Predebridement wound culture in open fractures does not predict postoperative wound infection: A pilot study

Reddy Lingaraj,
John Ashutosh Santoshi[1],
Sheela Devi[2],
Syed Najimudeen,
James J. Gnanadoss,
Rengasamy Kanagasabai,
Reba Kanungo[2]

Departments of Orthopaedics and [2]Microbiology, Pondicherry Institute of Medical Sciences, Puducherry, [1]Department of Orthopaedics, All India Institute of Medical Sciences, Bhopal, Madhya Pradesh, India

Address for correspondence:
Dr. John Ashutosh Santoshi, Department of Orthopaedics, All India Institute of Medical Sciences, Bhopal, Madhya Pradesh, India. E-mail: jasantoshi@gmail.com

Abstract

Background: There is confusion in the current literature regarding the value of obtaining predebridement wound cultures in the management of open fractures with several studies reporting contrasting results. We undertook a pilot study to determine the initial bacterial flora of open fractures in our environment and determine the correlation between subsequent wound infection if any, and the initial bacterial flora. **Materials and Methods:** Initial/predebridement wound swabs were obtained for 32 patients with open fractures. Patients underwent a debridement of the open wound and preliminary stabilization of fracture in the operating room within 24 h. Postdebridement wound cultures were obtained at 48 h and repeated subsequently, if indicated, during the follow-up period. The antibiotic therapy was modified based on the culture reports. **Results:** Initial wound swab culture showed bacterial contamination in 18 patients (56%); 14 patients (44%) developed an infection in the immediate postoperative period or during follow-up. Age, gender, co-morbid medical condition, delay in presentation, and grade of open fracture were not found to be predictors of postoperative infection. No patient had an infection with the same organism, which was present in the initial culture. **Conclusion:** The findings of this study suggest that the initial flora are not the infecting organisms in the open fracture wounds, and predebridement wound cultures have no value in predicting postdebridement wound infection.

Key words: Culture, infection, initial, open fracture

INTRODUCTION

Open fracture wounds are contaminated wounds[1] and postoperative infection is the main complication. Communication of the fractured bone fragments to the external environment, severity of the fracture, patient co-morbidities, the presence of devascularized soft tissue, and the delay in treatment contribute to the risk of bacterial infection. The landmark article by Gustilo and Anderson, way back in 1976, revealed a positive bacterial culture in 70.3% of 158 open long-bone fracture wounds.[2] Various authors have reported bacterial contamination in initial cultures of fracture wounds at a presentation in 8-83%[3-7] cases. It has been suggested that determining the bacterial

Access this article online	
Quick Response Code:	**Website:** www.jnsbm.org
	DOI: 10.4103/0976-9668.166088

How to cite this article: Lingaraj R, Santoshi JA, Devi S, Najimudeen S, Gnanadoss JJ, Kanagasabai R, *et al*. Predebridement wound culture in open fractures does not predict postoperative wound infection: A pilot study. J Nat Sc Biol Med 2015;6:S63-8.

flora of the fracture wound before instituting antibiotic therapy and definitive wound management would allow rational and effective antibiotic treatment.[5,8] In open fractures, contaminating bacteria are community-acquired and, as such, should be sensitive to most routine antibiotics.[5] In general, broad-spectrum empiric antibiotic therapy effective against both Gram-positive and Gram-negative organisms is recommended.[1]

If the initial contaminating organism persists in a subsequent wound culture, it may signify technical failure of debridement and a very high risk of postoperative infection.[5] However, reports suggest that postoperative infections are caused by hospital-acquired organisms.[6] This has led to a discussion on the need and rationale of obtaining initial wound cultures with some authors postulating no predictive value of initial cultures to postoperative infection.[3,9] while others are claiming high sensitivity in identifying wounds, which would develop postoperative infection though lacking specificity.[10,11]

There are not many studies on the community-acquired initial bacterial flora of open fracture wounds in the Indian setting. The lack of consensus among different studies regarding the utility of initial cultures led us to undertake a pilot study to determine the initial bacterial flora of open fractures in our environment and determine the correlation between subsequent wound infection, if any, and the initial bacterial flora.

MATERIALS AND METHODS

We planned a pilot study with a technically feasible sample size of 30 cases to determine the initial/predebridement bacterial flora of open fractures in our environment and determine the correlation between subsequent wound infection, if any, and the initial bacterial flora. Institutional human ethics committee approval for the design and conduct of the study was obtained prior to commencing the study. The study was conducted in the Department of Orthopedics, Pondicherry Institute of Medical Sciences, Puducherry, India from September 2011 to March 2012. The inclusion criteria were - all patients presenting in the emergency room (ER) or orthopedic out-patient clinic with open fractures during the study period, and from whom initial wound swabs were taken. The exclusion criteria were:

(a) Patients presenting with a delay of more than 24 h following injury,
(b) Patients who had received oral or parenteral antibiotics before presentation,
(c) Patients who did not have definitive treatment at our institution, and

(d) Patients who could not have been followed up for 6 months.

All patients were assessed for the fracture severity as per Gustilo and Anderson classification.[2] Wound swabs were taken after the initial stabilization of the patients' general condition. Systemic antibiotic prophylaxis was commenced at the earliest with parental cefazolin for all type 1 and type 2 injuries; gentamicin was added for all type 3 injuries. Metronidazole was added if contamination with anaerobic organisms was suspected. The wounds were lavaged with copious saline, and sterile dressings were applied. Patients underwent a debridement of the open wound and stabilization of fracture in the operating room (OR), depending on the wound contamination and fracture pattern, within 24 h as per institutional protocol. Repeat debridement was performed if the patient had a fever, local warmth or increased wound soakage or blood parameters suggesting infection at 48 h and subsequently, as warranted. Postdebridement wound cultures were obtained at 48 h and repeated subsequently, if indicated, during the follow-up period. The antibiotic therapy was modified based on the culture reports.

The data collected were patient demographics, mode of injury, place of injury, any preexisting disease/co-morbidity, time of injury, severity/grade of open fracture, whether the patient received preliminary care before presentation to the ER, the delay in presentation, whether empiric antibiotic therapy as per institutional protocol was administered at presentation, delay in preliminary care in the OR, whether wound swab was taken, Gram-stain report of the wound swab, culture report of the infecting organism(s) with antibiotic susceptibility pattern, whether the patient had wound infection in the postoperative period, and final outcome (which was recorded at minimum 6 months follow-up).

Statistical analysis was performed using SPSS 21 software (IBM Corp., released 2012. IBM SPSS Statistics for Windows, version 21.0. IBM Corp., Armonk, NY, USA). Descriptive statistical measures such as mean, median, standard deviation, minimum and maximum values for each variable are described. McNemar's test was performed to check for significance as we have paired nominal data.

RESULTS

Totally 32 patients fulfilling the study criteria were included for final analysis [Table 1]. Of these, there were 28 men (87.5%); mean age of patients was 37.9 years (range: 12-74 years; median: 34 years). Five patients (15.6%) had co-morbidities, which included type 2 diabetes mellitus in

Table 1: Summary of cohort metadata

Age	Gender	Gustilo and Anderson[2] grade of open fracture	Delay in hours	Initial gram stain	Initial culture	Delay in treatment in OR (h)	Postdebridement culture
14	Male	II	2	No organism seen	No growth	2	No growth
32	Male	IIIC	3	GNB	*E. faecalis*	2	*A. baumannii* and *A. lwoffii*
55	Male	IIIB	3	No organism seen	No growth	2	MRSA
28	Male	IIIC	5	No organism seen	*E. faecalis*	2	No growth
43	Female	II	9	No organism seen	*E. coli*	2	No growth
60	Male	II	2	No organism seen	No growth	3	*Klebsiella* species
12	Male	IIIA	3	No organism seen	No growth	3	No growth
25	Male	IIIB	6	GPC in pairs	No growth	3	No growth
45	Male	IIIB	8	No organism seen	*E. coli*	3	No growth
35	Male	IIIB	11	GNB	*A. lwoffii*	3	No growth
34	Male	IIIA	2	GPC in pairs	No growth	4	Coagulase negative *Staphylococcus*
30	Male	IIIA	7	GNB + GPC in pairs	*P. aeruginosa*	4	*A. baumannii* and *C. diversus*
76	Female	IIIB	10	GPC in chains	*S. aureus*	4	No growth
54	Male	II	5	No organism seen	No growth	5	*A. baumannii* and MRSA
26	Male	IIIB	14	No organism seen	No growth	5	*E. faecalis*
28	Male	II	7	GNB	*C. diversus*	6	No growth
42	Male	IIIB	5	GPC in pairs	*A. baumannii*	8	No growth
47	Male	I	9	No organism seen	No growth	8	*A. baumannii* and MRSA
35	Male	IIIB	5	GNB	No growth	10	No growth
58	Male	IIIB	10	No organism seen	*E. coli*	10	*E. faecalis*
60	Female	IIIB	9	No organism seen	No growth	11	*P. aeruginosa*
34	Male	I	1	GPC in pairs	No growth	12	Coagulase negative *Staphylococcus*
25	Male	IIIB	3	No organism seen	No growth	12	No growth
34	Male	I	4	No organism seen	No growth	12	No growth
25	Female	IIIB	5	No organism seen	No growth	12	*A. baumannii*
47	Male	IIIB	12	GNB	*Enterobacter* species	12	No growth
40	Male	IIIB	10	GPC in pairs	No growth	13	No growth
25	Male	I	2	No organism seen	No growth	14	Normal skin flora
23	Male	IIIA	18	No organism seen	No growth	18	No growth
25	Male	I	6	No organism seen	No growth	20	No growth
40	Male	IIIA	3	No organism seen	No growth	24	Normal skin flora
55	Male	IIIB	5	GPC in clusters	No growth	24	No growth

E. faecalis: Enterococcus faecalis, *A. baumannii*: Acinetobacter baumannii, *A. lwoffii*: Acinetobacter lwoffii, MRSA: Methicillin-resistant *S. aureus*, *S. aureus*: Staphylococcus aureus, *E. coli*: Escherichia coli, *P. aeruginosa*: Pseudomonas aeruginosa, *C. diversus*: Citrobacter diversus, GNB: Gram-negative *bacilli*, GPC: Gram-positive cocci

three, chronic anemia in one, and pulmonary tuberculosis on treatment in one. With regard to the grade of open fracture - there were five patients each of type 1 and type 2; four patients of type 3A, 16 patients of type 3B, and two patients of type 3C. Motor vehicle accidents were the most common mode of injury in 27 (84.4%) cases; the remaining cases had the following distribution - fall from height 3, fishing accident 1 and farm-yard injury 1.

There was an average delay of 6.4 h (range: 1-18 h; median: 5 h) in a presentation following the injury; with 19 (59.4%) presenting within the first 6 h. Patients presenting later than 24 h were not included in the study. Eight patients had received wound care before presentation to the ER; 4 of these showed positive initial wound culture for bacterial contamination, and 6 developed a postoperative wound infection. The average delay in preliminary care in the OR was 8.5 h (range: 2-24 h; median: 5 h).

Initial wound culture showed bacterial contamination in 18 patients (56%) (13 with positive Gram-stain and 11 positive cultures) [Table 2]; 14 patients (44%) actually developed infection in the immediate postoperative period or during follow-up [Table 3]; of these, 4 had mixed infection with *Acinetobacter baumannii* being the common organism in each of these. No patient had an infection with the same organism, which was present in the initial culture.

The initial wound contamination did not predict postoperative infection ($P < 0.523$) [Table 4]. Age, gender, co-morbid medical condition, delay in presentation, and grade of open fracture were also not found to be predictors of postoperative infection. All the three patients with type 2 diabetes mellitus developed a postoperative infection. Two patients with type 3C open fractures underwent amputation as the primary procedure.

Table 2: Initial wound culture

Initial/predebridement contaminating organism	Number of cases
Escherichia coli	3
Enterococcus faecalis	2
Acinetobacter species	2
Enterobacter species	1
Citrobacter species	1
Staphylococcus aureus	1
Pseudomonas aeruginosa	1

Table 3: Postoperative culture

Postoperative culture infective organism	Number of cases
Enterococcus faecalis	2
Pseudomonas aeruginosa	1
MRSA	1
Klebsiella species	1
A. baumannii	1
A. baumannii and MRSA	2
A. baumannii and *Acinetobacter lwoffii*	1
A. baumannii and *Citrobacter diversus*	1
Coagulase negative *Staphylococcus*	2
Normal skin flora	2

MRSA: Methicillin-resistant *Staphylococcus aureus*, A. baumannii: *Acinetobacter baumannii*

Table 4: Comparison of predebridement culture and postoperative infection

Predebridement contamination	Postoperative infection		Total	McNemar's test two-tailed *P*-value
	No	Yes		
No	5	9	14	0.523
Yes	13	5	18	
Total	18	14	32	

DISCUSSION

Although surgical debridement and fracture fixation are of utmost importance for preventing open fracture infections, the use of antibiotics is a topic of interest.[12] Predicting which patient after an open fracture will develop infection remains difficult. There is confusion in the current literature regarding the value of obtaining wound cultures in the management of open fractures with several studies reporting contrasting results. Studies have documented initial/predebridement cultures, cultures taken from the debrided material itself, cultures obtained postdebridement, cultures obtained at the time of wound closure, and cultures taken from the closed wound. Bumbasirevic *et al.*[13] in a recent article recommended taking bacterial culture swabs before administering prophylactic antibiotics as a treatment protocol for mangled limbs. Whereas, others have strongly recommended against such practice.[3,9,14]

Patzakis *et al.*[15] in a randomized control trial on 310 patients in 1974, first demonstrated the reduction of infection rate in patients with open fractures who received prophylactic antibiotics. Since then prophylactic antibiotics are routinely administered to all patients with open fractures. Prophylactic antibiotics are chosen based on reports of the prevalent infectious organisms. Most current protocols, as in this study, include the administration of parenteral antibiotic prophylaxis consisting of first-generation cephalosporin, usually cefazolin. Aminoglycosides are usually added when Gram-negative cover in warranted, typically type 3 open fracture wounds.[16]

Agrawal *et al.*[17] conducted a study to find out the frequency of bacterial flora in open fractures, bedsores, and wounds clinically suspected to be infected. Of the 111 positive cases out of 209 cultures, 30 cases with open fractures wounds had contamination at the time of initial presentation, with predominance of Gram-negative organisms (76%). The various organisms in their study were *Escherichia coli* (9/30), and *Pseudomonas* species (9/30), *Staphylococcus aureus* (6/30), *Klebsiella* species (4/30), *Streptococcus* species (1/30), and *Proteus* species (1/30). In this study, we had initial cultures predominantly growing Gram-negative organisms; 8 out of 11 (72%) positive cultures revealed wound contamination with Gram-negative organisms [Table 2]. They, however, did not report if the initial organism caused subsequent infection in the patient.

The study by Carsenti-Etesse *et al.*[14] found coagulase-negative *Staphylococci*, *Bacillus* species, *Acinetobacter* species, and *Enterobacter* species as the most common bacterial contaminants in the initial wound cultures obtained in the ER. However, cultures at the time of infection showed the most common Gram-positive organisms to be methicillin-sensitive and methicillin-resistant *Staphylococcus aureus* (MRSA), and Gram-negative organisms, including *Enterobacter* species, *Klebsiella* species, *E. coli*, and *Pseudomonas* species. In the present study, we had 11 patients who had positive initial cultures, whereas 14 patients actually developed infection in the immediate postoperative period or during follow-up with no patient having infection with the same organism, which was present in the initial culture. There were 7 postoperative cultures showing Gram-positive organisms and 9 showing Gram-negative organisms; three cases had an infection with more than one organism.

This discrepancy in the initial contamination and the subsequent infecting organism has been explained by Carsenti-Etesse *et al.*[14] They concluded from their study that among the patients who developed a deep infection, patients who were given prophylaxis against Gram-negative bacteria grew primarily Gram-positive bacteria, whereas patients who were given prophylaxis against Gram-positive bacteria grew Gram-negative bacteria from deep infected

tissue. The current trend in the antibiotic prophylaxis protocols of short-course therapy may have a role in the development of resistant organisms. It is likely that patients who receive prophylactic Gram-positive cover with first-generation cephalosporin like cefazolin at the time of their initial wound management reduce the burden of disease attributed to low-pathogenicity Gram-positive organisms early in their treatment course and increase the role of nosocomial pathogens. This may also potentially allow the organisms to propagate within the wounds after the antibiotic is discontinued, contributing to wound complications later.[18]

Recent studies report an increasing incidence of MRSA in the community setting.[12] In the present study, the incidence of MRSA infection was 3 (out of 14 postdebridement infections) which included 2 compromised hosts with type 2 diabetes mellitus. There are recent reports of increasing incidence of infection by *Acinetobacter* species, most commonly by multi-drug resistant *A. baumannii* and *Acinetobacter lwoffii*.[19,20] *Acinetobacter* species are aerobic Gram-negative *bacilli* commonly present as commensals of skin, throat, and secretions of healthy people. Given the high incidence of MRSA and Gram-negative rods in open fracture infections, future consideration for changing antibiotic prophylaxis to cover MRSA and Gram-negative organisms may be effective for reducing the rate of infection in open fractures.[12,21]

D'Souza *et al.*[11] studied the role of qualitative cultures for detecting infection in 108 open tibial fractures. Wound swabs were taken before and after a standard debridement procedure. Predebridement cultures were found to have high sensitivity in detecting infection; if the infection was present, then the chance of detecting the offending organism was almost 84%. Postdebridement cultures yielded good specificity; if an open fracture wound did not display any evidence of infection, then no organism was isolated in almost 87% of cases. The findings of the present study do not reveal any correlation between initial wound contamination and postoperative infection.

Sen *et al.*[22] studied the role of quantitative bacteriology in the tissues and its predictive value for infection in 20 patients with open fractures. Postdebridement pieces of skin, muscle, and periosteal tissue were obtained for the quantitative bacterial count. Nine out of the 20 patients developed an infection within 1-month. It is generally observed that wounds with tissue contamination of $>10^5$ bacteria/g develop an infection. Eight of these patients had contamination of $>10^5$/g in 8 of the skin but only 3 muscle samples. They suggested that any level of muscle contamination was predictive of future wound infection, and could represent a subclinical phase in the development

of subsequent infection. We did not perform quantitative bacteriology in the present study.

The use of high-throughput DNA sequencing technology enables the study of human microbiome via sequencing of the bacteria-specific 16S small subunit ribosomal RNA (rRNA) gene. In a recent study, Hannigan *et al.*[23] using DNA sequencing techniques found a great diversity of microbiota in open fractures. Their findings reveal that, upon presentation to the ER, traumatic open fractures harbor a nearly equally abundant combination of commensal Gram-positive and Gram-negative bacteria, though the skin is dominated by Gram-positive bacteria. The traumatic wound bacterial communities are least similar to the healthy skin upon presentation but become more similar as healing progresses indicating the potential prognostic value of 16S rRNA profiling for identifying those open fractures at risk for complication. These genomic approaches provide greater resolution and precision by eliminating biases associated with culturing bacteria.[20,23]

Thorough wound debridement, meticulous soft tissue handling and early stabilization of the fracture should be the guiding principles in the care of open fractures.[1] The findings of this study suggest that the initial flora are not the infecting organisms in the open fracture wounds, and predebridement wound cultures have no value in predicting postdebridement wound infection. The role of quantitative cultures and DNA sequencing techniques could be the future direction of research for predicting cases at risk of infection.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Cross WW 3rd, Swiontkowski MF. Treatment principles in the management of open fractures. Indian J Orthop 2008;42:377-86.
2. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: Retrospective and prospective analyses. J Bone Joint Surg Am 1976;58:453-8.
3. Lee J. Efficacy of cultures in the management of open fractures. Clin Orthop 1997;339:71-5.
4. Ikem IC, Oginni LM, Bamgboye EA, Ako-Nai AK, Onipede AO. The bacteriology of open fractures in Ile-Ife, Nigeria. Niger J Med 2004;13:359-65.
5. Robinson D, On E, Hadas N, Halperin N, Hofman S, Boldur I. Microbiologic flora contaminating open fractures: Its significance in

the choice of primary antibiotic agents and the likelihood of deep wound infection. J Orthop Trauma 1989;3:283-6.

6. Seekamp A, Köntopp H, Schandelmaier P, Krettek C, Tscherne H. Bacterial cultures and bacterial infection in open fractures. Eur J Trauma 2000;26:131-8.

7. Ojo OD, Oluwadiya KS, Ikem IC, Oginni LM, Ako-Nai AK, Daniel FV. Superficial swab cultures in open fracture management: Insights from a resource-poor setting. J Wound Care 2010;19:432-8.

8. Heitmann C, Patzakis MJ, Tetsworth KD, Levin LS. Musculoskeletal sepsis: Principles of treatment. Instr Course Lect 2003;52:733-43.

9. Faisham WI, Nordin S, Aidura M. Bacteriological study and its role in the management of open tibial fracture. Med J Malaysia 2001;56:201-6.

10. Kreder HJ, Armstrong P. The significance of perioperative cultures in open pediatric lower-extremity fractures. Clin Orthop 1994;302: 206-12.

11. D'Souza A, Rajagopalan N, Amaravati RS. The use of qualitative cultures for detecting infection in open tibial fractures. J Orthop Surg (Hong Kong) 2008;16:175-8.

12. Chen AF, Schreiber VM, Washington W, Rao N, Evans AR. What is the rate of methicillin-resistant *Staphylococcus aureus* and gram-negative infections in open fractures? Clin Orthop 2013;471: 3135-40.

13. Bumbasirevic M, Stevanovic M, Lesic A, Atkinson HD. Current management of the mangled upper extremity. Int Orthop 2012;36:2189-95.

14. Carsenti-Etesse H, Doyon F, Desplaces N, Gagey O, Tancrède C, Pradier C, *et al.* Epidemiology of bacterial infection during management of open leg fractures. Eur J Clin Microbiol Infect Dis 1999;18:315-23.

15. Patzakis MJ, Harvey JP Jr, Ivler D. The role of antibiotics in the management of open fractures. J Bone Joint Surg Am 1974;56:532-41.

16. Lane JC, Mabvuure NT, Hindocha S, Khan W. Current concepts of prophylactic antibiotics in trauma: A review. Open Orthop J 2012;6:511-7.

17. Agrawal AC, Jain S, Jain RK, Raza HK. Pathogenic bacteria in an orthopaedic hospital in India. J Infect Dev Ctries 2008;2:120-3.

18. Johnson EN, Burns TC, Hayda RA, Hospenthal DR, Murray CK. Infectious complications of open type III tibial fractures among combat casualties. Clin Infect Dis 2007;45:409-15.

19. Guerrero DM, Perez F, Conger NG, Solomkin JS, Adams MD, Rather PN, *et al. Acinetobacter baumannii*-associated skin and soft tissue infections: Recognizing a broadening spectrum of disease. Surg Infect (Larchmt) 2010;11:49-57.

20. Fenollar F, Roux V, Stein A, Drancourt M, Raoult D. Analysis of 525 samples to determine the usefulness of PCR amplification and sequencing of the 16S rRNA gene for diagnosis of bone and joint infections. J Clin Microbiol 2006;44:1018-28.

21. Saveli CC, Belknap RW, Morgan SJ, Price CS. The role of prophylactic antibiotics in open fractures in an era of community-acquired methicillin-resistant *Staphylococcus aureus*. Orthopedics 2011;34: 611-6.

22. Sen RK, Murthy N, Gill SS, Nagi ON. Bacterial load in tissues and its predictive value for infection in open fractures. J Orthop Surg (Hong Kong) 2000;8:1-5.

23. Hannigan GD, Hodkinson BP, McGinnis K, Tyldsley AS, Anari JB, Horan AD, *et al.* Culture-independent pilot study of microbiota colonizing open fractures and association with severity, mechanism, location, and complication from presentation to early outpatient follow-up. J Orthop Res 2014;32:597-605.