

Comparison of delayed and primary wound closure in the treatment of open tibial fractures

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Abstract

Introduction Primary wound closure in the management of open tibial fractures has generally been discouraged. Several prior studies suggest that infections are not caused by the initial contamination, but are instead the result of organisms acquired in the hospital. Primary wound closure after adequate wound care and fracture stabilisation could therefore be considered a reasonable option.

Materials and methods We analysed 95 patients with open tibial fractures (Gustilo–Anderson type 1 to 3A) treated with primary fracture stabilisation and either delayed wound closure (group I) or primary wound closure (group II), with a minimum follow-up of 12 months.

Results Group I included 46 patients with a mean age of 30.2 years (16–56), and a mean follow-up of 13.5 months (12–18). Group II included 49 patients with a mean age of 33.4 (18–69), and a mean follow up of 13.7 months (12–16). One infection developed in group I (2%), and two infections developed in group II (4%). This difference was not found to have any statistical significance.

Conclusion Our results support other recent reports that the infection rate is not increased following primary wound closure after thorough debridement of less severe open fractures. The length of stay following primary closure (group II) was significantly shorter, and that should result in substantially more cost effective care of these serious injuries. We conclude that primary wound closure is a safe option in properly selected cases. Prospective multi-centre studies are needed to further evaluate the safety and efficacy of this treatment alternative.

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Introduction

The treatment of open tibial fractures has undergone many changes over the past two decades. The focus of treatment with current techniques and modern antibiotics has shifted attention towards limb salvage, attempting to preserve function while avoiding complications. Modern open fracture wound care is still largely based on experiences from war surgery, leaving wounds open until clean and then performing a

delayed wound closure. The current standard of care is based on the principles established by Gustilo and Anderson over 25 years ago [17, 18]. Urgent aggressive debridement with excision of dead and devitalised tissue, early fracture stabilization [24], and use of broad spectrum antibiotics [34], are important initial measures. The wound is left open, and a repeat debridement is then performed every 48–72 h thereafter as required. Wound closure or coverage with skin grafting or flaps is performed as soon as debridement is complete and the wound margins are clean and well perfused. Optimal wound closure occurs within seven days of injury, as closure delayed beyond seven days is associated with an increased risk of infection [5, 6, 13, 26]. Infection remains the major risk and plays a vital role in determining the outcome of treatment. Primary wound closure for open tibial fractures has not been generally recommended [13, 16, 17, 36]. However, the delayed wound closure protocol was developed before the widespread use of prophylactic intravenous antibiotics, as well as improved techniques for fracture stabilisation. Several prior reports [13, 19, 38] suggest infections are not caused by the initial contamination, but the organisms are instead acquired secondarily by nosocomial routes. Therefore, primary closure after adequate wound care in conjunction with early fracture stabilisation should not only be a safe concept, but could potentially reduce the rate of hospital acquired infection [40, 41].

This study was designed to consider the feasibility of primary closure for simple, isolated, low grade open fracture wounds. The open fracture wounds included were the result of low energy injuries, without periosteal stripping and with only limited contamination. In order to assess the potential safety and efficacy of primary closure of these uncomplicated open tibial fracture wounds, we conducted this study of patients treated by two distinctly different standard protocols. This study retrospectively reviews the accepted practice at two major teaching hospitals in Johannesburg, South Africa, over a 2-year period. The treatment of open tibial fractures at Johannesburg Hospital (group I) followed the generally accepted standard treatment of initial debridement and preliminary immobilisation, subsequently followed by definitive fixation and delayed wound closure. The treatment at Helen Josef Hospital (group II) instead involved aggressive debridement, immediate fixation and primary wound closure. We hypothesized there would be no significant difference between the two groups, using documented infection as the principle outcome measure.

Materials and methods

We retrospectively analysed the medical records of a consecutive series of adult patients with isolated open tibial fractures (Gustilo–Anderson type 1, 2 and 3A) treated at two different hospitals, where the admitting hospital dictated the treatment option selected. Both hospitals are leading academic institutions in South Africa, and are the major trauma referral centres for the greater Johannesburg region. The charts and radiographs of all patients with an open fracture of the tibia were reviewed, amongst those patients treated at either Johannesburg Hospital or Helen Josef Hospital between January 1998 and December 1999. The following conditions were specified as exclusion criteria: grade 3B and 3C fractures, polytrauma and associated injuries, significant unrelated co-morbid conditions, a history of surgery within the 6 months prior to admission, delayed presentation of >24 h, and admission to the Intensive Care Unit. The treatment at Johannesburg Hospital (group I) followed the current accepted standard, and consisted of early surgical debridement, intravenous antibiotics (cefazolin 1 g tid), and stabilization in a plaster splint. The wound was initially left open, and a repeat debridement was performed at a minimum of 48 h after the first surgical debridement. At the time of repeat debridement the wound was closed secondarily if possible, and an unreamed AO tibial nail was inserted for fracture stabilization. At Helen Josef Hospital (group II) the fracture was stabilized with an unreamed AO tibial nail after initial debridement and primary wound closure. Intravenous antibiotics were commenced in the emergency room and continued 72 h post surgery. Clinical criteria for establishing a diagnosis of infection included new onset of pain located at the level of the fracture, at the nail insertion site, at the locking screws or along the entire tibia. Fever, night sweats, tachycardia, or chills were additional symptoms looked for on review of the medical records. The presence of localized swelling, erythema, tenderness and sinuses or drainage was evaluated. Radiographs were analysed for early signs of infection, such as lucency around the nail or locking screws, subtle loss of cortical density at the fracture site, endosteal lysis, or periosteal reaction suggesting early evidence of deep infection. Final radiographs were reviewed for signs of established osteomyelitis, such as sequestra or involucrum formation suggesting chronic infection. All patients included in the study were followed up for a minimum of 12 months at the time of review.

Descriptive statistics for infection rates between the two treatment groups were calculated. Chi-square analyses were then used to compare the frequency of

infection between groups I and II. A level of significance $P < 0.05$ was selected to limit the chance of type I error to 5%. Analyses were conducted using statistical package, SPSS version 12.0 (SPSS for Windows, SPSS Inc., Chicago, IL, USA).

Results

During the specified 2 year period, 49 open fractures were seen at Johannesburg Hospital (group I). At Helen Josef Hospital (group II), 46 open fractures were admitted. The group I cohort included 49 patients (36 males, 13 females) with a mean age of 33.4 (18–69). There were 19 grade 1 open injuries, 19 grade 2 open and 3 grade 3A open; 8 were gunshot fractures (Table 1). The group II cohort included 46 patients (38 males, 8 females) with a mean age of 30.2 years (16–56). There were 19 grade 1 open injuries, 16 grade 2 open and 4 grade 3A open; 7 were gunshot fractures to the shaft of the tibia. The mean follow up in group I was 13.5 months (12–18), and in group II was 13.7 months (12–16). The average time from admission to surgical debridement in group I was 5.4 h (1–17). Final wound closure and fixation was performed 9.3 days (1.5–37) after the initial debridement. The mean operating time at surgical debridement was 67 min (25–150), and 96 min (45–180) at the time of final fixation and delayed wound closure. In group II the average time from admission to surgical debridement, definitive fixation and primary wound closure was 7.2 h (0.5–20). The mean total operating time was 101 min (40–170). The hospital stay in group I was 15.4 days (4–52), and in group II was 8.6 days (3–20) (Table 2). There was one infection in group I (2%) and there were two infections in group II (4%) (Table 3).

Further analysis was undertaken of the infected cases, to determine if they had any common characteristics or diverged from the standard treatment protocols. In group I was a 33-year-old female with a grade 1 open

oblique tibial mid-diaphyseal fracture, and her time from admission to debridement was only 12 h. However, it was not until 30 days before final wound closure and fixation with an unreamed tibial nail. This specific case was admitted during the closure of a third local trauma centre, probably contributing to the long waiting period due to an overflow of acute trauma cases. Earlier fixation and wound closure may have prevented subsequent infection. In group II, one infected case involved a 20-year-old male with a grade 2 open mid-diaphyseal fracture. The time from admission to debridement, wound closure and fixation was 20 h. Unfortunately, the patient received only three doses of a first generation cephalosporin (cefazolin) post operative. The cause for infection in this case was possibly inadequate antibiotic coverage as well as the delay to surgery. Infection may have been avoided with more timely operative intervention and adequate antibiotic cover. The other infected case in group II involved a 24-year-old male with a grade 3A open comminuted midshaft fracture sustained in a motor vehicle accident. The time from admission to operation was only 4 h. His treatment consisted of early debridement, administration of intravenous antibiotics (cefazolin) for 72 h, primary stabilization with an AO unreamed tibial nail, and primary wound closure, adhering to the protocol. Two of the infected cases clearly varied significantly from the established treatment protocols, and could therefore be excluded. However, as these were the cases of most interest here, they obviously could not reasonably be discounted completely. If these outliers are excluded, the corrected infection rate in group I was therefore 0% and in group II was 2%. As noted above, even without excluding these two cases the infection rate was still only 2% in group I and 4% in group II.

Discussion

The standard treatment of open tibial fractures has undergone several changes over the last 20 years. Prompt assessment in the emergency room, early aggressive soft-tissue and bone debridement, high volume pulsatile lavage, and the administration of intravenous antibiotics are all widely accepted aspects of care [5, 6, 8, 11, 13, 15, 25, 27, 33, 36]. Based on prior experience in military trauma, many authors have recommended the wound initially be left open. If necessary, serial debridements are performed until the wound is clean, and the wound is then closed in a delayed setting. When closure with normal suturing techniques cannot be achieved without excessive tension on the wound margins, several authors have suggested other methods to allow gradual closure as local oedema

Table 1 Demographics of patients included in the study: group I Johannesburg Hospital (JBH); group II Helen Josef Hospital (HJH)

	JBH	HJH
Open fractures	49	46
Grade 1	19	19
Grade 2	19	16
Grade 3A	3	4
Gunshot fractures	8	7
Sex m/f	36/13	38/8
Age	18–69	16–56
Mean age	33.4	30.2

Table 2 Comparison of time to admission, operating time and hospital stay

	JHB	HJH
Average admission to debridement	5.4 h (1–17)	7.2 h (0.5–20)
Average debridement to fixation and closure	9.3 days (1.5–37)	
Average OP time debridement	67 min (25–150)	
Average Op time debridement, fixation and closure	96 min (45–180)	101 min (40–170)
Average hospital stay	15.4 days (4–52)	8.6 days (3–20)

Table 3 Incidence of infection

	JHB	HJH
Open fractures	49	46
Infection	1	2
Grade 1	1	–
Grade 2	–	–
Grade 3A	–	1
Gunshot fractures	–	1

resolves [3, 4, 29]. Delayed wound closure or soft tissue coverage with local or distant flaps has proven highly effective [14, 17, 25, 39], and is believed to minimize the risk of late deep infection. This treatment protocol results in an overall infection rate between 3 and 5% for all open tibial fractures [9, 14]. The risk of infection with open fractures is clearly related to the severity of the associated soft tissue injury; Gustilo–Anderson grade 2 fractures have a reported incidence of infection of as much as 10%, while grade 3 fractures have the highest reported rate of infection, as great as 20% [23]. Confounding variables such as smoking [1], type of fixation [2, 5, 7, 15, 17, 35], and vascularity [12] are believed to further influence both the infection rate and time to union.

Heitmann et al. [20] reported 64% of all open tibial fractures are contaminated on presentation in the emergency room. Faisham et al. [13] have independently confirmed this, with a reported contamination rate of 60% on admission. Robson et al. [31] demonstrated virtually all open fractures are contaminated to some degree, and introduced the concept of the “Golden Period of Opportunity”, referring to the initial 4–12 h period following the injury. Wound infections generally occur when bacterial counts exceed 10^5 on an initial swab taken during this early period. However, rarely are the organisms cultured prior to debridement responsible for documented subsequent deep infection [13, 25, 30]. Many of the organisms that cause deep infection are either enteric or nosocomial flora. The majority of those organisms responsible demonstrate multiple antibiotic resistance, and are typically acquired during the period of initial hospitalisation [13].

There are, therefore, at least two potential advantages of primary wound closure that should be clearly stated. The first would be the ability to minimize the risk of nosocomial infection related to open wound management prior to delayed closure. The second advantage would be a reduction in the length of stay associated with these injuries, presumably leading to a secondary reduction in the overall cost of treatment. Although we have no specific data related to costs incurred, the length of stay in group II (primary closure) was only 9 days, compared to 15 days for group I (delayed closure) (Table 2). This represents a 40% reduction in the length of stay, and independent samples *t*-test revealed that this difference was statistically significant ($P < 0.05$).

Osterman et al. [27] treated 1,085 open fractures using early wound closure when possible. Wounds were either closed early (within 7 days), or delayed (average 18 days). Although the design of this study suggests an obvious selection bias, their reported infection rate was significantly lower in the early closure group. This result is consistent with other studies discussing the general advantages associated with early soft tissue coverage of open fractures [8, 39]. Early closure of open fracture wounds is further supported by Henley et al. [21], who demonstrated a higher incidence of wound infection when soft tissue coverage is delayed. They reported an infection rate of only 6% if soft tissues were closed in less than 72 h, but this rose to 30% if coverage was delayed beyond that point. Unfortunately, this study was again complicated by the possibility of selection bias reflecting the complex nature of decision making associated with the treatment of open fracture wounds.

Early soft tissue coverage is now generally believed [8, 19, 20, 26] to limit the risk of subsequent deep infection after open fracture, but the central issue here concerns immediate, primary closure. Very early wound closure is not a radical or new concept in trauma surgery. As early as 1947, Davis [10] described his success with the use of penicillin, blood transfusion, radical debridement and primary wound closure, reporting a significant reduction in the infection rate. Established

criteria for primary closure include complete debridement of all necrotic and foreign material, normal perfusion, intact sensation, and that local conditions allow tension free wound apposition [2, 22, 24, 25, 35]. Regardless, optimal timing for wound closure remains controversial. Advocates for delayed closure [14, 39] cite the need for a repeat debridement 48 h later, as the wound may deteriorate. Advocates of primary closure [22, 28] argue it is the most effective means of preventing secondary contamination with nosocomial organisms, the most frequent source of late infection. Considering the published literature [4, 13, 19, 25, 28, 29, 30], the wisdom of mandatory delayed closure for low energy, minimally contaminated open tibial fractures can legitimately be reconsidered.

There is by no means universal agreement regarding the potential advantages of primary wound closure [13, 38], although it has been a topic of prolonged debate. DeLong et al. [11] compared primary versus delayed wound closure in 119 open fractures, and could not demonstrate a significant difference in rates of either infection or union. A direct comparison between delayed and primary closure by Russel et al. [33] in 207 open tibial fractures demonstrated no significant difference between the two groups. Templeman et al. [37] treated 82 open fractures, comparing primary to delayed wound closure, also monitoring infection as the principle outcome measure. Consistent with our results, they also concluded primary wound closure following thorough debridement is a safe treatment option for uncomplicated open fractures.

In the present study almost all open tibia fractures were included and considered equally, excluding only the highest grades of associated soft tissue injury (grades 3B and 3C). To our knowledge there is no published literature documenting significant clinical inconsistency when distinguishing open from closed fractures. Therefore, the open fracture grading scheme is in itself of little consequence with respect to these results. Furthermore, we have excluded polytrauma patients, as well as those with unrelated co-morbid conditions and other confounding variables. These patients sustained a significant, but isolated, injury to the involved limb. This was done specifically to limit the possible selection bias inherent when simultaneously balancing acute trauma care against the role of early soft tissue management and wound closure.

This study was, admittedly, limited in scope and design. The data was gathered retrospectively from two independent case series at different, but similar, institutions. The two groups were not formally randomised, nor were they matched for age or gender. However, the cohorts were drawn from a common population within

one large city, and the demographics of the two groups are remarkably similar (Table 1). There is no significant element of selection bias, as all patients at a given institution were managed according to a single treatment protocol. Randomization effectively occurred prior to presentation in the emergency department. Different surgical teams with different mixes of experience may contribute to potential treatment bias. However, given that patients were treated by different surgeons with a wide range of experience in our opinion reinforces the belief that surgical debridement technique does not seem to contribute to the outcome of treatment in both groups. This would appear to be valid provided basic principles as excision of dead and devitalised tissue, tension free wound closure were followed. Patients were only reviewed clinically if the chart demonstrated evidence of wound infection or radiographs were suspicious of infection. When the records did not demonstrate any signs of wound breakdown, discharge, or erythema, and if the radiographs did not demonstrate signs of infection, it was assumed no infections occurred during the 12 month follow-up period.

It should be intuitively obvious to that chi-square analysis demonstrated no significant difference ($P < 0.05$) in infection rates between these two treatment groups, consistent with our stated null hypothesis. Considering the relatively small number of patients involved, it would be reasonable to question the power of this study to distinguish a true difference between the groups. It is certainly possible the data considered here provides a type I error, failing to distinguish a true difference and instead falsely supporting the null hypothesis. Given the 2% difference in infection rates between the two treatment groups in our limited series, one can readily calculate the number of patients necessary to adequately exclude this possibility. With 80% power and an alpha level error of 5%, 40 patients in each group are needed to detect greater than the clinically significant difference in infection rates (2%) between subject groups. Our study cohort exceeds that number and therefore add adequate power to exclude that possibility.

It is unlikely presentations of late infection were missed, as Rommens et al. [32] has previously demonstrated. In their study, open fractures developed deep infections at an average of 4.8 months, and no later than 12 months after surgery.

The merit of our study principally lies in determining if there is any significant disadvantage to primary wound closure in the management of a very specific and well-defined subset of open fractures. The results of our data have convincingly failed to refute our null hypothesis. Therefore, we believe there is little, if any, difference in rates of infection following either delayed

or primary closure of isolated, low energy, uncomplicated open fracture wounds.

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