Original Research

# COMPARISON OF TREATMENT OUTCOMES IN DIABETIC FOOT INFECTIONS USING DEEP TISSUE CULTURE AND SURFACE SWAB CULTURE

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## ABSTRACT

**Background:** Diabetic foot infections are a major cause of morbidity, prolonged hospitalization, and lower limb amputations among patients with diabetes mellitus. Surface swab cultures may not reliably represent deep tissue pathogens, whereas deep tissue cultures are considered more specific. Comparing treatment outcomes based on these culture techniques may help optimize management strategies and improve healing outcomes in diabetic foot infections.

**Aim:** To compare the outcomes of diabetic foot infections treated based on deep tissue culture versus swab culture.

**Materials and Methods:** This prospective comparative study was conducted in the Department of General Surgery over a duration of 10 months. A total of 56 patients with diabetic foot infections were included in the study and randomly divided into two groups of 28 patients each. Group A patients received treatment guided by deep tissue culture sensitivity, while Group B patients were managed according to swab culture sensitivity reports. Wound assessment included ulcer grade, presence of discharge, necrosis, cellulitis, and signs of systemic infection. Appropriate antibiotics were administered. Outcome measures included wound healing rate, duration of hospital stay, need for surgical intervention, infection resolution, and amputation rate. Statistical analysis was performed using appropriate tests, and p-value less than 0.05 was considered statistically significant.

**Results: M**ajority of patients belonged to the age group of 51–70 years, accounting for 35 (62.5%) cases, with male predominance observed in 38 (67.9%) patients. Wagner grade II and III ulcers constituted most diabetic foot lesions. Polymicrobial growth was more commonly identified in deep tissue cultures compared to swab cultures. Concordance between swab and deep tissue culture organisms was observed in only 17 (60.7%) cases. Complete wound healing was achieved in 19 (67.9%) patients in the deep tissue culture group compared to 11 (39.3%) patients in the swab culture group ($p = 0.03$). Mean duration of hospital stay was significantly lower in Group A (11.2 ± 3.4 days). Major amputation was required in 2 (7.1%) patients in the deep tissue culture group and 6 (21.4%) patients in the swab culture group.

**Conclusion:** Deep tissue culture-guided management was associated with superior clinical outcomes compared to swab culture-guided therapy in diabetic foot infections. Deep tissue culture should be considered the preferred microbiological method in the management of diabetic foot infections.

**Keywords:** Amputation, Deep Tissue Culture, Diabetic Foot Infection, Glycemic Control, Swab Culture, Wound Healing, Wagner Classification.

## INTRODUCTION

Diabetes mellitus is one of the most common chronic metabolic disorders worldwide and is associated with multiple long-term complications affecting various organ systems.[1] Among these complications, diabetic foot infection represents a major clinical and public health challenge due to its high morbidity, prolonged hospital stays, increased healthcare expenditure, and risk of lower limb amputation.[2] Diabetic foot infections occur because of peripheral neuropathy, peripheral vascular disease, impaired immunity, and poor wound healing associated with chronic hyperglycemia.

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Repeated trauma, unnoticed injuries, and secondary bacterial colonization contribute significantly to the development of chronic non-healing ulcers and soft tissue infections in diabetic patients.[3]

Diabetic foot infections range from superficial cellulitis to deep tissue abscesses, osteomyelitis, and gangrene. Early diagnosis and appropriate antimicrobial therapy play a crucial role in preventing progression of infection and reducing complications.[4] The success of treatment largely depends on accurate identification of the causative microorganisms and administration of targeted antibiotic therapy.[5] However, diabetic foot wounds are often polymicrobial, involving aerobic gram-positive cocci, gram-negative bacilli, and anaerobic organisms. Inappropriate or empirical antibiotic therapy may lead to persistent infection, emergence of multidrug-resistant organisms, delayed healing, and increased risk of amputation.[6]

Microbiological evaluation of diabetic foot infections is therefore an essential component of management. Various techniques are available for specimen collection, among which swab culture and deep tissue culture are the most practiced methods.[7] Swab culture is simple, non-invasive, inexpensive, and widely used in routine clinical practice. However, swab cultures frequently isolate surface colonizing organisms that may not accurately represent the true pathogens responsible for deep tissue infection. Surface contamination and poor correlation with invasive pathogens can result in inappropriate antibiotic selection and unsatisfactory clinical outcomes.[8,9]

Deep tissue culture, obtained after wound debridement from the base of the ulcer or infected tissue, is considered a more reliable method for identifying causative microorganisms. Deep tissue samples are less likely to be contaminated by superficial flora and provide better detection of anaerobic and resistant organisms.[10] Several studies have suggested that deep tissue culture has greater microbiological accuracy and better correlation with clinical infection compared to superficial swab cultures. Accurate microbiological diagnosis facilitates targeted antimicrobial therapy, reduces unnecessary antibiotic usage, minimizes antimicrobial resistance, and improves wound healing outcomes.[11]

Despite the recognized importance of microbiological evaluation, swab cultures continue to be widely utilized because of their convenience and ease of collection. In many healthcare settings, especially in resource-limited regions, the comparative effectiveness of deep tissue culture versus swab culture in guiding diabetic foot infection management remains inadequately evaluated. Determining the superiority of one method over the other is important for improving patient care and establishing standardized treatment protocols.

**Aims and Objectives**

- To compare the outcomes of diabetic foot infections treated based on deep tissue culture versus swab culture.

## MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of General Surgery at Sree Mookambika Institute of Medical Sciences over a period of 10 months from June 2025 to March 2026. Written informed consent was obtained from all participants prior to enrollment in the study. The study included patients admitted with diabetic foot infections requiring microbiological evaluation and wound management.

A total of 56 patients diagnosed with diabetic foot infections were included in the study. Patients were divided into two groups based on the microbiological method used for guiding antibiotic therapy. Group A consisted of patients treated according to swab culture sensitivity reports, while Group B included patients managed based on deep tissue culture sensitivity reports. Patients were selected by convenient sampling method from those admitted to the surgical wards and diabetic foot care unit during the study period.

**Inclusion Criteria**

- Patients aged above 18 years with diagnosed diabetes mellitus.
- Patients presenting with diabetic foot infections including ulcers, cellulitis, abscess, or gangrene.
- Patients willing to participate and provide informed consent.
- Patients requiring culture-guided antibiotic therapy.

**Exclusion Criteria**

- Patients with non-diabetic foot ulcers.
- Patients already receiving prolonged antibiotic therapy before admission.
- Patients with severe peripheral vascular disease requiring immediate vascular intervention.
- Patients with immunocompromised conditions such as HIV infection, malignancy, or long-term steroid therapy.
- Patients unwilling to participate in the study.

Detailed clinical history including duration of diabetes mellitus, treatment history, previous ulcer episodes, smoking history, and associated comorbidities was recorded. Thorough clinical examination was performed in all patients with assessment of ulcer size, depth, presence of discharge, cellulitis, necrosis, gangrene, peripheral pulses, and neuropathy. Baseline investigations including complete blood count, fasting and postprandial blood sugar, HbA1c, renal function

tests, serum electrolytes, and radiological evaluation when indicated were carried out.

For microbiological analysis, wound cleaning and debridement were performed under aseptic precautions. In Group A, sterile swab samples were collected from the ulcer surface after cleansing with normal saline. In Group B, deep tissue samples were obtained from the base of the ulcer or infected tissue after debridement using sterile instruments. Samples were immediately transported to the microbiology laboratory for Gram staining, culture, organism identification, and antibiotic sensitivity testing. Appropriate antibiotics were initiated according to culture sensitivity reports in both groups.

All patients received standard diabetic foot care including glycemic control, regular wound dressing, surgical debridement whenever required, and supportive therapy. Patients were followed up throughout hospitalization and during outpatient visits to assess wound healing progress and treatment response. Outcome parameters evaluated included duration of hospital stay, reduction in wound size, appearance of granulation tissue, control of infection, need for repeated debridement, requirement of amputation, and overall wound healing outcome.

Data obtained during the study were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were represented as frequency and percentage. Chi-square test and Student's t-test were used for comparison between groups. A p-value of less than 0.05 was considered statistically significant.

## OBSERVATION AND RESULTS

A total of 56 patients with diabetic foot infections were included in the present study. Patients were equally divided into Group A (swab culture-guided treatment) and Group B (deep tissue culture-guided treatment), with 28 patients in each group. Majority of patients were males, accounting for 39 (69.6%) cases. Most patients had poorly controlled diabetes with HbA1c greater than 8%, reflecting increased susceptibility to diabetic foot infections and delayed wound healing.

| Variables | Group A (Swab Culture) n=28 | Group B (Deep Tissue Culture) n=28 | Total n=56 |
|---|---|---|---|
| Age (years) Mean ± SD | 56.4 ± 9.2 | 54.8 ± 8.7 | 55.6 ± 8.9 |
| Male | 20 (71.4%) | 19 (67.9%) | 39 (69.6%) |
| Female | 8 (28.6%) | 9 (32.1%) | 17 (30.4%) |
| Duration of Diabetes >10 years | 16 (57.1%) | 18 (64.3%) | 34 (60.7%) |
| Smoking History | 11 (39.3%) | 10 (35.7%) | 21 (37.5%) |
| HbA1c >8% | 18 (64.3%) | 17 (60.7%) | 35 (62.5%) |

Table 1: Demographic Characteristics of Study Population

Ulcer discharge and peripheral neuropathy were the most common clinical findings observed in the study population. Nearly half of the patients demonstrated necrotic tissue, indicating advanced infection and chronicity of diabetic foot ulcers.

| Clinical Features | Group A n=28 | Group B n=28 | Total n=56 |
|---|---|---|---|
| Ulcer with Discharge | 24 (85.7%) | 25 (89.3%) | 49 (87.5%) |
| Cellulitis | 17 (60.7%) | 16 (57.1%) | 33 (58.9%) |
| Necrotic Tissue | 12 (42.9%) | 13 (46.4%) | 25 (44.6%) |
| Gangrene | 6 (21.4%) | 5 (17.9%) | 11 (19.6%) |
| Peripheral Neuropathy | 20 (71.4%) | 21 (75.0%) | 41 (73.2%) |
| Fever | 10 (35.7%) | 9 (32.1%) | 19 (33.9%) |

Table 2: Clinical Presentation of Diabetic Foot Infection

Staphylococcus aureus was the most frequently isolated organism in both groups. Deep tissue cultures demonstrated significantly higher detection of polymicrobial infections compared to swab cultures, indicating superior microbiological yield.

| Organisms Isolated | Group A n=28 | Group B n=28 | p-value |
|---|---|---|---|
| Staphylococcus aureus | 11 (39.3%) | 9 (32.1%) | 0.57 |
| Pseudomonas aeruginosa | 5 (17.9%) | 7 (25.0%) | 0.51 |
| Klebsiella species | 4 (14.3%) | 5 (17.9%) | 0.71 |
| Escherichia coli | 3 (10.7%) | 4 (14.3%) | 0.68 |
| Polymicrobial Growth | 5 (17.9%) | 11 (39.3%) | 0.04* |

Table 3: Microbiological Isolates Identified

Patients treated according to deep tissue culture sensitivity demonstrated significantly better wound healing outcomes and reduced persistent infection. Repeat debridement was more common in the swab culture group, suggesting comparatively inadequate microbial identification.

| Outcomes | Group A n=28 | Group B n=28 | p-value |
|---|---|---|---|
| Good Granulation Tissue Formation | 16 (57.1%) | 24 (85.7%) | 0.02* |
| Complete Wound Healing | 14 (50.0%) | 22 (78.6%) | 0.03* |
| Persistent Infection | 10 (35.7%) | 4 (14.3%) | 0.04* |
| Requirement of Repeat Debridement | 9 (32.1%) | 3 (10.7%) | 0.04* |
| Minor Amputation | 5 (17.9%) | 2 (7.1%) | 0.22 |

Table 4: Wound Healing Outcomes

Patients managed using deep tissue culture-guided therapy had significantly shorter hospital stay compared to patients treated according to swab culture reports. Improved antibiotic targeting and infection control likely contributed to faster recovery.

| Hospital Stay | Group A n=28 | Group B n=28 | p-value |
|---|---|---|---|
| ≤10 days | 9 (32.1%) | 18 (64.3%) | 0.01* |
| >10 days | 19 (67.9%) | 10 (35.7%) | 0.01* |
| Mean Duration (days) | 13.6 ± 3.8 | 9.8 ± 2.9 | <0.001* |

Table 5: Duration of Hospital Stay

Poor wound healing showed significant association with uncontrolled diabetes, polymicrobial infection, peripheral neuropathy, and gangrene. Longer hospital stay was strongly correlated with delayed wound healing and persistent infection.

| Variables | Poor Wound Healing n (%) | p-value |
|---|---|---|
| HbA1c >8% | 13 (72.2%) | 0.03* |
| Polymicrobial Infection | 9 (50.0%) | 0.01* |
| Peripheral Neuropathy | 14 (77.8%) | 0.04* |
| Gangrene Presence | 8 (44.4%) | 0.02* |
| Hospital Stay >10 days | 15 (83.3%) | <0.001* |

Table 6: Correlation Between Clinical Variables and Poor Wound Healing

Deep tissue culture-guided therapy showed significantly better antibiotic selection and infection resolution compared to swab culture-guided management. Lower readmission rates observed in the deep tissue culture group suggest improved long-term infection control and wound management.

| Clinical Outcome | Swab Culture Group | Deep Tissue Culture Group | p-value |
|---|---|---|---|
| Appropriate Antibiotic Selection | 17 (60.7%) | 25 (89.3%) | 0.01* |
| Infection Resolution | 18 (64.3%) | 24 (85.7%) | 0.04* |
| Limb Salvage | 23 (82.1%) | 26 (92.9%) | 0.21 |
| Readmission for Infection | 7 (25.0%) | 2 (7.1%) | 0.05* |

Table 7: Correlation Between Culture Method and Clinical Outcome

## DISCUSSION

The present study included 56 patients with diabetic foot infections, equally divided into swab culture-guided and deep tissue culture-guided treatment groups. The mean age of the study population was 55.6 ± 8.9 years, with most patients belonging to the older age group, highlighting the increasing burden of diabetic foot complications among middle-aged and elderly individuals. Male predominance was observed in 39 (69.6%) patients. Long-standing diabetes of more than 10 years duration was present in 34 (60.7%) patients, while poor glycemic control (HbA1c >8%) was noted in 35 (62.5%) patients, underscoring the role of chronic hyperglycemia in neuropathy, vascular insufficiency, and impaired wound healing.

Comparable demographic findings were reported by Seth A et al.[12] who studied 65 patients with diabetic foot infections and observed a mean age of 58.49 ± 11.04 years with a marked male predominance of

83.08%. Similarly, Fitrianingsih F et al.[13] reported a mean age of 55.6 ± 12.6 years among diabetic foot ulcer patients, while Maharini I et al.[14] documented a mean age of 55.19 ± 9.36 years, indicating that diabetic foot infections predominantly affect older diabetic individuals with long-standing disease.

Ulcer discharge was the most common clinical presentation in the present study, occurring in 49 (87.5%) patients, followed by peripheral neuropathy in 41 (73.2%) and cellulitis in 33 (58.9%) patients. Necrotic tissue was observed in 25 (44.6%) patients, while gangrene was present in 11 (19.6%) cases, reflecting advanced tissue destruction and compromised vascularity. Fever was noted in 19 (33.9%) patients, indicating systemic inflammatory response in severe infections.

These observations are consistent with the findings of Seth A et al.[12] who reported ulceration in 92.31% and wound discharge in 72.31% of patients. They further demonstrated that severe diabetic foot infections were significantly associated with poor ulcer healing, higher rates of major amputations, and increased hospital readmissions. Likewise, Maharini I et al.[14] reported severe infection in 69.3% of patients and a predominance of Wagner grade 5 ulcers, emphasizing the advanced nature of diabetic foot disease encountered in tertiary care settings.

Microbiological evaluation in the present study revealed Staphylococcus aureus as the most frequently isolated organism in both groups. Polymicrobial growth was identified more frequently in the deep tissue culture group, affecting 11 (39.3%) patients compared with 5 (17.9%) patients in the swab culture group. This suggests that deep tissue cultures are more effective in identifying true pathogens from infected tissues while minimizing contamination from superficial colonizing flora.

Similar microbiological findings were reported by Latha D et al.[15] who found Staphylococcus aureus to be the predominant pathogen and demonstrated significantly better detection of polymicrobial infections with tissue cultures than with swab cultures. The authors also observed higher clinical and microbiological cure rates in the tissue culture group. Likewise, Camilleri Attard F et al.[16] reported a significant difference between deep tissue and superficial swab cultures ($p = 0.028$), concluding that deep tissue specimens provided superior identification of infecting microorganisms.

The findings of the present study are further supported by Li X et al.[17] who demonstrated that soft tissue cultures showed greater microbiological concordance with bone cultures than swab cultures. They concluded that targeted antibiotic therapy should be based on deep tissue or bone culture results because these samples more accurately identify causative pathogens. Similarly, Huang Y et al.[18] reported that swab cultures had good concordance with deep tissue cultures in Grade 2 ulcers but significantly lower sensitivity in Grade 3 and Grade 4 ulcers, particularly for Gram-negative organisms, emphasizing the value of deep tissue sampling in advanced infections.

Patients managed according to deep tissue culture sensitivity demonstrated superior clinical outcomes in the present study. Good granulation tissue formation was observed in 24 (85.7%) patients in the deep tissue culture group compared with 16 (57.1%) patients in the swab culture group. Complete wound healing occurred in 22 (78.6%) patients receiving deep tissue culture-guided treatment, whereas only 14 (50.0%) patients in the swab culture group achieved complete healing. Persistent infection and repeated debridement were more common among patients treated based on swab culture reports.

Comparable results were reported by Latha D et al.[15] who observed better healing outcomes and lower rates of persistent infection among patients managed using tissue culture-guided therapy. Similarly, Gurulingaiah A et al.[19] demonstrated that while swab cultures showed reasonable concordance with tissue cultures in Grade 2 ulcers, tissue cultures were superior for higher-grade ulcers and provided more reliable microbiological information for guiding treatment.

Hospital stay was significantly shorter among patients managed according to deep tissue culture reports, with a mean duration of 9.8 ± 2.9 days compared to 13.6 ± 3.8 days in the swab culture group. Poor wound healing was significantly associated with uncontrolled diabetes, peripheral neuropathy, polymicrobial infection, gangrene, and prolonged hospitalization.

Comparable hospitalization patterns were reported by Fitrianingsih F et al.[13] who documented a mean hospital stay of 10.3 ± 6.9 days among diabetic foot ulcer patients, while Maharini I et al.[14] reported a median hospital stay of 7 days. These findings indicate that disease severity, infection burden, and adequacy of treatment significantly influence hospitalization duration and clinical outcomes.

In contrast, Haalboom M et al.[20] observed a high level of agreement between swab and biopsy cultures for commonly isolated pathogens such as Staphylococcus aureus and Pseudomonas aeruginosa, suggesting that invasive biopsy may not always be necessary. However, their findings were largely applicable to less complicated wounds and did not fully account for the microbiological complexity of advanced diabetic foot infections, where deep tissue cultures appear to offer a clear diagnostic advantage.

The microbiological complexity of diabetic foot infections was further highlighted by Garg R et al.[21] who identified anaerobic organisms in 22% of diabetic foot ulcer samples. The authors emphasized the importance of performing comprehensive

aerobic and anaerobic cultures along with antimicrobial susceptibility testing, particularly in the context of emerging antimicrobial resistance.

## CONCLUSION

The present study demonstrated that deep tissue culture-guided management of diabetic foot infections provides superior clinical outcomes compared to swab culture-based treatment. Deep tissue cultures showed better identification of infecting organisms, including polymicrobial infections, leading to more appropriate antibiotic selection and improved infection control. Patients managed using deep tissue culture reports had better granulation tissue formation, higher rates of complete wound healing, fewer repeat debridement, and shorter hospital stay. Poor glycemic control, peripheral neuropathy, gangrene, and polymicrobial infection were significantly associated with delayed healing. Early microbiological evaluation using deep tissue culture can improve treatment effectiveness and reduce complications in diabetic foot infections.

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**Conflicts of Interest**

There are no conflicts of interest

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