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Original Research

# Role of bone biopsy specimen culture in the management of diabetic foot osteomyelitis

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ABSTRACT

*Introduction:* There has been increasing evidence in favor of conservative management of diabetic foot osteomyelitis which requires targeted antibiotic therapy to the causative pathogen. But the method of reliable microbiological isolation is controversial.
*Aims and objectives:* To study the concordance of superficial swab culture with bone biopsy specimen culture in patients with diabetic foot osteomyelitis.
*Materials and methods:* A prospective study was conducted from July 2008 to July 2010. All consecutive patients with suspected diabetic foot osteomyelitis were included in the study. Superficial swab and Percutaneous bone biopsy specimens were obtained for culture. The culture results in these two groups were compared for concordance.
*Results:* A total of 144 patients were included in the study. 134 cases of bone biopsy specimen and 140 cases of superficial swab showed positive culture results. Mean number of isolate per sample was similar. Staphylococcus aureus was the commonest organism grown in both cultures. The bone pathogen was identified in the corresponding swab culture in only 55 cases (38.2%). Staphylococcus aureus had the highest concordance percentage of 46.5% which was not statistically significant.
*Conclusion:* Superficial swab culture may not be accurate in identifying all the organisms causing diabetic foot osteomyelitis. Bone biopsy specimen taken simultaneously would increase the accuracy of detecting the bacterial isolate.



## 1. Introduction

Management of diabetic foot osteomyelitis is controversial. Even though the traditional approach for diabetic foot infection is surgical resection of infected tissue, there is growing evidence to support conservative management.[1] Conservative management chiefly consists of antibiotic therapy with little or no surgery. Conservative management of diabetic foot osteomyelitis warrants a reliable microbiological documentation of the causative pathogens.[2] Use of ulcer swab cultures and deep tissue culture for deciding the antibiotics seems to be unreliable as there is chance of these specimens getting contaminated by superficial colonizing flora. Bone specimen culture is considered the gold standard for isolating the causative organism.[3] Since bone biopsy culture is not readily available, expensive and has a theoretical possibility of adverse effects it has been largely replaced by wound culture. The aim of the study was to analyze the concordance of superficial swab culture and bone biopsy culture in diabetic foot ulcer patients with underlying osteomyelitis.

## 2. Methods

The study was conducted in the Department of surgery, JIPMER from July 2008 to July 2010. It was a prospective analytic study. All diabetic foot ulcer patients attending JIPMER casualty or outpatient department with clinical features suspicious of underlying osteomyelitis were included in the study. Diabetic foot osteomyelitis was suspected in patients who had atleast two of the following clinical criteria. 1. Ulcer lasting for more than or equal to 2 weeks. 2. Ulcer overlying a bony prominence. 3. Ulcer with a surface area $> 2$ cm$^2$. 4. Ulcer depth $> 3$ mm. 5. Positive probing of bone in ulcer base. 6. Foot ulcer with primary bone exposure. Patients with gangrene of the foot and Charcot's joint were excluded from the study. Plain radiograph of the affected foot was done to document osteomyelitis. Superficial ulcer swab from the base of the ulcer was taken for culture. Bone biopsy specimen for culture was obtained from the underlying bone either percutaneously or by open biopsy using an 11-gauge bone biopsy needle. Under sterile precautions and local anaesthesia, bone biopsy was obtained from the underlying bone through a 5 mm incision in the apparently normal skin.

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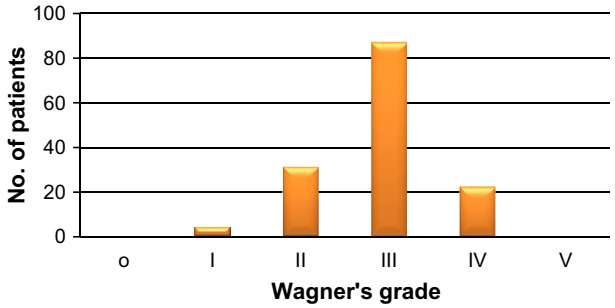


**Fig. 1.** Wagner's grade of diabetic foot infection ($n$ - 144).

Aerobic culture of superficial ulcer swabs and bone biopsy specimens was done. Percentage of concordance with regard to organisms grown in both the culture was assessed. Kappa value and percentage agreement were calculated to assess the concordance. The percentage of agreement was interpreted using Kappa value. Kappa value - <0.4 denoted poor agreement, 0.4–0.7 - good agreement and >0.7 - excellent agreement.

## 3. Results

A total of 144 diabetic foot ulcer patients with suspected osteomyelitis were included in the study. The mean age of the patients was 56.6 ± 4.2 years and the mean duration of diabetes was 8.6 ± 2.3 years. The mean duration of foot ulceration prior to hospital visit was 13.5 ± 3.5 days. 83(57.2%) patients had received treatment for foot ulceration in the form of oral or intravenous antibiotics or debridement prior to admission. 87(60.4%) patients were found to have grade III foot infection (Fig. 1). The common sites of foot ulcers were over the first metatarsal (33.3%) and in the region of phalanx (20.1%). 37(25.7%) patients had primary exposure of underlying bone and hence Probe to bone test was done in the remaining 107 patients. Of these 90(84.1%) patients had positive probing. 86(59.7%) patients had radiological signs of osteomyelitis in the underlying bone in the form of osteolysis or cortex destruction. Ulcer swabs and bone biopsy specimens were taken from all 144 patients. No adverse effects like bleeding or fracture were encountered while taking bone biopsy. Of the 144 patients, 140 ulcer swabs and 134 bone biopsy specimens showed positive culture. Mean number of isolates per specimen was 2.02 and 1.9 for ulcer swab and bone biopsy specimen respectively. Most common organism grown in cultures of swab and bone biopsy specimen was *Staphylococcus aureus*. Overall, pathogens were equally represented in cultures of ulcer swab and bone biopsy specimen (Table 1). On comparing the cultures of ulcer swab and bone biopsy specimens, the cultures were strictly identical in 17 cases (11.8%) (Table 2). Atleast one bone pathogen was grown in the corresponding ulcer swab culture in 55 cases (38.2%). Concordance between the cultures was assessed by the percentage of bone and swab samples which isolated same pathogen in a given patient. Concordance percentage ranged from 0 to 46.5% with an overall concordance of 29.1% (Table 4). Best concordant results were observed for *Staphylococcus aureus* (46.5%). Kappa value to assess percentage of agreement was calculated for the 2 most common organisms grown in the culture. Both had Kappa value of <0.4 which denoted a poor agreement (Table 4). A subgroup analysis was done in 86 patients who had radiological evidence of osteomyelitis (Table 3). Overall concordance among pathogens grown in bone biopsy and ulcer swab culture in this subgroup was 31.2% with *Staphylococcus aureus* having the highest correlation of 51.1% which also had poor agreement on calculating Kappa value (<0.4) (Table 5).

**Table 1**
Organisms isolated in ulcer swab and bone biopsy specimen culture in diabetic foot ulcer patients with suspected osteomyelitis.

| Organism | Swab (%) ($n$ = 288) | Bone biopsy (%) ($n$ = 264) |
|---|---|---|
| *Staphylococcus aureus* | 66(22.9) | 82(31.1) |
| *Pseudomonas* species | 50(17.4) | 50(18.8) |
| *Acinetobacter baumannii* | 41(14.2) | 35(13.3) |
| *Escherichia coli* | 37(12.8) | 37(14.0) |
| *Proteus* species | 34(11.8) | 25(9.5) |
| *Klebsiella* species | 26(9.1) | 19(7.2) |
| *Streptococcus pyogenes* | 18(6.2) | 8(3.0) |
| *Enterobacter* species | 6(2.1) | 2(0.8) |
| Others | 10(3.5) | 6(2.3) |

**Table 2**
Concordance between ulcer swab and bone biopsy specimen cultures diabetic foot ulcer patients with suspected osteomyelitis($n$ - 144).

| Degree of concordance | No. of cultures | Percentage |
|---|---|---|
| Identical | 17 | 11.8 |
| At least 1 organism similar | 38 | 26.4 |
| Different | 89 | 61.8 |

## 4. Discussion

Detection of diabetic foot osteomyelitis requires high index of suspicion. In the present study ulcer characteristics like duration of ulceration for >2 weeks, surface area > 2 $cm^2$, ulcer overlying bony prominence, depth more than 3 mm and positive probing, which have been reported to have increased risk of diabetic foot osteomyelitis were used for selecting patient.[4] Bone culture was positive in 97% of the patients included in the present study. This shows that these criteria are more sensitive in identifying patients with diabetic foot osteomyelitis. Depth and surface area of the ulcer were found to be the most important factors in the development of osteomyelitis. Probe to bone test is one of the standard test used to detect osteomyelitis.[5] In the present study, all probing positive patients had positive bone culture. This shows the high specificity rate of this test. Use of plain X-ray radiographs to detect osteomyelitis is the most economical investigation in patients with diabetic foot.[6] In the present study, plain X-ray radiographs of the foot taken at the time of admission showed signs of osteomyelitis in only 56.7% of patients and this was significantly low when compared to 93% positive bone culture. This can be explained by the fact that the radiological changes might not have developed at the time of presentation.

Swab specimens taken from the ulcer base has been the traditional method of isolating causative pathogens in diabetic foot infection. In the present study, swab culture had a positivity of 97.2% which was comparable to 96.8% in a similar retrospective study by Senneville et al.[7] Though culture of bone specimen is considered to be the gold standard for conclusive microbiological diagnosis in osteomyelitis, it has not been well accepted by the medical community because of its invasiveness and the possibility of worsening of peripheral vascular disease and neuropathy.[8] Several studies have documented the safety and efficacy of bone

**Table 3**
Concordance between ulcer swab and bone biopsy specimen cultures diabetic foot ulcer patients with radiologically proven osteomyelitis ($n$ - 86).

| Degree of concordance | No. of cultures ($n$ - 86) | Percentage |
|---|---|---|
| Identical | 12 | 13.9 |
| Atleast 1 organism similar | 24 | 27.9 |
| Different | 50 | 58.2 |

**Table 4**
Distribution of organism in ulcer swab and/or bone biopsy specimen cultures in diabetic foot ulcer patients with suspected osteomyelitis (*n* - 144).

| Organism | From swab only | From bone only | From both bone and swab | Concordance[a] % | Kappa value[b] |
|---|---|---|---|---|---|
| *Staphylococcus aureus* | 19 | 35 | 47 | 46.5 | 0.25 |
| *Pseudomonas* species | 22 | 22 | 28 | 38.9 | 0.2 |
| *Acinetobacter baumunii* | 27 | 21 | 14 | 22.6 | |
| *Escherichia coli* | 23 | 23 | 14 | 23.3 | |
| *Proteus* species | 24 | 15 | 10 | 20.4 | |
| *Klebsiella* species | 20 | 13 | 6 | 15.3 | |
| *Streptococcus pyogenes* | 16 | 6 | 2 | 8.3 | |
| *Enterobacter* species | 6 | 2 | 0 | 0 | |
| Total | 157 | 137 | 121 | 29.1 | |

[a] Percentage of bone and swab cultures which isolated the same pathogen in a given patient.
[b] Kappa value - <0.4 = poor agreement. Calculated for 2 most common organisms isolated.

**Table 5**
Distribution of organism in ulcer swab and/or bone biopsy specimen cultures in diabetic foot ulcer patients with radiologically proven osteomyelitis (*n* - 86).

| Organism | From swab only | From bone only | From both bone and swab | Concordance[a] % | Kappa value[b] |
|---|---|---|---|---|---|
| *Staphylococcus aureus* | 5 | 21 | 28 | 51.1 | 0.3 |
| *Pseudomonas* species | 12 | 16 | 18 | 39.1 | 0.2 |
| *Acinetobacter baumunii* | 18 | 9 | 10 | 27.0 | |
| *Escherichia coli* | 17 | 11 | 8 | 22.2 | |
| *Proteus* species | 13 | 7 | 6 | 23.1 | |
| *Klebsiella* species | 11 | 6 | 3 | 15.0 | |
| *Streptococcus pyogenes* | 11 | 3 | 1 | 6.7 | |
| *Enterobacter* species | 3 | 0 | 0 | 0 | |
| Total | 90 | 73 | 74 | 31.2 | |

[a] Percentage of bone and swab cultures which isolated the same pathogen in a given patient.
[b] kappa value - <0.4 = poor agreement. Calculated for 2 most common organisms isolated.

biopsy in diabetic foot.[9] In the present study, bone biopsy was obtained by a bone biopsy needle through a normal area in the surrounding skin. This technique was followed to avoid contamination by the organisms in the ulcer. There were no complications during or after performing bone biopsy. In the present study culture of bone biopsy specimen was positive in 93% of the patients, contrary to the study by Senneville et al in 2009 which reported only 67.7%.[10] This difference may be due to higher grade of wound infection in the patients included in the present study.

Overall concordance percentage between bone and swab culture in patients with suspected diabetic foot osteomyelitis as well as radiologically proven osteomyelitis in the present study were comparable to results of earlier similar studies. Senneville et al in 2006 based on a retrospective analysis on 69 patients with documented diabetic foot osteomyelitis showed that the bone and swab culture had an overall concordance of 22.5%.[7] Ertugrul in their prospective study on 45 patients with diabetic foot infections showed that the bone and soft tissue cultures were identical in 49% of the cases.[11] The concordance between the cultures results of ulcer swab and of bone biopsy specimens was found to be maximum for *Staphylococcus aureus* (46.5%) which was comparable to previous similar studies.[7,11]

This study had few limitations like use of clinical criteria to select osteomyelitis patients, use of open bone biopsy technique in some cases and no confirmation of bone infection by histopathology.

In conclusion, this study confirms the poor reliability of ulcer swab culture in isolating all the pathogens causing osteomyelitis in diabetic foot ulcer patients. Bone biopsy specimen culture along with ulcer swab culture would give a reliable isolate for effective management. As bone biopsy specimen culture is not readily available and needs expertise for obtaining it, we recommend bone biopsy specimen culture at least for diabetic foot ulcer patients with suspected underlying osteomyelitis.

*Ethical approval*

Approval was given by Ethics committee, JIPMER, Puducherry. Reference no. DME/34/EC.

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None.

*Conflict of interest*

None to declare.

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