

## WAYS TO PREVENT INFECTION AFTER OPEN FRACTURE OF THE LOWER LIMB

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### Abstract

**Background and aims.** Despite the great effectiveness of antibiotics, no principle is more important in the care of open fractures than aggressive irrigation and debridement. Fixation of open fractures has a number of beneficial effects, including even the reduction of the risk of infection.

**Materials and Methods.** This prospective study of the treatment of 116 open fractures of the lower limb offered us the possibility to determine the ways to prevent the infection. All the patients were studied prospectively and the type of treatment and the rate of infection were evaluated.

**Results.** In the course of the treatment, 96 wounds were closed by primary closure (82.8%) and 2 wounds were closed by secondary closure on the 5<sup>th</sup> postoperative day (1.7%). There were 14 skin grafts (12.1%), 2 muscle flap closures (1.7%) and 2 healings by granulation (1.7%). The antibiotics used were ceftriaxone + gentamycin for type I, II fractures; metronidazole was added for type III fractures. The duration of the antibiotic therapy was 7-10 days, according to the severity of the fracture. The infection rate was 0% for type I, 0% for type II and 5.17% for type III fractures (6/116).

**Conclusions.** The treatment of open fractures by intensive debridement of the wound and immediate fixation, as well as by primary closure of the wound with prolonged use of antibiotics, led to a dramatic decrease of the rate of infections.

**Keywords:** open fracture, infection, primary closure of the skin, antibiotics.

### Introduction

One hundred and fifty years ago, mortality was common following open fractures [1,2]. Along with the advances in modern therapy however, the expected outcome has improved significantly.

Antibiotics have been considered as standard therapy since 1947. Patzakis et al reported their seminal randomized, controlled trial of cephalothin, a first generation cephalosporin for the management of open fractures [3]. In the past, cultures were routinely done before and after debridement of open fractures. Recent studies show that cultures of the wound specimen often fail to identify the organisms that subsequently cause the infection [4,5]. In fact, there is evidence that most infections at the site of open fractures are caused by nosocomial bacteria [6].

Despite the great effectiveness of antibiotics, no principle is more important in the care of open fractures than aggressive irrigation and debridement. Penetration of antibiotics into the necrotic tissue is still under investigation.

Theories range from decreased penetration secondary to an interruption in the blood supply to an increased penetration related to local inflammatory mediators [7,8].

Fixation of open fractures has a number of beneficial effects, including protection of soft tissues from additional injury by fracture fragments, improvement of wound care and tissue healing, promotion of mobilization and rehabilitation and possibly even the reduction of the risk of infection [9].

In the multiply injured patient fractures, fixation also reduces the risk of acute respiratory distress by claiming the systemic inflammatory response [3].

### Materials and Methods

Between January 2007 and January 2010, 108 patients with open fractures of the lower limb were admitted and treated in Alsafwa Hospital in Taiz - Yemen. All the patients were studied prospectively to evaluate the type of treatment and the rate of infection.

The average age of the patients was 28.11 years, in a range of 6-65 years; 98 patients were males (90.7%) and 10 patients were females (9.3%); 36 patients had

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open fractures of the femur shaft (33.3%), 70 patients had tibia fractures (64.8%) and 2 patients had open calcaneal fractures with Achilles tendon rupture (1.9%). Regarding the cause of the fracture, 40 patients had suffered car accidents (37%), 20 had fallen from a height (18.3%), 14 had suffered motorcycle accidents (12%), 4 had suffered industrial injuries (3.7%), 14 had suffered motorcycle collisions against pedestrians (13%), 2 patients had been struck by stones (1.9%) and 14 had suffered gun shots (13%).

The open fractures were classified according to the Gustilo-Anderson classification of open fractures – of the 116 open fractures in 108 patients, 20 open fractures were type I (17.2%), 32 were type II (27.6%), 20 were type IIIA (17.2%), 30 fractures were type IIIB (17.2%) and 14 fractures were type IIIC (12.1%).

The average time of fracture healing was 9.44 months, with a range of 3-18 months, standard deviation 3.2.

Ninety-six wounds were closed by primary closure (82.8%) and 2 wounds were closed by secondary closure, on the 5<sup>th</sup> postoperative day (1.7%). There were 14 skin grafts (12.1%), 2 muscle flaps (1.7%) and 2 healings by granulation (1.7%).

Time of debridement of the wound: 84 open fractures before 6 hours (72.4%) and 32 open fractures after 6 hours (27.6%), depending on the time of arrival of the patients to the hospital.

All the fractures were thoroughly irrigated and debrided in the operating room with the protocol from table I.

**Table I.** Irrigation volume of the wound in terms of wound classification.

Gustilo-Anderson Classification	Irrigation volume / additives
I	3L Normal saline with liquid soap additive
II	6L Normal saline with liquid soap additive
III A,B,C	9L Normal saline with liquid soap additive Local antibiotics for highly contaminated wounds, gentamycin in irrigation solution

The antibiotics we used were ceftriaxone + gentamycin for type I and type II fractures, and intravenous metronidazole added for type III fractures. The duration of antibiotic administration was for 7 to 10 days, according to the severity of the wound.

Prophylaxis against tetanus was also administered.

After resuscitation, irrigation and debridement, if the wound could be converted to a clean wound and if no soft tissue procedure was needed, immediate fixation of the fracture and primary closure of the wound was performed. If soft tissue procedure (skin graft or flap) was needed, a delayed closure of the wound (within 3-5 days) was performed. In rare cases (2 patients), the wounds were left to heal by secondary intention (granulation).

Out of 36 open femoral shaft fractures, 12 fractures were fixed by plates and screws (33.3%), 12 fractures were fixed with reamed intramedullary nails (33.3%) and 2 fractures with unreamed nails (5.6%), 8 fractures were fixed with external fixators (22.2%) and 2 cases of open fractures of femur medial condyle were fixed with 2 cancellous screws.

As regards open leg fractures, 42 were open fractures of tibia shaft. From these, 20 fractures were fixed by plates and screws (47.6%), 6 fractures were fixed with POP casts (14.2%), 2 fractures were fixed with unreamed intramedullary nails (4.8%) and 14 fractures were fixed with external fixators (33.3%).

Out of 36 open fractures of the tibia and fibula, 2 fractures were fixed with plates (5.61%), 6 fractures were fixed with unreamed intramedullary nails (16.7%) and 28 fractures were fixed with external fixators (77.8%).

As regards foot fractures, we had two open calcaneum fractures of type IIIB according to Gustilo classification, with Achilles tendon rupture. Each fracture was fixed with two k-wires.

## Results

Ninety-six wounds were closed by primary closure (81.8%) (Table II). They included 36 wounds of open femoral shaft fractures (type I, II, IIIA, IIIB, IIIC), 58 wounds of open tibial shaft fractures (type I, II, IIIA, IIIB, IIIC) (fig. 1 and 2) and 2 open calcaneal fractures of type III. The wounds of primary closure were healed within 2 weeks.



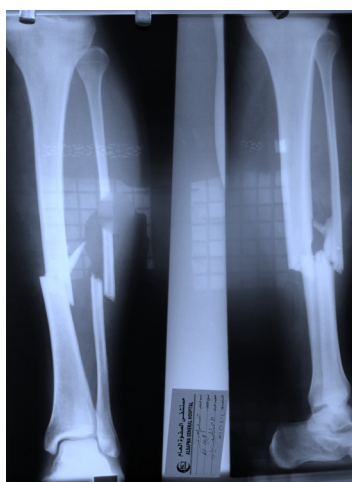
**Figure 1A.** Open fracture of the tibia, type II.



**Figure 1B.** Open fracture of the tibia, type II, with fixation with unreamed intramedullary nail and primary closure.



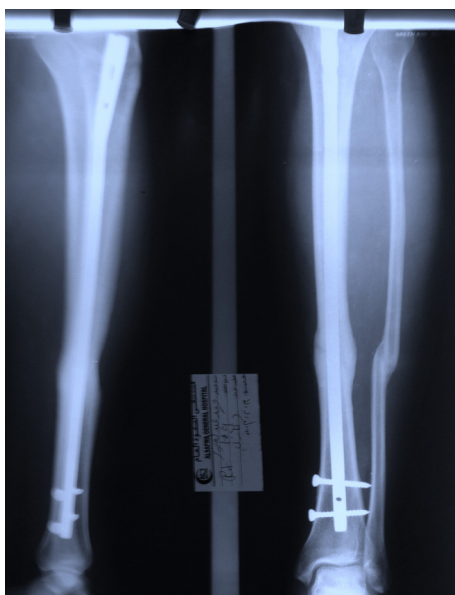
**Figure 2A.** Open fracture of the tibia, type IIIB.



**Figure 1C.** X-rays of the open fracture of the tibia.



**Figure 2B.** Open fracture of the tibia, type IIIB, with fixation with external fixator and primary closure of the skin.



**Figure 1D.** Open fracture of the tibia, type II, with primary closure and fixation with unreamed intramedullary nail, X-rays after bone union.

Two wounds of tibial shaft fracture of type II were healed by secondary wound closure within 3-5 days postoperatively (1.7%).

Two wounds of tibial shaft of type II were healed by granulation (1.7%), 14 wounds needed skin graft (12.1%) and 2 needed flap wound closure.

**Table II.** Methods of wound closure used in our cases.

	Frequency	Percentage
Primary	96	82.8
Secondary	2	1.7
Skin graft	14	12.1
Granulation	2	1.7
Flap	2	1.7
<b>Total</b>	<b>116</b>	<b>100</b>

### Infection

Six fractures had infections – four pin tract infections (3.44%) and two deep infections (1.7%), but neither of them progressed to osteomyelitis.



## Discussion

The rate of infection of open fractures is associated with the fracture characteristics, antibiotics therapy and host parameters [10,11]. The infection risks differ by the type of fracture and they have been reported to be ranging from 0 to 2% for type I fractures, from 2 to 10% for type II fractures and from 10 to 50% for type III fractures [12,13].

More recent studies have shown that the rate of clinical infection increased to 1.4% (7/497) for type I fractures, 3.5% (25/695) for type II fractures and to 22.7% (45/198) for type III fractures [10].

In our series, the rate of infection was 0% for type I fractures, 0% for type II fractures and 5.17% for type III fractures (6/116). The prevalence of infection associated with open fractures of the tibia has been reported to be 10-20 times greater than that associated with other skeletal injury. This coincides with our results, 66.6% of infections occurred in open fractures of the tibia (2 pin infections of the external fixator in femoral open fracture and 4 infections in tibial open fractures, from which 2 pin infections and 2 deep infections).

Historically, the closure of open fracture wounds was delayed in order to prevent infection with clostridium and other contaminating organisms. While this strategy remains the generally accepted approach in settings characterized by substantial contamination (such as barnyard and battle field), many surgeons have begun to consider earlier closure of open fractures wounds that have been adequately debrided. Recently, a number of authors have investigated the feasibility of primary closure. In a study of 119 open fractures, De Long et al. did not find immediate closure (within twenty-four hours) to be associated with a higher rate of infection or non-union as compared with delayed closure (after more than 24 hours) [15]. In a double blind prospective study, Benson et al. [16] assessed the benefit of delaying primary closure of the wound associated with open fractures. Eighty-two fractures were divided into groups of primary closure (44 wounds) and delayed closure (38 wounds), on average 5 days after injury. Only 3 superficial wound infections were reported, having occurred in the primary closure wounds. Finally, Hertel et al. [17] performed a retrospective study of 29 open tibial fractures of type IIIA and type IIIB and found that immediate coverage was associated with a lower rate of infection: 0% (zero of 14), as compared with 27% (4 of 15) after late coverage.

These results were similar to our results, where 96 open fractures wounds were closed primarily after thorough debridement. The infection rate was 0% in type I, 0% in type II, 2.08% in type IIIA (2 pin infection /96 cases), 0% in type IIIB, 0% in type IIIC. In the delayed closure of the wound (20 cases) the infection rate was 0% in type I, II and IIIA, and 2.08% in each type IIIB and IIIC.

We believe that our results support the performance of primary closure of the wound of open fractures, where adequate debridement can be applied. The low rate

of infection in our results may be due to the thorough debridement, the early closure of the wound and to the long duration of antibiotic therapy.

While there is ample evidence supporting the administration of antibiotics in open fractures, there is however a lack of evidence indicating an optimal regimen – whereas some authors recommend the treatment of all open fractures with a combination of a first generation cephalosporin for type I and type II fractures [3], most agree that penicillin or ampicillin should be added when there is a high risk of anaerobic infection. The optimal duration of antibiotic administration is less clear. Many authors recommend an initial three-day course supplemented by an additional three-day course at the time of any subsequent procedures [18].

In our series we used ceftriaxone + gentamycin for type I and type II fractures and intravenous metronidazole added for type III fractures; the duration of antibiotic administration was from seven to ten days, according to the severity of the fracture.

## Conclusion

The treatment of open fractures by intensive debridement of the wound and immediate fixation, as well as by primary closure of the wound with prolonged use of antibiotics, seven to ten days, led to a dramatic decrease of the rate of infections.

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