it is important not to disregard primary closure as a viable option. Based on the above literature review, if adequate debridement and appropriate antibiotics are administered, primary closure has not been associated with an increased rate of infection, and is associated with an increased fracture healing rate. Primary closure of open fractures should be considered a safe and potentially cost saving way to treat open fractures.

REFERENCES

1. Weitz-Marshall, A. D., & Bosse, M. J. (2002). Timing of closure of open fractures. Journal of the American Academy of Orthopaedic Surgeons, 10(6), 379-384.
2. Hamilton, G. (2015). Open Fractures Lecture. CSPM Podiatric Trauma Course. Samuel Merritt University, Oakland CA. January 29, 2015.
3. McNamara, M. G., Heckman, J. D., & Corley, F. G. (1994). Severe Open Fractures of the Lower Extremity: A Retrospective Evaluation of the Mangled Extremity Severity Score (MESS). Journal of orthopaedic trauma, 8(2), 81-87.
4.Helfet, D. L., Howey, T., Sanders, R., & Johansen, K. (1990). Limb Salvage Versus Amputation: Preliminary Results of the Mangled Extremity Severity Score. Clinical orthopaedics and related research, 256, 80-86.
5. Patzakis, M. J., Bains, R. S., Lee, J., Shepherd, L., Singer, G., Ressler, R., & Holtom, P. (2000). Prospective, randomized, double-blind study comparing single-agent antibiotic therapy, ciprofloxacin, to combination antibiotic therapy in open fracture wounds. Journal of orthopaedic trauma, 14(8), 529-533.
6. Semer, N. B., & ADLER-LAVAN, M. A. R. T. H. E. (2001). Practical plastic surgery for nonsurgeons (pp. 137-144). Philadelphia: Hanley & Belfus.
7. Zalavras, C. G., Marcus, R. E., Levin, L. S., & Patzakis, M. J. (2007). Management of open fractures and subsequent complications. The Journal of Bone & Joint Surgery, 89(4), 884-895.
8. Russell GG, Henderson R, Arnett G. (1990). Primary or delayed closure of open tibial fractures. Journal of Bone and Joint Surgery Br, vol 72-B no 1, 125-128.
9. Mckibben B. The biology of fracture healing in long bones. J Bone Joint Surg 1978; 60B: 150
10. Sinclair, J.S., McNally M.A., Small, J.O., Yeates, H.A., (1997). Primary free-flap cover of open tibial fractures. Injury, 28(9-10). 581-586.
11. Gopal, S., Majumder, S., Batchelor, A. G. B., Knight, S. L., De Boer, P., & Smith, R. M. (2000). Fix and flap: the radical orthopaedic and plastic treatment of severe open fractures of the tibia. Journal of Bone & Joint Surgery, British Volume, 82(7), 959-966.
12. Moola, F. O., Carli, A., Berry, G. K., Reindl, R., Jacks, D., & Harvey, E. J. (2014). Attempting primary closure for all open fractures: the effectiveness of an institutional protocol. Canadian Journal of Surgery, 57(3), E82.