International Journal of Research in Orthopaedics
Thomas A et al. Int J Res Orthop. 2026 Mar;12(2):427-432
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20260511

Perioperative microbiological assessment in open fractures: a prospective comparative study of wound swab and tissue sample cultures

Alvin Thomas[1], Henry Mathews[2]*, Joe Joseph Cherian[3], Likhith Theodore[4], Natasha Varghese Isaac[5]

[1]Department of Orthopaedics, Sree Gokulam Medical College and Research Foundation, Venjaramoodu, Thiruvananthapuram, Kerala, India
[2]Department of Orthopaedics, Al-Azhar Medical College and Super Speciality Hospital, Thodupuzha, Kerala, India
[3]Department of Orthopaedics, St. John's Medical College and Hospital, Bengaluru, Karnataka, India
[4]Department of Orthopaedics, Pushpagiri Institute of Medical Sciences and Research Centre, Thiruvalla, Kerala, India
[5]Department of Orthopaedics, Ramaiah Medical College and Hospital, Bengaluru, Karnataka, India

Received: 28 December 2025
Accepted: 07 February 2026

***Correspondence:**
Dr. Henry Mathews,
E-mail: nirmajoyderm@gmail.com

ABSTRACT

Background: Infection remains a major complication affecting the management and outcome of open fractures. The usefulness of perioperative microbiological cultures in predicting infection has been debated. Commonly used sampling techniques include wound swab (WS) culture and tissue sample (TS) culture. While previous studies have compared swab cultures at different stages of debridement, limited evidence exists comparing WS and TS cultures obtained both before and after debridement in acute open fractures. This study aimed to compare the effectiveness of WS and TS cultures in detecting bacterial contamination during the perioperative period of open fracture management.
Methods: This prospective study included 83 patients presenting with open fractures. WS and TS cultures were obtained from all patients during both pre-debridement and post-debridement phases. The microbiological growth patterns from the two techniques were recorded and compared. The association between bacterial growth and factors such as fracture type, time to hospital presentation, and time to surgery was also analyzed. Postoperative infection rates were correlated with culture results.
Results: TS cultures demonstrated significantly higher bacterial detection rates compared to WS cultures. Higher rates of bacterial contamination were observed in Gustilo-Anderson type III B fractures and in patients with delayed presentation to hospital and operating theatre. Post-debridement TS cultures showed higher sensitivity and specificity in predicting postoperative infections when compared with WS cultures.
Conclusions: TS culture is a more reliable method than WS culture for detecting bacterial contamination in open fracture wounds. Post-debridement TS cultures are particularly effective in identifying patients at risk of postoperative infection and may aid in optimizing infection prevention strategies in open fracture management.

Keywords: Open fractures, Wound swab, Tissue sample culture, Debridement, Postoperative infection

INTRODUCTION

A fracture is defined as a disruption in the structural continuity of bone and may range from an incomplete crack to a complete break with displacement of fragments. Fractures are classified as closed when the overlying skin remains intact and open when there is a breach in the skin or surrounding soft tissues, allowing communication

between the fracture site and the external environment. Open fractures are associated with contamination of the fracture hematoma and carry a significantly higher risk of infection. It is important to recognize that the skin wound may not directly overlie the fracture and may communicate with it through degloved or undermined soft tissues; therefore, any fracture associated with a wound in the same anatomical region should be considered open until proven otherwise by surgical exploration.[1]

Open fractures commonly result from high-energy trauma such as road traffic accidents, occupational injuries, assaults, and gunshot wounds. Bacterial contamination has been reported in 60-70% of open fracture wounds and can lead to serious complications, including delayed wound healing, deep surgical site infection, osteomyelitis, non-union, malunion, prolonged hospital stay, increased treatment costs, and in severe cases, limb loss.[2] Several factors influence the risk of infection, including the severity of soft-tissue injury, the presence of devitalized tissue, degree of contamination, host immune status, associated comorbidities, delay in hospital presentation, and delay in surgical intervention. The loss of skin integrity creates a favorable environment for microbial colonization, particularly in the presence of foreign material and necrotic tissue.[2]

The principles of open fracture management include early administration of antibiotics, thorough surgical debridement and wound irrigation, appropriate fracture stabilization, and timely wound closure. Among these, meticulous debridement combined with antibiotic prophylaxis remains the cornerstone of infection prevention. Despite advances in surgical techniques and antimicrobial therapy, infection continues to be a major challenge affecting the outcome and prognosis of open fractures.[3]

The role of perioperative microbiological cultures in predicting infection in open fractures remains controversial.[4] Sampling techniques commonly used include WS cultures and TS cultures. Previous studies have largely focused on comparing WS cultures obtained at different stages, particularly before and after debridement, with post-debridement cultures shown to be more reliable in identifying infecting organisms and predicting subsequent infection.[5-10]

However, there is limited evidence comparing the effectiveness of WS and TS cultures when obtained during both pre- and post-debridement phases in acute open fractures.

Objectives

This prospective study was undertaken to compare the bacteriological yield of WS cultures and TS cultures obtained before and after surgical debridement in patients with acute open fractures, and to evaluate their usefulness in predicting postoperative infection.

METHODS

This prospective study was conducted over a period of two years in the Department of Orthopaedics at St. John's Medical College Hospital, Bengaluru, after obtaining approval from the institutional ethics committee and informed consent from all participants. A total of 83 patients aged 18-45 years with Gustilo-Anderson type II, IIIA, and IIIB open fractures were included using convenient sampling, while immunocompromised patients and those on immunosuppressive therapy were excluded. Sequential WS and TS cultures were obtained during both pre-debridement (after initial wound wash in the emergency department) and post-debridement (in the operating theatre before antiseptic wash) phases under aseptic precautions. TSs were collected from the deep central part of the wound, and WSs were obtained using Levine's technique. Patients received standard care including anti-tetanus prophylaxis, intravenous broad-spectrum antibiotics, surgical debridement, and appropriate fracture stabilization. All patients were followed for six weeks postoperatively, and cultures were repeated if clinical signs of infection were noted. Microbiological results were compared between sampling techniques and stages of debridement. Sensitivity, specificity, accuracy, positive predictive value, and negative predictive value were calculated. Statistical analysis was performed using McNemar and Chi-square tests, with a $p<0.05$ considered statistically significant. The sample size was calculated based on a previous comparative study evaluating agreement between pre- and post-debridement cultures in open fractures, which reported a kappa value of 0.26 with a standard error of 0.18 and positivity rates of 26% and 30%. Based on these parameters, a minimum sample size of 34 patients was required. To improve statistical reliability, 83 patients were included in the present study.

RESULTS

A total of 83 patients with open fractures were included in this prospective study. Overall, 56.6% of samples showed positive bacterial growth, while 43.4% showed no growth during perioperative assessment.

Baseline characteristics

The study population had a mean age of 32.1±9.4 years, with a male predominance (84.3%). Most injuries were due to road traffic accidents (85.6%). The majority of fractures were classified as Gustilo-Anderson type II (53%), followed by type IIIA (22.9%) and IIIB (24.1%). A significant association was observed between Gustilo-Anderson fracture type and postoperative infection ($\chi^2=18.05$, $p<0.001$). Infection rates increased with fracture severity, occurring in 25.0% of type II, 31.6% of type III A, and 80.0% of type III B fractures, indicating a markedly higher risk of infection in type III B injuries. Most patients reached the hospital within 4 hours of injury, and 60.2% underwent surgery within 5-10 hours of

presentation. Patients who developed postoperative infection had significantly longer delays in both hospital presentation and surgical intervention. The median time to hospital arrival was 7 hours in infected patients compared to 3 hours in non-infected patients ($p<0.001$). Similarly, the median time to surgery was 12 hours in the infection group versus 7.5 hours in the non-infection group ($p<0.001$) Although a higher proportion of patients with comorbidities developed infection (46.7% vs 38.2%), this difference was not statistically significant ($p=0.546$) (Table 1).

Microbiological profile

Across all sampling phases, *Acinetobacter baumannii* and *Enterococcus faecalis* were the most frequently isolated organisms. TS cultures consistently demonstrated higher bacterial detection rates compared to WS cultures in both pre- and post-debridement phases (Table 2 and Figure 1 and 2).

Agreement between sampling techniques

Comparison of WS and TS cultures showed moderate agreement in the pre-debridement phase ($\kappa=0.585$, $p<0.001$) and excellent agreement in the post-debridement phase ($\kappa=0.803$, $p<0.001$), with TSs identifying additional positive cases missed by swabs (Table 3).

Prediction of postoperative infection

Post-debridement TS cultures demonstrated the highest diagnostic performance in predicting postop infection, with 100% sensitivity and 90% specificity. Diagnostic accuracy progressively improved from pre-debridement WS to post-debridement TS cultures (Table 4).

Table 1: Baseline demographic and injury characteristics, (n=83).

Variables	Category	N	Percentage (%)
Age (in years)	Mean±SD	32.14±9.42	-
	18-20	12	14.5
	21-30	26	31.3
	31-40	20	24.1
	41-45	25	30.1
Sex	Male	70	84.3
	Female	13	15.7
Mode of injury	Road traffic accident	71	85.6
	Work-related injury	6	7.2
	Fall from height	6	7.2
Gustilo-Anderson type	Type II	44	53.0
	Type IIIA	19	22.9
	Type IIIB	20	24.1

Table 2: Comparison of bacterial growth between WS and TS cultures (pre- and post-debridement).

Sampling technique	Phase	Positive cultures, n (%)	Negative cultures, n (%)
WS	Pre-debridement	27 (32.5)	56 (67.5)
TS	Pre-debridement	33 (39.8)	50 (60.2)
WS	Post-debridement	32 (38.6)	51 (61.4)
TS	Post-debridement	38 (45.8)	45 (54.2)

Table 3: Agreement (Kappa statistics) between WS and TS cultures.

Phases	Kappa value	Standard error	P value
Pre-debridement	0.585	0.092	<0.001*
Post-debridement	0.803	0.065	<0.001*

*Statistically significant ($p<0.05$).

Table 4: Diagnostic accuracy of sampling techniques in predicting postoperative infection.

Sampling techniques	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
WS (Pre-debridement)	51.5	80.0	63.0	71.4	68.7
TS (Pre-debridement)	75.8	84.0	75.8	84.0	80.7
WS Post-debridement)	81.8	90.0	84.4	88.2	86.8
TS (Post-debridement)	100.0	90.0	86.8	100.0	94.0

PPV: Positive predictive value; NPV: Negative predictive value.

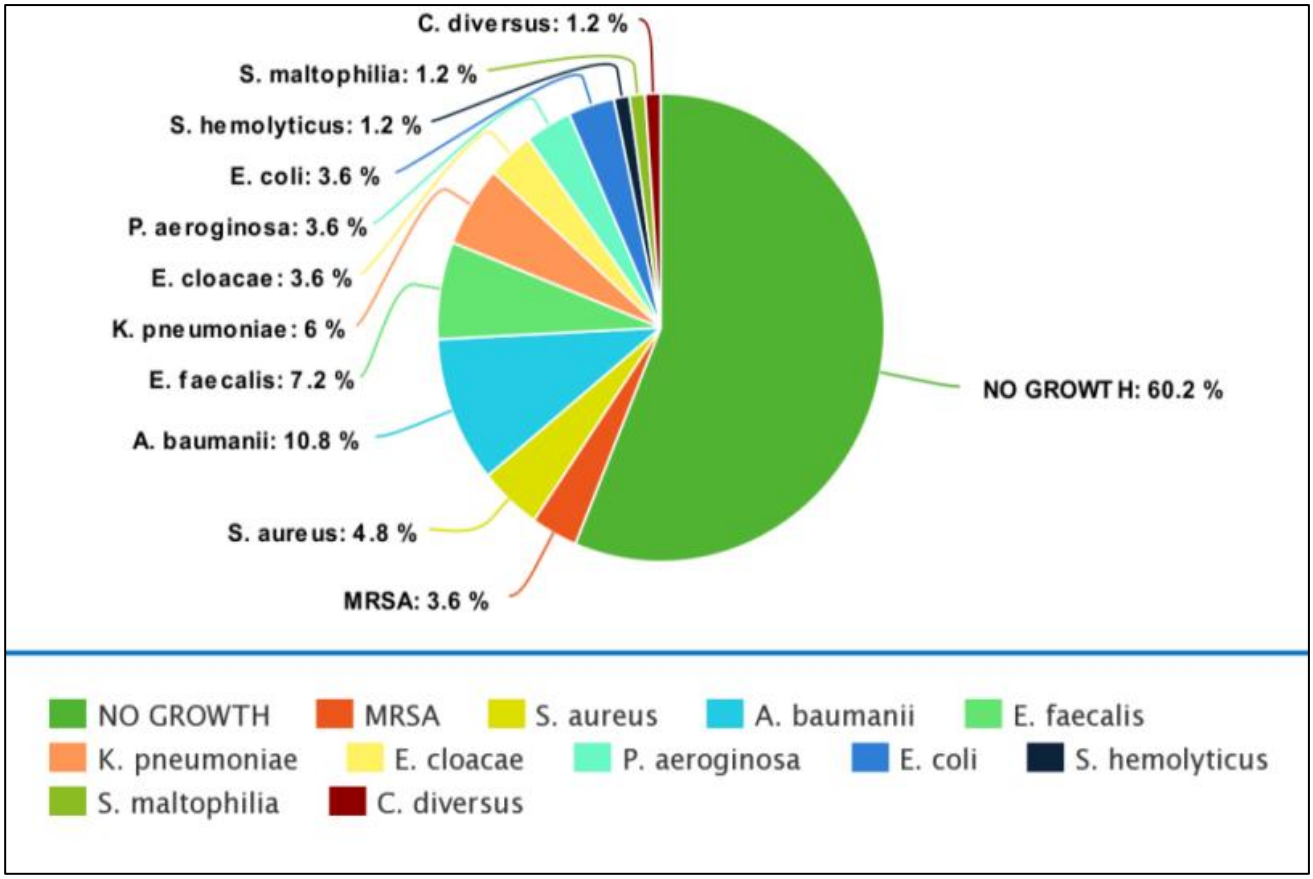

Figure 1: Analysis of pre-debridement TS cultures.

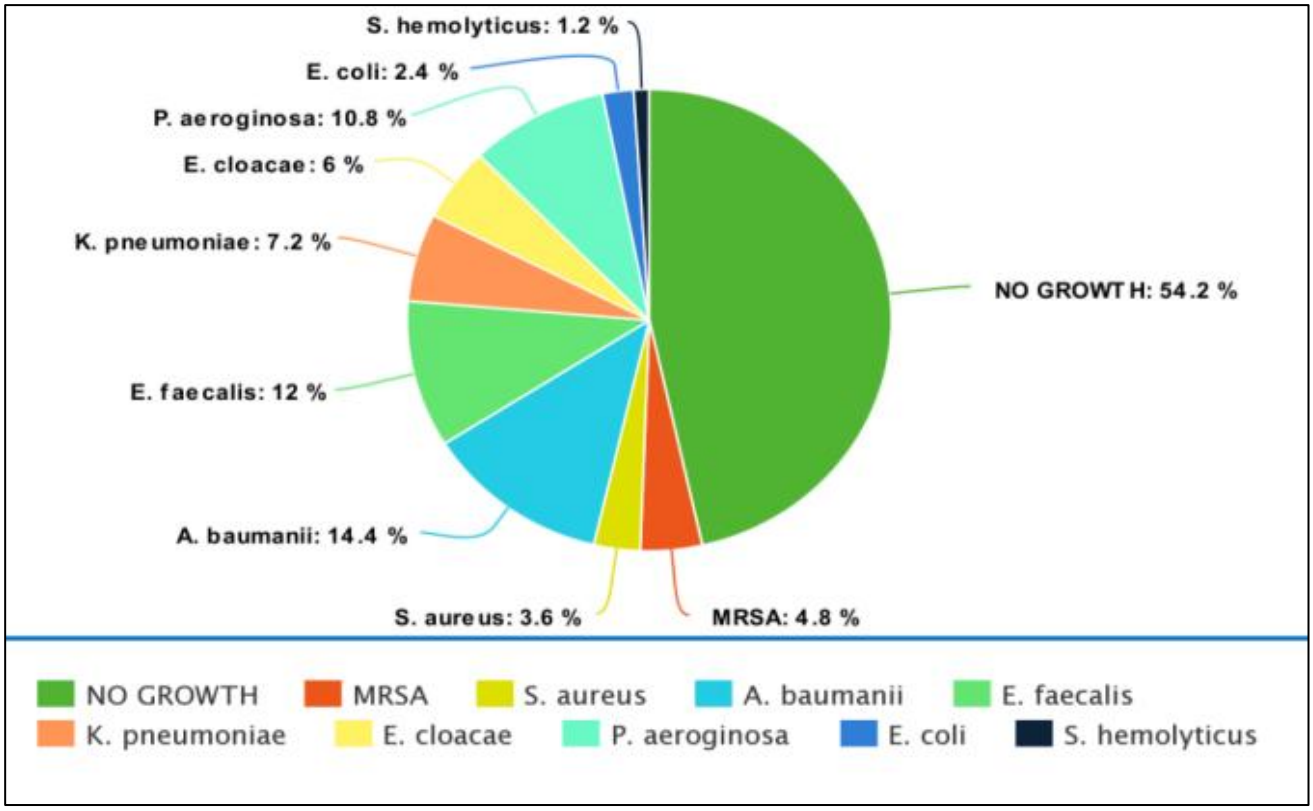

Figure 2: Analysis of post-debridement TS cultures.

DISCUSSION

Open fractures continue to represent a major challenge in orthopaedic trauma because of their high susceptibility to infection and the lack of consensus regarding optimal microbiological assessment. The present prospective study was undertaken to evaluate the diagnostic utility of WS and TS cultures obtained during the perioperative period and their ability to predict postoperative infection.

The study population predominantly comprised young males (84.3%), reflecting the economically active age group commonly involved in road traffic accidents, which was the leading mechanism of injury (85.6%). Similar demographic patterns have been consistently reported in previous studies.[4,5,8,11] Gustilo-Anderson type II fractures constituted the majority (53%), though a substantial proportion of type III injuries were included, providing a representative spectrum of open fractures.

A key finding of this study was the significant association between delayed presentation and postoperative infection. Patients who took longer to reach the hospital and operating theatre had significantly higher infection rates ($p<0.001$). This reinforces the established concept that delay in debridement increases bacterial load and tissue devitalization, thereby predisposing to infection, as also demonstrated by Agarwal et al and Gupta et al. [5,6]

With regard to microbiological assessment, TS cultures consistently outperformed WS cultures in both pre-debridement and post-debridement phases. In the pre-debridement phase, TS detected significantly more bacterial growth than WS ($p<0.001$), and this difference became more pronounced in the post-debridement phase. Importantly, post-debridement TS cultures showed the highest sensitivity and specificity for predicting postoperative infection, with no false-negative results observed. This finding highlights the superior diagnostic accuracy of deep tissue sampling over superficial swabs.

These results are in agreement with the pilot study by Joseph et al who demonstrated better organism isolation with tissue cultures compared to swabs, although organism concordance was limited.[11] Similar conclusions were drawn by Faisham et al who observed limited prognostic value of pre-debridement swabs but greater relevance of post-debridement cultures.[4] Our study strengthens this evidence by demonstrating that post-debridement TS cultures not only detect bacterial contamination more reliably but also correlate strongly with clinical infection.

Fracture severity was another important determinant of infection. A statistically significant association was observed between Gustilo-Anderson classification and postoperative infection, with type IIIB fractures showing the highest infection rates. This finding is consistent with earlier studies by D'Souza et al and Lee et al where higher-grade open fractures were associated with increased infection risk due to extensive soft-tissue damage and contamination.[8,10] In contrast, comorbid status did not show a significant association with infection in our cohort, similar to observations by Lingaraj et al.[7]

Several studies have questioned the utility of routine cultures in open fractures, suggesting limited prognostic value.[10,12] However, the present study demonstrates that while pre-debridement cultures may have limited predictive value, post-debridement tissue cultures provide clinically meaningful information that can aid in early identification of high-risk cases and guide targeted antibiotic therapy. This distinction is crucial and addresses an important gap in existing literature.

Overall, our findings support the growing body of evidence favoring post-debridement tissue culture as the most reliable microbiological sampling technique in open fractures. By combining early surgical debridement, timely intervention, and appropriate culture-guided antibiotic therapy, postoperative infection rates can potentially be reduced.

Limitations

The limitations of this study include a relatively modest sample size and exclusion of Gustilo-Anderson type I and IIIC fractures. Larger multicentric studies including all fracture grades would further strengthen these conclusions.

CONCLUSION

This prospective study of 83 patients with open fractures demonstrates that postoperative infection is strongly influenced by fracture severity (particularly Gustilo-Anderson type 3 B) and delays in reaching the hospital and operating theatre. While WS and tissue sampling techniques both showed utility, TS cultures-especially when obtained post-debridement-consistently demonstrated superior diagnostic performance, with the highest sensitivity (100%) and high specificity (90%) for predicting postoperative infection. Pre-debridement cultures showed limited prognostic value, whereas post-debridement tissue cultures were most reliable in identifying clinically relevant bacterial contamination. These findings support the routine use of post-debridement tissue sampling in acute open fractures to guide targeted antibiotic therapy and potentially reduce infection-related morbidity.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Brown CM, Heckman JD. Open fractures. In: Rockwood and Green's fractures in adults. 8th ed. Vol 1. Philadelphia, PA: Wolters Kluwer. 2015;353-97.

2. Wood GW II. Open fractures. In: Campbell's operative orthopaedics. 12th ed. Vol 1. Philadelphia, PA: Elsevier. 2013;2561-87.
3. Badia JM, Casey AL, Petrosillo N, Hudson PM, Mitchell SA, Crosby C. Impact of surgical site infection on healthcare costs and patient outcomes: a systematic review in six European countries. J Hosp Infect. 2017;96(1):1-15.
4. Faisham WI, Nordin S, Aidura M. Bacteriological study and its role in the management of open tibial fracture. Med J Malaysia. 2001;56(2):201-6.
5. Agarwal D, Maheshwari R, Agrawal A, Chauhan V, Juyal A. Pattern of bacterial isolates in open fractures. J Orthop Traumatol Rehabil. 2015;8(1):1.
6. Gupta S, Saini N, Sharma R, Kehal J, Saini Y. Comparative study of efficacy of pre- and post-debridement cultures in open fractures. Internet J Orthop Surg. 2012;19(3):1-7.
7. Lingaraj R, Santoshi JA, Devi S, Najimudeen S, Gnanadoss JJ, Kanagasabai R, et al. Pre-debridement wound culture in open fractures does not predict postoperative wound infection: a pilot study. J Nat Sci Biol Med. 2015;6(1):S63-8.
8. D'Souza A, Rajagopalan N, Amaravati RS. Use of qualitative cultures for detecting infection in open tibial fractures. J Orthop Surg (Hong Kong). 2008;16(2):175-8.
9. Mangala A, Arthi K, Deepa R. Comparison of pre-debridement and post-debridement cultures in predicting postoperative infections in compound fractures. J Clin Diagn Res. 2018;12(7):DC06-9.
10. Lee J. Efficacy of cultures in the management of open fractures. Clin Orthop Relat Res. 1997;(339):71-5.
11. Cherian JJ, Lobo JO, Ramesh LJ. A comparative study of bacteriological culture results using swab and tissue in open fractures: a pilot study. J Orthop Case Rep. 2019;9(1):33-6.
12. Valenziano CP, Chattar-Cora D, O'Neill A, Hubli EH, Cudjoe EA. Efficacy of primary wound cultures in long bone open extremity fractures: are they of any value? Arch Orthop Trauma Surg. 2002;122(5):259-61.

Cite this article as: Thomas A, Mathews H, Cherian JJ, Theodore L, Isaac NV. Perioperative microbiological assessment in open fractures: a prospective comparative study of wound swab and tissue sample cultures. Int J Res Orthop 2026;12:427-32.