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How debridement, definitive fixation and final coverage determine the infection rate in grade III B open fractures of long bones managed with primary internal fixation

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How debridement, definitive fixation and final coverage determine the infection rate in grade III B open fractures of long bones managed with primary internal fixation

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Abstract

The management of grade III open fractures remains controversial. While the time tested external fixators have their advantages of ease of application and facilitating repeated debridements in extensive uncovered open wounds, their use has been marred with pin tract infections, delayed union, non-union, joint stiffness and patient discomfort. Advantages of internal fixation include access for soft tissue care, secure control of alignment and rotation and early weight bearing. But surgeons have feared using internal fixators in grade III open wounds for the risk of deep infection. With lack of adequate data regarding time to first debridement, number of debridements, time to definitive fixation, mode of final coverage and time to coverage affecting the final infection rate, this study plans to study these variables in the use of internal fixation in grade III B open fractures of long bones.

Introduction

In past decades open fractures often resulted in loss of life and/or loss of limb[1]. Tscherne has described the four major eras in the treatment of open fractures: the era of life preservation, the era of limb preservation, the era of avoidance of infection, and the era of the preservation of function[2]. In the past two decades, because of advances in fracture care, most of the effort in managing open fractures has been devoted to the preservation of function. Management of grade III open fractures continues to be a major therapeutic problem. The rates of infection and nonunion are higher in Gustilo type IIIB than in types I, II, and IIIA open fractures.[3] There is excessive wound contamination, bone comminution or skin loss often associated with a nerve or tendon injury. There is increased risk of infection as bone communicates with outside. Union is often delayed due to bone loss causing long treatment duration and high costs[3].

To prevent complications, various treatment regimens have been developed, including acute delivery of intravenous antibiotics, repeated radical debridement followed by early local or free flap closure, [4] rigid stabilization with external fixation[5] or interlocking unreamed nailing, [6] and prophylactic bone grafting.[7]

The advantages of internal fixation include high patient acceptance, cosmesis, access for soft tissue care, secure control of alignment and rotation, early mobilization, and the potential for biomechanically safe early weight bearing.[8] Over the past 5 decades, improved metallurgy, surgical techniques, antibiotic therapy, and understanding of the pathophysiology of infection have led to the wide-spread use of immediate internal fixation of open fractures.[9] Several sentinel works have demonstrated acceptable infection rates.[10]

The primary focus of selection of skeletal fixation methods involves avoiding infection. For many years the concept of immediate application of internal fixation implants for open fracture stabilization was strongly discouraged.[11] The presence of metal within a wound is a foreign body that is a potential substrate for biofilm formation, with a theoretical increased risk for acute infection.[9] Additionally, the potential bone devitalisation required to apply an extra medullary implant was thought to contribute to development of infection. There remains fear of implanting metal in a contaminated field leading to intramedullary deep infection in massively contaminated wounds where inadequate debridement may further increase the risk[12]. Several decades ago traditional teaching was that intramedullary nailing, particularly with associated reaming, significantly damaged the osseous blood supply, and was ill-advised in open fractures.[13]

Still the issue of primary internal fixation in grade 3B open fractures is controversial. Since Davis[14] performed the first immediate internal fixation following timely initial debridement of open fractures in 1948, many surgeons[8]have reported the utility of immediate internal fixation. However the degree of severity of open fractures and type of wound to which these procedures can be applied is still unclear.

Emergency operative treatment has long been the standard of care for open fractures. The origin of the

so-called “six-hour rule” is unclear, however. Some believe that it stems from an 1898 experiment by **Friedrich**, in which guinea pigs with contaminated soft-tissue wounds had lower rates of infection when debridement was performed within six hours[15]. In 1973, in a study by **Robson et al**., who reported that 10^5 organisms per gram of tissue was the open-fracture infection threshold, which was reached in an average of 5.17 hours[16].To date, two studies have shown a decreased rate of infection when debridement is performed within six hours[17]. A number of studies have called the “six-hour rule” into question[18]. A few authors have gone so far as to suggest that operative debridement might not be necessary for low-grade open fractures. In contrast, it is not possible at this point in time to argue for or against a firm “six-hour rule” in the management of open fractures. In the prevention of infection after open fracture, the time from injury to debridement is probably less important than other factors, such as the adequacy of debridement and the timeliness of soft-tissue coverage. Patients with an open fracture should be taken to the operating room on an urgent basis, with the stability of the patient, the preparation of the operating room, and the availability of appropriate assistance (including orthopedic-trained scrub personnel, assistant surgeons, radiography technicians, and other operating- room personnel) taken into account.

Historically, the closure of open fracture wounds has been delayed 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 the barnyard and the battlefield), many orthopedic surgeons practicing in the developed world have begun to consider earlier closure of open fracture wounds that have been adequately debrided. In this setting, where nosocomial organisms have emerged as the main source of open- fracture infections, several studies have documented significantly better outcomes with early closure (within seven days) than with late closure ($p < 0.05$)[19]. Also, a number of studies have demonstrated excellent outcomes with closure performed within three days after injury [20]. Recently, a number of authors have investigated the feasibility of immediate closure (within twenty-four hours after injury). Of note, the trend toward early closure of open fractures conflicts with recommendations for routine debridement of open fractures[21]. While the goal is thorough debridement at the time of the initial presentation, it is possible that polytrauma or other concerns may cause the surgeon to doubt the adequacy of the initial debridement. In addition, it may be difficult to evaluate muscle viability in the acute setting. In these instances, repeat debridement is certainly appropriate. There are a number of methods for achieving closure, including direct suturing, split-thickness skin-grafting, and use of free or local muscle flaps. The optimal method depends on a number of factors, including the location of the defect, its size, associated injuries, and patient characteristics such as the amount of function retained and the desired level of function.

We still do not know for sure how safely can the first debridement be delayed, what is the minimum number of debridements required, how much can the definitive fixation can be delayed, what coverage method is best and for how long to leave the wound open. With lack of adequate studies this study might throw some light on the role of primary internal fixation in grade III B open fractures of long bones especially relating to variables like debridement, definitive fixation and coverage.

Materials and Methods

This study was an uncontrolled interventional study. It was a one year prospective study involving 34 patients with Grade III B Open diaphyseal fractures of long bones including humerus, forearm bones, femur and tibia with or without fibula. The minimum period of follow up was nine months. Patients were evaluated both subjectively and objectively.

A standard treatment protocol was followed. The life-saving assessment and resuscitation of severely injured patients was undertaken first. The involved limb was then examined with careful neurologic and vascular assessment and calculation of MESS score. Early first dose antibiotic was given in the casualty itself. A third generation cephalosporin like Cefperazone/Sulbactum (1.5g q8h) with amikacin (750mg OD) and metronidazole (500 mg q8h) or a combination of Piperacillin /Tazobactum (4.5g q8h) was used.

Tetanus toxoid and tetanus immune globulin according to immunization status and contamination of wound was also given preoperatively. The wound was washed with copious amount of saline and a sterile dressing applied after taking adequate pictures of the wound. Plastic surgery consult was taken for coverage and where ever vascularity was in doubt. The fracture was splinted and adequate x-rays done. The patient was taken to the OT on an urgent basis but not always necessarily within the so called golden period of 6 hours because of the usual delays. In the OR the wound was first washed with copious amount of saline.

Minimum 9 liters of normal saline was used. Either bulb syringes or sometimes pulse lavage was used where deep seated dirt or grit was suspected. No additives were used. Then the wound was adequately debrided. All dead and damaged tissues and foreign bodies were removed.

When the wound looked appreciably clean the limb was redraped and painted. All the fractures were internally fixed in the primary sitting either with a plate or a nail. Diaphyseal fractures usually require relative stability to heal and healing by secondary intention is found to be stronger. So most commonly a plate in a bridge mode or an interlocking nail was used. Both reamed and unreamed nails were used to stabilize the fractures. If the wound looked adequately clean and margins opposable it was closed in the primary sitting. If it was felt that the wound will need further debridements before final closure, it was either dressed or preferably a negative pressure dressing was applied. Patient was taken for a redebridement usually within 48-72 hours. Deep tissue cultures were taken after each wash and debridement. When the wound looked clean enough and the last cultures came out to be negative the wound was either closed or covered with a split thickness skin graft if adequate granulation tissue was present or covered with a local fasciocutaneous or a muscle flap.

Wounds were covered at the earliest, but where ever delay was anticipated because of unhealthy condition of the wound or doubtful vascularity or absence of granulation tissue preferably a VAC dressing was applied. VAC dressings were changed in 4-5 days till adequate granulation had appeared which took on an average around 3-4 dressings. IV Antibiotics were continued for 72 hours after the initial procedure and for 48 hours after each additional procedure and were continued till 3 days after wound coverage or closure. Post op immediate joint ROM and strengthening exercises were started. NWB gait training was also started immediately once the wounds were covered. PWB was started usually around 6 weeks when a good soft callus had well formed. FWB was started usually around 3 months when at least 3 cortices had united in 2 views. Follow up with clinical and radiological assessment was obtained at immediately post op, at discharge, at 3 weeks, 6 weeks, 3 months, 6 months and 9 months.

Observations, Results and Analysis

34 diaphyseal fractures of long bones were fixed primarily within 24 hours of presentation. Leg bone fractures were most common (16 cases or 47.06%). Mean age was 31.62 years. 94.12 % of patients were males. Road traffic accidents (52.94%) was the most common mode of injury. 52.94% patients presented within 6 hours and antibiotics were also started within 6 hours. Mean time to presentation was 8 hours and the Range was 2-20 hours. 20.62% cases had a MESS score of 2. None had a score of 7 or more. Mean MESS score was 3.17 and the Range was 2-6. 61. 76% fractures were fixed with a nail. 38.24% fractures were fixed with a plate. The single case of humerus was fixed with a locked plate. 46.67% of forearm fractures were fixed with a LC-DCP. 26.67% forearm fractures were fixed with a TENS nail. Both the femur fractures were fixed with a reamed hollow nail. 43.75% of tibia fractures were fixed with an unreamed solid nail. 37.5% of tibia fractures were fixed with a reamed cannulated nail. In 38.24% of the cases time to first debridement was less than 6 hours. Mean was 10.21 hours and the Range was 4-22 hours. In 41.18 % of cases total number of debridements before closure was three. Mean was 2.65 and the Range was 1-7. In 47.06% of the cases time to definitive fixation was 12-24 hours. Mean was 11.21 hours and the Range was 5-23 hours. 35.29% received a split thickness skin graft for wound coverage. 29.41% wounds were managed with a delayed primary closure. 64.71% of wounds were covered only after 72 hours. Average time to coverage was 7.1 days. Range was 7 hours to 2 months. Single case of Deep infection was found when MESS score was 6. No statistical correlation could be found between time to 1st debridement and infections but infection percentage was more in 12-24 hr. group than less than 6 hr. group. The time to definitive fixation also did not matter when it remained any value less than 24 hours. Where the wound needed a STSG or flap coverage, infection rates were found to be higher. Highest infection rate was seen when the wound had to be covered with a flap. One case of deep infection occurred when time to coverage was 5 days. But no statistical correlation could be proven between time to coverage and infection rate.

Recommendations from this study

An early but adequate rather radical first debridement should be the aim which need not necessarily be within the so called golden period of 6 hours. Relative but stable fixation with a bridge locked plate or a locking nail after limited reaming should be ideally

done. Reaming has advantages of stimulating periosteal blood flow and better stability as a wider nail can be put. Don't damage or strip the already compromised soft tissues any further. Wound can be closed primarily if it is relatively clean and margins could be approximated. Serial debridements at 24-48 hours need to be done if required. Cover preferably with VAC therapy till closure or coverage. Can change in 4-5 days if wound is clean. Wound coverage needs to be achieved preferably within 72 hours but not more than 5-7 days which decreases infection, promotes early union and decreases rate of secondary procedures like bone grafting.

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Illustrations

Illustration 1

Tables

Table: 1 Number

Bones	Number	%
Humerus	1	2.94
Forearm	15	44.12
Femur	2	5.88
Leg	16	47.06
Total	34	

Table: 2 Mode of Injury

Bones	Assault	Fall	Farming	Industrial	RTA	Total
Humerus	0	0	0	0	1	1
Forearm	6	1	2	4	2	15
Femur	0	0	0	0	2	2
Leg	1	0	0	2	13	16
Total	7	1	2	6	18	
%	20.59	2.94	5.88	17.65	52.94	

P value 0.11

Table: 3 MESS Score

Bones	2	3	4	5	6	7 or more	Total
Humerus	1	0	0	0	0	0	1
Forearm	6	4	2	3	0	0	15
Femur	1	1	0	0	0	0	2
Leg	5	4	4	2	1	0	16
Total	13	9	6	5	1	0	
%	20.62 %	14.27 %	9.51 %	7.93 %	1.59 %	0.00%	

P value 0.96

Table: 4 Fracture Fixation

Bones	Nailing	Plating	Total
Humerus	0	1	1
Forearm	6	9	15
Femur	2	0	2
Leg	13	3	16
Total	21	13	
%	61.76	38.24	

P value 0.04 (Significant)

Table: 5 Time to 1st debridement

Bones	less than 6hr.	6-12 hr.	12-24 hr.	Total
Humerus	0	1	0	1
Forearm	9	4	2	15
Femur	0	1	1	2
Leg	4	5	7	16
Total	13	11	10	
%	38.24	32.35	29.41	

P value 0.20

Table: 6 Number of debridements

Bones	1	2	3	4	5	6	7	Total
Humerus	0	0	1	0	0	0	0	1
Forearm	3	6	3	3	0	0	0	15
Femur	0	0	2	0	0	0	0	2
Leg	2	4	8	1	0	0	1	16
Total	5	10	14	4	0	0	1	
%	14.71	29.41	41.18	11.76	0.00	0.00	2.94	

P value 0.66

Table: 7 Time to definitive fixation

Bones	Less than 6 hr.	6-12 hr.	12-24 hr.	Total
Humerus	0	1	0	1
Forearm	5	5	5	15
Femur	0	0	2	2
Leg	1	6	9	16
Total	6	12	16	
%	17.65	35.29	47.06	

P value 0.21

Table: 8 Wound coverage

Bones	Primary Suturing	Delayed Primary	Flap coverage	Secondary intention	STSG	Local transposition flap and STSG	Total
Humerus	0	1	0	0	0	0	1
Forearm	4	3	0	0	7	1	15
Femur	0	0	0	1	1	0	2
Leg	3	6	1	0	4	2	16
Total	7	10	1	1	12	3	
%	20.59	29.41	2.94	2.94	35.29	8.82	

P value 0.08

Table: 9 Time to coverage

Bones	**Early (<24hr)**	**Late (24-72hr)**	**Delayed (>72hr)**	**Total**
Humerus	0	0	1	**1**
Forearm	5	4	6	**15**
Femur	0	1	1	**2**
Leg	2	0	14	**16**
Total	**7**	**5**	**22**	
%	20.59%	14.71%	64.71%	

P value 0.91

Table: 10 **Correlation of MESS Score and Infection**

MESS score	None	Superficial	Deep	Osteomyelitis	Total
2	12	1	0	0	13
3	9	0	0	0	9
4	6	0	0	0	6
5	5	0	0	0	5
6	0	0	1	0	1
7 or more	0	0	0	0	0
Total	32	1	1	0	
%	94.12	2.94	2.94	0.00	

P value <0.0001 (Significant)

Table: 11 **Correlation of Time to 1st debridement and Infection**

Time to 1st deb	None	Superficial	Deep	Osteomyelitis	Total
less than 6hr	12	1	0	0	13
6-12 hr.	11	0	0	0	11
12-24 hr.	9	0	1	0	10
Total	**32**	1	1	0	
%	94.12	2.94	2.94	0.00	

P value 0.39

Table: 12 Correlation of Time to definitive fixation and Infection

Time to definitive fixation	None	Superficial	Deep	Osteomyelitis	Total
less than 6 hr.	5	1	0	0	6
6-12 hr.	12	0	0	0	12
12-24 hr.	15	0	1	0	16
Total	32	1	1	0	
%	94.12	2.94	2.94	0.00	

P value 0.21

Table: 13 Correlation of Coverage method and Infection

Coverage	None	Superficial	Deep	Osteomyelitis	Total
Primary Suturing	6	1	0	0	7
Delayed Primary	10	0	0	0	10
Flap coverage	0	0	1	0	1
Secondary intention	1	0	0	0	1
STSG	12	0	0	0	12
Local transposition flap and STSG	3	0	0	0	3
Total	32	1	1	0	
%	94.12	2.94	2.94	0.00	

P value <0.0001 (Significant)

Table: 14 **Correlation of Time to Coverage and Infection**

Time to coverage	None	Superficial	Deep	Osteomyelitis	Total
Early (<24hr)	6	1	0	0	7
Late (24-72hr)	5	0	0	0	5
Delayed (>72hr)	21	0	1	0	22
Total	32	1	1	0	
%	94.12 %	2.94%	2.94 %	0.00%	

P value 0.35

Reviews

Review 1

Review Title: How debridement, definitive fixation and final coverage determine the infection rate in grade III B open fractures of long bones managed with primary internal fixation

Posted by Dr. Mohit K Patralekh on 15 Apr 2016 08:20:45 PM GMT

1	Is the subject of the article within the scope of the subject category?	
2	Are the interpretations / conclusions sound and justified by the data?	
3	Is this a new and original contribution?	
4	Does this paper exemplify an awareness of other research on the topic?	
5	Are structure and length satisfactory?	
6	Can you suggest brief additions or amendments or an introductory statement that will increase the value of this paper for an international audience?	
7	Can you suggest any reductions in the paper, or deletions of parts?	
8	Is the quality of the diction satisfactory?	
9	Are the illustrations and tables necessary and acceptable?	
10	Are the references adequate and are they all necessary?	
11	Are the keywords and abstract or summary informative?	

Rating: 7

Comment:
Good

Competing interests: .

Invited by the author to make a review on this article? : Yes

Experience and credentials in the specific area of science:
Qualified Orthopaedic Surgeon.Experienced in handling such cases

Publications in the same or a related area of science: No

How to cite: Patralekh M. How debridement, definitive fixation and final coverage determine the infection rate in grade III B open fractures of long bones managed with primary internal fixation[Review of the article 'How debridement, definitive fixation and final coverage determine the infection rate in grade III B open fractures of long bones managed with primary internal fixation ' by Ahluwalia T].WebmedCentral Orthopaedics 1970;7(4):WMCRW003282

Review 2

Review Title: Role of debridement or primary fixation did the job?

Posted by Dr. Sanjay S Deo on 25 Feb 2015 12:58:43 PM GMT

1	Is the subject of the article within the scope of the subject category?	
2	Are the interpretations / conclusions sound and justified by the data?	
3	Is this a new and original contribution?	
4	Does this paper exemplify an awareness of other research on the topic?	
5	Are structure and length satisfactory?	
6	Can you suggest brief additions or amendments or an introductory statement that will increase the value of this paper for an international audience?	
7	Can you suggest any reductions in the paper, or deletions of parts?	
8	Is the quality of the diction satisfactory?	
9	Are the illustrations and tables necessary and acceptable?	
10	Are the references adequate and are they all necessary?	
11	Are the keywords and abstract or summary informative?	

Rating: 6

Comment:
I would like to see the follow up of these patients on long term basis.

Invited by the author to make a review on this article? : Yes

Experience and credentials in the specific area of science:
I have been doing these trauma surgeries in similar in Indian conditions so I understand the limitations in such work.

Publications in the same or a related area of science: No

How to cite: Deo S.Role of debridement or primary fixation did the job?[Review of the article 'How debridement, definitive fixation and final coverage determine the infection rate in grade III B open fractures of long bones managed with primary internal fixation ' by Ahluwalia T].WebmedCentral Orthopaedics 1970;6(2):WMCRW003184