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Osteomyelitis in Diabetic Foot Ulcers: Frequency and Associated Risk Factors at the National Diabetes Centre, Iraq

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Research Article

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Osteomyelitis in Diabetic Foot Ulcers: Frequency and Associated Risk Factors at the National Diabetes Centre, Iraq

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Abstract

Objective of the study: Objective: To determine the frequency of diabetic foot osteomyelitis and identify independently associated factors among adults with type 2 diabetes and foot ulcers attending a specialist diabetic foot clinic in Baghdad, Iraq.

Methods: This analytical cross-sectional study consecutively enrolled 208 adults with type 2 diabetes and diabetic foot ulcers between 1 February 2025 and 5 January 2026. Demographic, clinical, ulcer, laboratory, microbiological, vascular, and neurological data were obtained through interviews, examinations, and medical record review. Osteomyelitis was classified using the study's prespecified clinical, probe-to-bone, radiographic, and culture criteria. Binary logistic regression was used to identify factors independently associated with osteomyelitis.

Results: Of the 387 patients initially assessed for eligibility, 179 were excluded, leaving 208 patients who completed the structured interview and clinical assessment and were included in the final analysis. Osteomyelitis was identified in 45 patients (21.6%). Recurrent ulcers, prolonged ulcer duration, hypertension, and neuropathy were independently associated with osteomyelitis.

126 (60.6%) males and 82 (39.4%) females, aged between 31 and 93 years, with a mean age (± SD) of 60.9 (± 10.85) years; the mean duration of diabetes was 16.88 years (± SD 7.42) among the study participants. 80 patients (38.5%) were overweight, and 67 patients (32.2%) were obese. According to the HbA1c reading, 173 patients (83.2%) had uncontrolled diabetes, and the mean HbA1c was 9.06 ± 1.96. Most patients had hypertension and dyslipidemia (68.3%, 59.6%, respectively). The frequency of retinopathy was 62.5%, and microalbuminuria was 16.3%.

Conclusion: The frequency of osteomyelitis among type 2 DM patients with foot ulceration attending the diabetic foot clinic was 21.6%. Osteomyelitis of the foot bones is often difficult to diagnose and a serious problem in patients with diabetic foot ulcer (DFU)**.** This study showed that diabetic patients with recurrent ulceration, ulcers with long duration, hypertension, and neuropathy have a significantly increased risk of developing osteomyelitis.

Keywords: Diabetic foot osteomyelitis (DFO), Diabetic foot ulcer (DFU), Bone infection, Peripheral neuropathy, Peripheral vascular disease, Wound infection.

Introduction:

Osteomyelitis represents one of the most taxing conditions in orthopedic and infectious disease medicine, impacting patients both physically and economically. In people with type 2 diabetes, diabetic foot ulceration provides a route for infection to extend into bone, increasing the need for prolonged antimicrobial therapy, surgery, hospitalization, and lower-extremity amputation (Benyakorn., 2024)

As reported by the World Health Organisation (WHO) in 2020, over 13.9% of adults in Iraq have diabetes, with many unaware of their condition.

Regardless of the type of diabetes, prolonged poor glycemic control can lead to damage in both small and large blood vessels, as well as nerves. This damage contributes to various complications, particularly affecting the feet. Diabetic foot complications are among the most common causes of hospital admissions for patients with diabetes (Feleke et al., 2024)

Four to ten per cent of diabetics develop lower-extremity ulcers (Luo et al., 2024). Patients with diabetes may have a 25% lifetime chance of getting a foot ulcer (Shachar et al., 2025). The risk of amputation in patients with diabetes is 15 to 25 times higher than in non-diabetic patients, and according to one study, every 20 seconds, a lower limb is amputated worldwide. (Mganwa and others, 2022). Patients with diabetes have a nearly seven-fold increased risk of infection; over half of their ulcers will develop a clinical infection.

Wounds among diabetic patients represent a class of ulcers that extend to underlying bone (Jais et al., 2023). Chronic non-healing wounds that can lead to the development of soft tissue infections and osteomyelitis. Hospitalisation is the most expensive part of treating wound infection in diabetic patients. Patients with wound infection need early and close follow-up and observation to make sure that the selected medical and surgical treatment regimens are appropriate and effective. (Hwekwete et al., 2025).

Diabetic foot infections frequently cause morbidity, hospitalisation, and amputations Ali. (2020). Underlying osteomyelitis frequently complicates ulceration of the foot in patients with diabetes; the bones involved are usually in the forefoot, especially the first digit (Biz et al., 2025). Bone Infection may be due to Gram-positive aerobic bacteria and Gram-negative aerobic and anaerobic bacteria, alone or in combination. Staphylococcus aureus and Staphylococcus epidermidis are the most frequent agents causing bone infection, which are often methicillin resistant, particularly in Europe and Iraq (Arnold et al., 2026; Ali et al., 2024). Healing of osteomyelitis is difficult when associated with extensive surrounding soft tissue infection in a diabetic patient, and therefore, amputation might be unavoidable (Lipsky & Uçkay., 2021). Treatment of osteomyelitis is costly and requires a long period; it includes removal of infected bone with a long-term course of antimicrobial therapy (Cloob., 2020).

Previous studies have described the diagnostic performance of the probe-to-bone test and imaging, the microbiology of diabetic foot infection, and selected predictors of osteomyelitis. However, reported frequencies and associated factors vary substantially across settings, and evidence from Iraq remains limited. In particular, the independent contributions of ulcer characteristics, neuropathy, vascular disease, and cardiometabolic comorbidity have not been adequately evaluated in Iraqi specialist-clinic populations. Therefore, this study aimed to determine the frequency of osteomyelitis among adults with type 2 diabetes and foot ulcers and to identify demographic, clinical, ulcer-related, and laboratory factors independently associated with osteomyelitis.

METHODS

Study design and setting:

This analytical cross-sectional study was conducted at the diabetic foot clinic of the National Diabetes Centre / Baghdad, Iraq. The clinic is a specialist referral service providing preventive, diagnostic, and therapeutic diabetic foot care.

Data collection and procedure:

Data were collected from 1 February 2025 to 5 January 2026. The study was explained to each participant, and verbal informed consent was obtained before enrollment.

Data sources and measurement: A structured data-collection form was used to record information obtained from participant interviews, direct clinical examination, and medical records. Demographic and history variables were obtained by interview and record review; anthropometric, vascular, neurological, musculoskeletal, and ulcer variables were assessed clinically; and HbA1c, inflammatory markers, radiographs, probe-to-bone findings, and microbiological cultures were obtained from hospital records and the treating clinical team. Osteomyelitis was confirmed by positive bone culture combined with compatible clinical and radiological findings.

Variables collected:

The outcome was diabetic foot osteomyelitis status. Non-outcome variables comprised age, sex, body mass index (BMI), smoking status, diabetes duration, diabetes treatment, HbA1c, hypertension, dyslipidemia, retinopathy, microalbuminuria, previous amputation, peripheral vascular disease, neuropathy, foot deformity, ulcer grade, site, duration, recurrence, cause, white blood cell count, erythrocyte sedimentation rate, C-reactive protein, radiographic findings, probe-to-bone findings, culture positivity, and cultured organisms. Operational definitions are provided in the Supplementary Table.

Sampling:

Consecutive sampling was used; all eligible patients presenting during the study period were invited until the end of data collection. This approach reduced investigator selection of individual participants, although the clinic-based sample may still be affected by referral and selection bias. Initially, 387 patients with diabetic foot ulcers were screened for eligibility. After applying the inclusion and exclusion criteria, 179 patients were excluded, and 208 patients were included in the final analysis. All enrolled participants received standardised clinical, laboratory, radiological, and microbiological assessments. Forty-five (21.6%) of the patients included in the study were diagnosed with osteomyelitis, and 163 (78.4%) had diabetic foot ulcers without signs of osteomyelitis. As shown in Figure 1.

Outcome definition:

Diabetic foot osteomyelitis was operationally defined as clinically suspected contiguous bone infection in a diabetic foot ulcer supported by a positive bone/deep-tissue culture and/or compatible probe-to-bone and plain-radiographic findings, interpreted with clinical evidence of infection. Patients not meeting these criteria were categorized as non-osteomyelitis. Bone histopathology and magnetic resonance imaging were not routinely available.

Categorization of continuous variables:

Age, BMI, diabetes duration, ulcer duration, HbA1c, and laboratory markers were categorized using clinically interpretable thresholds adopted in the study protocol or routine practice. Categories were selected before analysis to facilitate clinical interpretation and comparison of risk strata; however, categorization may reduce information and statistical power. Continuous summaries were therefore also reported where available.

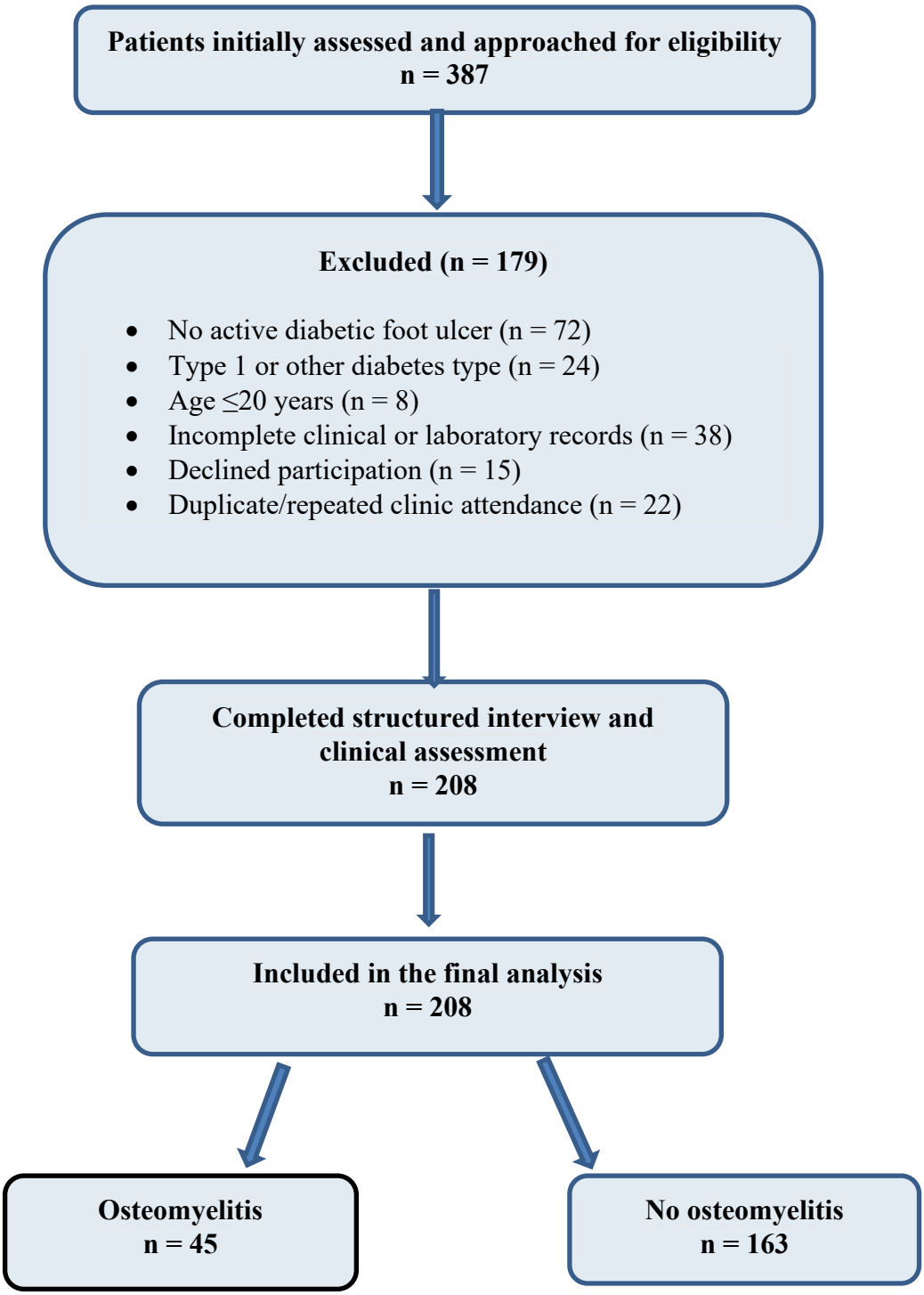
Sample-size justification:

For estimation of a single proportion, the minimum sample size was calculated using $n = Z^2p(1-p)/d^2$. Using a two-sided 95% confidence level ($Z = 1.96$), an anticipated osteomyelitis frequency of 19.9% from a prior diabetic-foot study (23), and an absolute precision of 6%, the minimum was 171 participants. Allowing 15% for incomplete data yielded a target of 197; the achieved sample of 208 exceeded this requirement. The calculation followed the approach described by Prasad, K. (2020).

Bias control:

Consecutive recruitment was used to reduce investigator-driven selection; a structured form and standardized clinical assessments were used to limit information and measurement bias; data-entry checks against source forms reduced transcription error; and multivariable logistic regression was used to reduce confounding. Because the study was cross-sectional and clinic-based, temporal ambiguity, residual confounding, referral bias, and diagnostic misclassification could not be eliminated.

Figure 1. Flowchart of patient screening, exclusions, clinical assessment, and inclusion in the final analysis.



Criteria for inclusion

Patients were eligible for inclusion if:

1. Were over 20 years old.
2. Had a definite diagnosis of diabetes mellitus type 2.
3. Had a current diabetic foot ulcer at the time of assessment.
4. Attended the diabetic foot clinic at the **National Diabetes Centre** during the study period 1 February 2025 to 5 January 2026
5. Consented verbally to participate.
6. Had adequate clinical and laboratory data for study assessments.

Exclusion Criteria

Exclusion criteria for patients were:

1. No active diabetic foot ulcer.
2. Had diabetes mellitus type 1 or any other type of diabetes.
3. Were 20 years old or younger.
4. Lacked clinical or laboratory information required for the analysis.
5. Did not consent to, or chose not to participate.

Statistical analysis

Statistical analysis was performed using SPSS version 17.0. Source forms were checked to identify and correct data-entry errors. Continuous variables were summarized as mean ± standard deviation, and categorical variables as number and percentage. Associations between categorical variables and osteomyelitis status were assessed using the chi-square test, as appropriate. The frequency of osteomyelitis was reported with a 95% confidence interval, and two-sided $p<0.05$ indicated statistical significance. Binary logistic regression was then used to estimate adjusted odds ratios (ORs) with 95% confidence intervals (CIs) and to determine which candidate factors were independently associated with osteomyelitis after adjustment for potential confounding. Candidate variables were selected from clinically relevant demographic, diabetes-related, comorbidity, ulcer, and examination factors.

Ethical Considerations

The study was conducted after approval by the ethics committee of the National Diabetes Centre. Verbal informed consent was obtained and documented for all participants. Data were de-identified, kept confidential, and used solely for scientific purposes. Vascular assessment included palpation of dorsalis pedis and posterior tibial pulses, history of intermittent claudication, and examination for clinical signs of ischemia, including hair loss, shiny or pale skin, and reduced skin temperature.

Neurological assessment included loss of protective sensation using a 10-g monofilament and symptoms of numbness or burning.

Musculoskeletal assessment, by detecting the presence of the following: deformity, callus, dryness, and previous amputation.

Ulcer assessment includes: ulcer location, ulcer duration, recurrence of ulcers and ulcer classification grade 1, 2, 3, 4 or 5 according to Wagner classification Table (1)

Table 1: Wagner Diabetic Foot Wound Classification System	
0 Grade	No ulcer in a high risk foot
1 Grade	Superficial ulcer involving the full skin thickness but not underlying tissues.
2 Grade	Deep ulcer, penetrating down to ligaments and muscle, but no bone involvement or abscess formation
3 Grade	Deep ulcer with cellulites or abscess formation, often with osteomyelitis
4 Grade	Localized gangrene
5 Grade	Extensive gangrene involving the whole foot

RESULTS

The study included 208 patients with type 2 diabetes, 126(60.6%) males and 82(39.4%) females, aged between 31and 93 years with a mean age (± SD) of 60.9 (± 10.85) years. Participant sociodemographic, anthropometric, clinical, and ulcer characteristics are summarized in Tables 2 and 3.

Table 2. Sociodemographic, anthropometric, clinical, and ulcer characteristics of participants (n=208). For binary variables, only the "Yes" category is shown.

Domain	Variable/category	n (%)
Sociodemographic/anthropometric: Gender	Male	126 (60.6)
Sociodemographic/anthropometric: Gender	Female	82 (39.4)
Sociodemographic/anthropometric: Age	<50	30 (14.4)
Sociodemographic/anthropometric: Age	50-65	108 (51.9)
Sociodemographic/anthropometric: Age	>65	70 (33.7)
Sociodemographic/anthropometric: BMI	Normal	61 (29.3)
Sociodemographic/anthropometric: BMI	Over Weight	80 (38.5)
Sociodemographic/anthropometric: BMI	Obese	67 (32.2)
Sociodemographic/anthropometric: Treatment	Diet	6 (2.9)
Sociodemographic/anthropometric: Treatment	Oral	41 (19.7)
Sociodemographic/anthropometric: Treatment	Insulin	87 (41.8)
Sociodemographic/anthropometric: Treatment	Insulin + Oral	74 (35.6)
Sociodemographic/anthropometric: Smoking	No	113 (54.3)
Sociodemographic/anthropometric: Smoking	Past	67(32.3)
Sociodemographic/anthropometric: Smoking	Current	28 (13.5)

Sociodemographic/anthropometric: HbA1c	Control	35 (16.8)
Sociodemographic/anthropometric: HbA1c	Uncontrolled	173 (83.2)
Sociodemographic/anthropometric: Duration of DM	<5	7 (3.4)
Sociodemographic/anthropometric: Duration of DM	5-10	40 (19.2)
Sociodemographic/anthropometric: Duration of DM	>10	161 (77.4)
Clinical: Hypertension	Yes	142 (68.3)
Clinical: Dyslipidemia	Yes	124 (59.6)
Clinical: Retinopathy	Yes	130 (62.5)
Clinical: Microalbuminuria	Yes	34 (16.3)

Table 3. Sociodemographic, anthropometric, clinical, and ulcer characteristics of participants (n=208). For binary variables, only the "Yes" category is shown.

Clinical: Deformity	Yes	46 (22.1)
Clinical: Amputation	Yes	47 (22.6)
Clinical: PVD	Yes	54 (26)
Clinical: Neuropathy	Yes	98 (47.1)
Ulcer: Ulcer classification	Grade 1	53 (25.5)
Ulcer: Ulcer classification	Grade 2	108 (51.9)
Ulcer: Ulcer classification	Grade3	41 (19.7)
Ulcer: Ulcer classification	Grade4	5 (2.4)
Ulcer: Ulcer classification	Grade5	1 (0.55)
Ulcer: Ulcer location	Forefoot	106 (51)
Ulcer: Ulcer location	Midfoot	57 (27.4)
Ulcer: Ulcer location	Hind Foot	45 (21.6)
Ulcer: Ulcer Duration	<30 Day	140 (67.3)
Ulcer: Ulcer Duration	30-90 Day	29 (13.9)
Ulcer: Ulcer Duration	>90 Day	39 (18.8)
Ulcer: Cause of ulcer	Friction	43 (20.7)
Ulcer: Cause of ulcer	Pressure	32 (15.4)
Ulcer: Cause of ulcer	Foreign Body	33 (15.9)
Ulcer: Cause of ulcer	Trauma	33 (15.9)
Ulcer: Cause of ulcer	Burn	32 (15.4)

Ulcer: Cause of ulcer	Fungal Infection	10 (4.8)
Ulcer: Cause of ulcer	Unknown	25 (12)
Ulcer: Ulcer recurrent	Yes	43 (20.7)
Ulcer: Ulcer recurrent	No	165 (79.3)

Their socio-demographic, clinical characteristics are presented in Table 4. All of the study participants had type 2 diabetes; seven patients had a duration of diabetes less than 5 years (3.4%), forty patients between 5 and 10 years (19.2%), and the mean duration of diabetes was 16.88 years ± (SD 7.44) among the study participants. Table 2 also shows that 80 patients (38.5%) were overweight and 67 patients (32.2%) were obese. According to HbA1c readings, 173 patients (83.2%) had uncontrolled diabetes among the study participants, and the mean HbA1c was 9.06± ± SD1.96. 13.5% of the study participants were current smokers, 32.2% were past smokers, and 54.3% were nonsmokers. A87 patients (41.8%) in the study group were on insulin alone and 41 patients (19.7%) were on oral hypoglycemic agents, 74 patients (36.6%) were on oral and insulin agents, and 6 patients (2.9%) were not receiving treatment.

Table 4: Socio-demographic and anthropometric characteristics of the study participants (n=208)

Variables	**NO (%)**
Gender	
Male	126 (60.6)
Female	82 (39.4)
Age	
<50	30 (14.4)
50–65	108 (51.9)
>65	70 (33.7)
BMI	
Normal	61 (29.3)
Over Weight	80 (38.5)
Obese	67 (32.2)
Treatment	
Diet	6 (2.9)
Oral	41 (19.7)
Insulin	87 (41.8)
Insulin + Oral	74 (35.6)
Smoking	
No	113 (54.3)
Past	67 (32.3)
Current	28 (13.5)
HbA1c	
Control	35 (16.8)
Uncontrolled	173 (83.2)
Duration of DM	
<5	7 (3.4)
5–10	40 (19.2)

>10	161 (77.4)

Clinical characteristics of study participants are shown in Table 5. Most patients have hypertension and dyslipidemia (68.3%, 59.6%, respectively). The frequency of retinopathy was 62.5%, and microalbuminuria was 16.3%. Patients who had deformity were 46 patients (22.1%), and 47 patients (22.6%) had amputation. Patients who didn't have peripheral vascular disease were 154 patients (74%). Patients who didn't have loss of protective sensation (neuropathy) were 110 patients (52.9%).

Table 5. Osteomyelitis status according to sociodemographic and anthropometric characteristics (n=208)

Variables	N (%)
Hypertension	
Yes	142 (68.3)
No	66 (31.7)
Dyslipidemia	
Yes	124 (59.6)
No	84 (40.4)
Retinopathy	
Yes	130 (62.5)
No	78 (37.5)
Microalbuminuria	
Yes	34 (16.3)
No	174 (83.7)
Deformity	
Yes	46 (22.1)
No	162 (77.9)
Amputation	
Yes	47 (22.6)
No	161 (77.4)
PVD	
Yes	54 (26.0)
No	154 (74.0)
Neuropathy	
Yes	98 (47.1)
No	110 (52.9)

Table 6 summarizes the clinical characteristics of diabetic foot ulcers among the 208 study participants. Grade 2 ulcers were the most common, occurring in 108 patients (51.9%), followed by Grade 1 ulcers in 53 (25.5%) and Grade 3 ulcers in 41 (19.7%). Followed by Grade 1 ulcers in 53 (25.5%) and Grade 3 ulcers in 41 (19.7%). Grades 4 and 5 were uncommon, affecting five (2.4%) and one (0.5%) patients, respectively. The forefoot was the most frequently affected location, reported in 106 patients (51.0%), followed by the midfoot in 57 (27.4%) and the hindfoot in 45 (21.6%). Most ulcers had been present for less than 30 days (140; 67.3%), whereas 29 (13.9%) had lasted 30–90 days and 39 (18.8%) had persisted for more than 90 days. Friction was the most frequently reported cause of ulceration (43; 20.7%). This was followed by foreign-body injury and

trauma, each affecting 33 patients (15.9%), and pressure and burns, each affecting 32 (15.4%). Fungal infection accounted for 10 cases (4.8%), while the cause was unknown in 25 (12.0%). Recurrent ulcers were reported in 43 patients (20.7%), whereas most participants—165 (79.3%)—had no history of ulcer recurrence.

Table (6): The clinical characteristics of ulcers of the study participants (n=208)

Variables	N (%)
Ulcer classification	
Grade 1	53 (25.5)
Grade 2	108 (51.9)
Grade 3	41 (19.7)
Grade 4	5 (2.4)
Grade 5	1 (0.55)
Ulcer location	
Forefoot	106 (51.0)
Midfoot	57 (27.4)
Hind foot	45 (21.6)
Ulcer duration	
<30 Day	140 (67.3)
30–90 Day	29 (13.9)
>90 Day	39 (18.8)
Cause of ulcer	
Friction	43 (20.7)
Pressure	32 (15.4)
Foreign Body	33 (15.9)
Trauma	33 (15.9)
Burn	32 (15.4)
Fungal Infection	10 (4.8)
Unknown	25 (12.0)
Ulcer recurrent	
Yes	43 (20.7)
No	165 (79.3)

Table 7 shows that 46 patients (22.1%) were positive in the probe test, 45 patients (21.6%) were positive in culture, and one patient was negative culture; 39 patients (18.8%) were positive on X-ray. The frequency of osteomyelitis in this study, according to culture, was 21.6%. And the mean of CRP was 6.52 $\pm$ (SD6.17), WBC 8.2 $\pm$ (SD2.54), and ESR 25.12$\pm$ (SD22.16).

Table (7): The frequency of laboratory tests and procedures used in the diagnosis of osteomyelitis among the study participants (n=208)

Laboratory test and procedure	N (%)
X-ray	
Positive	39 (18.8)
Negative	169 (81.3)
Probe test	
Positive	46 (22.1)
Negative	162 (77.9)
Culture	

Yes	45 (21.6)
No	163 (78.4)
CRP	
Normal	119 (57.2)
Abnormal	89 (42.8)
WBC	
Normal	167 (80.3)
Abnormal	41 (19.7)
ESR	
Normal	105 (50.5)
Abnormal	103 (49.5)

Table (8); shows the type of bacteria in positive cultures; there were 9 patients (20%) who had Staphylococcus aureus, 5 patients (11.1%) had Escherichiacoli,6 patients (13.3%) had Pseudomonas aeruginosa, 5 patients (11.1%) had Methicillin- resistant staphylococcus aureus, 3 patients (6.6%) had Staphylococcus epidermidis, 8 patients (17.7%) had Pseudomonas species.

Table (8): The frequency of bacteria among the study participants (n=45)

Single bacteria	**n=45 N (%)**	**Mixed bacteria**	**n=45 N (%)**
Escherichia coli	5 (11.11)	*Escherichia coli & Staphylococcus epidermidis*	1 (2.22)
Staphylococcus aureus	9 (20.0)		
Pseudomonas aeruginosa	6 (13.33)	*Staphylococcus epidermidis & Staphylococcus aureus*	3 (6.66)
Methicillin-resistant *Staphylococcus aureus*	5 (11.11)		
Staphylococcus epidermidis	3 (6.66)	*Staphylococcus aureus & Escherichia coli*	2 (4.44)
***Pseudomonas* spp.**	8 (17.77)	*Staphylococcus aureus & Pseudomonas aeruginosa*	3 (6.66)

Table (9): The frequency of osteomyelitis according to socio-demographic and anthropometric characteristics (n=208)

Variable	Osteomyelitis (n=45) N (%)	Non (n=163) N (%)	P value
Sex			
Male	30 (23.8)	96 (76.4)	0.38
Female	15 (18.3)	67 (81.7)	
Smoking			
Non	23 (20.4)	90 (79.6)	0.95
Past	17 (25.4)	50 (74.6)	
Current	5 (17.9)	23 (82.1)	
Treatment			
Diet	1 (16.7)	6 (85.4)	0.68
Oral	5 (83.3)	35 (85.4)	
Insulin	21 (24.1)	66 (75.9)	
Oral + Insulin	17 (23.0)	57 (77.0)	
Age			
<50	5 (16.7)	25 (83.3)	0.90
50–65	20 (18.3)	89 (81.7)	
>65	14 (20.3)	55 (79.7)	
BMI			
Normal	12 (19.7)	49 (80.3)	0.87
Overweight	15 (18.7)	65 (81.2)	
Obese	13 (19.4)	54 (80.5)	
Duration of DM			
<5	1 (14.3)	6 (85.7)	0.26
5–10	4 (10.0)	36 (90.0)	
>10	34 (21.1)	127 (78.9)	

Table (9 and 10) Results showed that osteomyelitis has a significant correlation with the presence of Microalbuminuria, Amputation, peripheral vascular disease, and neuropathy ($p<0.05$). However, there was no correlation between the prevalence of osteomyelitis and retinopathy, Deformity, and Hypertension. Moreover, osteomyelitis was not correlated with the socio-demographic characteristics such as sex, age, smoking, Treatment, BMI and Duration of DM.

Table (10): The frequency of osteomyelitis according to clinical characteristics			
Variable	**Osteomyelitis (N=45) N (%)**	**Non (N=163) N (%)**	**P value**
Hypertension			
Yes	35 (24.6)	107 (75.4)	0.17
Retinopathy			
Yes	30 (23.1)	100 (76.9)	0.37
No	15 (19.2)	63 (80.0)	
Microalbuminuria			
Yes	14 (41.2)	20 (58.8)	0.02
Dyslipidemia			
Yes	28 (22.6)	96 (77.4)	0.73
No	17 (20.2)	67 (79.3)	
Amputation			
Yes	16 (34.0)	31 (66.0)	0.04
No	29 (18.0)	132 (82.0)	
PVD			
Yes	19 (35.2)	35 (64.8)	0.01
No	26 (16.9)	128 (83.1)	
Deformity			
Yes	11 (23.9)	35 (76.1)	0.05
Neuropathy			
Yes	31 (31.6)	67 (68.9)	0.002
No	14 (12.7)	96 (87.3)	

Regarding the clinical characteristics of the ulcers Table 11, in our study, osteomyelitis was significantly related to Ulcer classification, Duration of ulcer, Cause of ulcer and recurrence of Ulcers ($p<0.05$), but no correlation was found between osteomyelitis and the location of ulcers.

Table (11) The frequency of osteomyelitis according to clinical characteristics of the ulcers			
Variables	**Osteomyelitis N=45 N (%)**	**Non N=163 N (%)**	**P value**
Ulcer Classification			
Grade 1	0 (0)	53 (100)	0.001
Grade 2	0 (0)	108 (100)	
Grade 3	40 (97.6)	1 (2.4)	
Grade 4	5 (100)	0 (0)	
Grade 5	0 (0)	1 (100)	
Ulcer Location			
Forefoot	21 (19.8)	85 (80.2)	0.60
Midfoot	16 (28.1)	41 (71.9)	
Hindfoot	8 (17.8)	37 (82.2)	
Ulcer Duration			
<30 Day	10 (7.1)	130 (92.9)	0.001
30–90 Day	13 (44.8)	16 (55.2)	
>90 Day	22 (56.4)	17 (43.6)	
Cause of Ulcer			
Friction	8 (18.6)	35 (81.4)	0.003

Pressure	7 (21.9)	25 (78.1)	
Foreign Body	15 (45.5)	18 (54.5)	
Trauma	10 (30.3)	23 (69.7)	
Burn	2 (6.3)	30 (93.8)	
Fungal Infection	1 (10.0)	9 (90.0)	
Unknown	2 (8.0)	23 (92.0)	
Ulcer Recurrent			
Yes	28 (65.1)	15 (34.9)	0.001
No	17 (10.3)	148 (89.7)	

Osteomyelitis was significantly associated with all three inflammatory laboratory markers (Table 12). Out of the patients with abnormal CRP, 40 (44.9%) had osteomyelitis, whereas only 5 (4.2%) patients with normal CRP had osteomyelitis. Similarly, osteomyelitis was diagnosed in 39 (37.9%) of 103 patients with abnormal ESR and in six (5.7%) of 105 with normal ESR. The greatest difference was in the WBC count: 29 (70.7%) of 41 patients with an abnormal WBC count had osteomyelitis, compared with 16 (9.6%) of 166 of the patients with a normal WBC count. The results indicate that abnormal CRP, ESR and WBC were significantly associated with osteomyelitis (all $p<0.001$).

Table (12): The frequency of osteomyelitis according to laboratory tests

Variable	Osteomyelitis (N=45) N (%)	Non (N=163) N (%)	P value
CRP			
Normal	5 (4.2)	114 (95.8)	0.001
Abnormal	40 (44.9)	49 (55.1)	
ESR			
Normal	6 (5.7)	99 (94.3)	0.001
Abnormal	39 (37.9)	64 (62.1)	
WBC			
Normal	16 (9.6)	151 (90.4)	0.001
Abnormal	29 (64.4)	12 (7.4)	

Logistic regression analysis was performed to test the independent variables (ulcer classification, ulcer location, ulcer duration, age, smoking, duration of diabetes, HBA1C, treatment of DM, BMI, hypertension, dyslipidemia, retinopathy, microalbuminuria, neuropathy, deformity, amputation, and peripheral vascular disease) on prevalence of osteomyelitis, The only variables that were associated with frequency of osteomyelitis were the neuropathy, ulcer duration, ulcer recurrence and hypertension. Table (13). As shown in the table, patients with recurrent ulceration were 23 times more likely to have osteomyelitis than patients without recurrent ulcer, and this association was statistically significant ($p = 0.000$). Patients with ulcer duration >3 months were 20 times more likely to have osteomyelitis than patients who had ulcer duration less than month, and this association was statistically significant ($p = 0.000$). Hypertensive patients were four times more likely to have osteomyelitis than patients with normal blood pressure, and this association was statistically significant ($p = 0.04$).

Patients who have neuropathy were three times more likely to have osteomyelitis than patients without neuropathy, and this association was statistically significant (p = 0.002).

Table (13): Multivariable logistic regression of factors independently associated with osteomyelitis

Variable	OR (95% CI)	P-value
Recurrent of ulcer		
Yes	23.32 (7.47–72.82)	0.001
No	1	
Duration of ulcer		0.001
<1 month	1	
1–3 months	18.58 (5.08–67.97)	
>3 months	20.14 (5.95–68.20)	
Hypertension		
Yes	4.16 (1.27–13.65)	0.048
No	1	
Neuropathy		
Yes	3.13 (1.15–8.48)	0.002
No	1	

Discussion

This is the first study carried out in Iraq to assess the frequency of osteomyelitis among 208 patients with diabetic foot ulcers who were diagnosed with diabetic foot osteomyelitis after bone culture and either a probe-to-bone test and/or a plain X-ray with the presence of soft tissue infection.

In our study, a positive probing test is considered positive when touching the bone after debridement of the wound from callus or necrotic tissue. It was found that probing of the ulcer to bone is an easy and highly specific method. In our study, plain X-ray demonstrated that it had a good prognosis related to the bone changes, bone destruction and soft tissue infection in all cases. Many studies were done to investigate the accuracy of the probe-to-bone test and X-ray for diagnosing osteomyelitis in patients with diabetic foot ulcer. Previous studies conducted at the Diabetic Foot Unit of La Paloma Hospital by (Sánchez et al.,2025) showed that diabetic foot osteomyelitis can be diagnosed confidently by using either the probe-to-bone test or a plain X-ray, or both, with positive findings. Another study by Xu et al. (2021) assessed the accuracy of the probe–to–bone (PTB) test; this study found that a positive PTB is probably quite helpful in diagnosing bone infection, and the PTB test is a better tool to exclude osteomyelitis.

A previous study conducted by Sanchez et al. (2025) showed that bone changes and bone destruction can be seen in simple X-rays in the cases of osteomyelitis. When our study was compared with previous studies we found that they used the same methods, and that diabetic foot osteomyelitis can be diagnosed confidently when either the Probe-to-bone tests or a plain X-ray, or both, are positive.

The frequency of osteomyelitis in our study was 21.6%. A previous study done in India by Gouniyal et al. (2023) to assess the frequency of osteomyelitis in diabetic foot ulcers (DFU) found that the frequency of osteomyelitis was 66.6%. This difference between the results could be due to the long duration of the previous study and the difference in the study protocols.

Another study was done in Chicago conducted by Bhasin et al. (2023), aimed to identify the severity of osteomyelitis, and showed a frequency of osteomyelitis (19.9%) in relation to an underlying bone infection. There was no difference between the results of our study and this study.

By comparing our results with the previous study, which was conducted by Baertl & Rupp. (2021), which focused on the development of osteomyelitis of the foot after a puncture wound in patients with diabetes in Germany, this study found that 33.2% was acute and 19.2% was unspecified osteomyelitis. It was found that there was a big difference in the frequency of osteomyelitis between our study and this study because of the difference in study population size and the fact that the previous study was a cohort study in design, while ours was a cross-sectional design.

According to laboratory tests, our study found that if patients have a normal ESR, WBC or CRP <5 mg/L, this did not rule out the diagnosis of osteomyelitis, especially for patients with puncture wounds or foot infections. Prevalence of osteomyelitis in relation to laboratory results was found to be significantly correlated to the prevalence of osteomyelitis with high CRP, WBC and ESR ($p<0.05$).

Another study was conducted by Balin et al. (2025) which showed that Diabetic osteomyelitis was the highest for ESR, CRP, and PCT were 0.466 ($p < 0.001$), 0.627 ($p < 0.001$), and 0.501 ($p < 0.001$), respectively, comparing these results with our results, we found similar results, and that means that the (ESR, WBC, CRP) was high because of presences of severe infection like osteomyelitis.

The frequency of osteomyelitis varied according to ulcer-related characteristics; it was found that the frequency of osteomyelitis was significantly related to microalbuminuria, amputation, peripheral vascular disease, neuropathy and recurrent of ulcers ($p<0.05$).

Our study showed the frequency of amputation was (22.6%), and PVD was (26%), while other studies such as the one conducted in India by Dhakad et al. (2024) found that severe peripheral vasculopathy was present in 42% of cases and in (66.6%) of cases an amputation was required.

When comparing these results to ours, there was a big difference in results due to the big difference in study population size.

We found the frequency of peripheral vascular disease was 26% among diabetic foot. A previous study was done by Zhan (2026) to determine the prevalence of lower limb ischemia in 60 patients with diabetic foot infection; ischemia was present in 35 out of 60 patients (58.4%). The differences in results of the previous study were due to the use of more tools to assess ischemia. This explanation showed that Foot ischemia certainly appears to be associated with an increased severity of infections. Diabetic patients often have a diminished inflammatory response to injury or infection; this deficit could be further impaired by ischemia. In addition, we found that the frequency of neuropathy was 47.1% among the entire sample of studies from the Arab world, showing a prevalence of neuropathy from 38-94% among patients with (DFU). (Regai et al., 2024); Ponirakis et al.,2022)

The frequency of peripheral sensory neuropathy to 10-g Semmes-Weinstein Monofilament was 71.7% among diabetic foot ulcers at (NCDEG) at the University of Calgary's according to Lindsay et al. (2024). This difference in results is because our study includes 208 patients with diabetic foot while the previous study included only 46 patients. Also, in our study, we used 10-g Semmes- Weinstein monofilament only, while in the previous study they used both a tuning fork and monofilament.

The reason was that uncontrolled (DM) displayed by an elevated HbA1c level leads to an increase in (DM) complications. Also, we found that patients with neuropathy were three times more likely to have osteomyelitis than patients without neuropathy, and this association was statistically significant ($p = 0.002$). These results explain that this sensory neuropathy causes loss of sensitivity to trauma and thermal injury, resulting in ulceration. Motor neuropathy produces muscle atrophy, weakness and paresis with deformity and anterior displacement of the plantar fat pads. Our study also showed that patients with recurrent ulcers were more than twenty times more likely to have osteomyelitis than patients without recurrent ulcers, and this association was statistically significant ($p < 0.0001$). Note that the previous study, done in West China Hospital of Sichuan University by Gong et al. (2023), illustrates that patients with diabetes who had previously undergone lower extremity amputation had a nearly 20-fold increased risk of developing a foot infection compared to non-diabetic patients. Patients who sustain multiple or recurrent wounds are likely to develop osteomyelitis because each wound carries a risk of contiguous spread of infection to bone. Urish et al (2020). Our study showed that the forefoot is the most common site for ulcers in comparison to the midfoot and hindfoot. Another study by Ali. (2020) showed the same results as our study. Our study also showed that the major cause for ulcers was friction, because most patients in our study had neuropathy and loss of protective sensation; and we found that patients who had ulcer duration >3 months were

20 times more likely to have osteomyelitis than patients who had ulcer duration less than one month, and this association was statistically significant (p = 0.000).

Hypertensive patients were four times more likely to have osteomyelitis than patients with normal blood pressure, and this association was statistically significant (p = 0.04). The most common type of bacteria in our study was Staphylococcus aureus (20%). By comparing these results with a previous study in Jordan by Ali. (2020), which showed that the most common pathogens found in all infections were Staphylococcus aureus (39.7%). Many studies showed Staphylococcus aureus, Streptococcus agalactiae and Escherichia coli are the most frequent causes of acute haematogenous osteomyelitis. (Masters et al.,2022; Arnold et al.,2026)

A recent review by Gonçalves et al. (2024) was carried out on 36 diabetic patients who had neuropathic ulcer-related osteomyelitis of the foot. It was determined that Streptococcus species were the most frequent bacterial pathogens in bone infections in the diabetic population, but S. aureus and anaerobes were uncommon. (Afonso et al.,2023)

Study Limitations

This study has several limitations. Its cross-sectional design precludes establishing temporal or causal relationships. Participants were recruited from a single specialist clinic, which may overrepresent more complex ulcers and limit generalizability to primary-care or community populations. Consecutive rather than probability sampling may introduce selection bias. The modest number of osteomyelitis cases produced wide confidence intervals and may have limited the stability of the multivariable model, particularly because many candidate predictors were considered. Categorizing continuous variables may have reduced statistical power and obscured dose–response relationships. Osteomyelitis classification relied on the diagnostic procedures available in routine practice; the absence of systematic magnetic resonance imaging and bone histopathology may have caused misclassification. Residual confounding and incomplete measurement of treatment, organism resistance, ulcer depth, perfusion, and off-loading are also possible.

Recommendations for Future Studies

Future research should use multicenter prospective cohorts with probability-based or clearly documented consecutive sampling, standardised IWGDF/IDSA diagnostic criteria, and uniform specimen collection procedures. Larger samples should support prespecified, parsimonious prediction models with validation and continuous-variable modelling. Where feasible, magnetic resonance imaging, bone culture, and histopathology should be incorporated to improve diagnostic accuracy. Studies should also examine antimicrobial resistance, treatment pathways,

recurrence, amputation, healing time, quality of life, and economic burden, and should evaluate locally feasible strategies for early detection and prevention.

CONCLUSIONS

- The frequency of osteomyelitis among patients with diabetic foot ulcers in our study was 21.6%.
- It was found that probing the ulcer to the level of bone is an easy, not costly, and highly specific method.
- When the plain X-ray was in our study, plain X-ray was a good indicator of bone changes, bone destruction and soft tissue infection in all cases.
- Hypertension, neuropathy, duration of ulcer and recurrent ulcers were significantly associated with osteomyelitis.
- The most common type of bacteria in our study was Staphylococcus aureus (20%).
- We found that the most common ulcer location was the forefoot, and friction was the most common cause of ulcers among diabetic foot, but foreign body was the most common cause of osteomyelitis.
- Neuropathy and peripheral vascular disease are the most important factors contributing to infection in patients with diabetes. Sensory, autonomic, and motor neuropathy all contribute to this process; peripheral vasculopathy plays an important role in the progression of diabetic foot ulcers.
- Diabetic patients with a history of a previously healed wound, recurrent wounds or a wound that penetrates to deep structures have a significantly increased risk of developing osteomyelitis

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REFERENCES

1. Álvaro-Afonso, F. J., García-Álvarez, Y., Tardáguila-García, A., García-Madrid, M., López-Moral, M., & Lázaro-Martínez, J. L. (2023). Bacterial diversity and antibiotic resistance in patients with diabetic foot osteomyelitis. Antibiotics, 12(2), 212. https://doi.org/10.3390/antibiotics12020212
2. Ali, M. S. (2020). Antibiotic Resistant Patterns of Bacteria Recovered from Infected Diabetic Foot as Correlated to Risk Factors (Master's thesis, Faculty of Pharmacy, Isra University).
3. Ali, M. S., Al-Shammari, A., Ismael, Q. A., Imran, O. A., & Al-Bayati, M. H. (2024). Effect of steroid treatment on tissue damage markers in diabetic patients. Journal of Angiotherapy, 8(1), 1–10.

4. Aragón-Sánchez, J., Víquez-Molina, G., Uçkay, I., Rojas-Bonilla, J. M., & Lipsky, B. A. (2025). A research-based, current approach to diabetes-related acute foot infections and chronic osteomyelitis. Expert Review of Endocrinology & Metabolism, 20(6), 481–495.
5. Arnold, S. R., Giordano, V., Obremskey, W. T., Schwarz, E. M., Smeltzer, M. S., Veis, D. J., & Cassat, J. E. (2026). Osteomyelitis. Nature Reviews Disease Primers, 12(1), 33.
6. Benyakorn, T., & Orrapin, S. (2024). Association between the Society for Vascular Surgery (SVS)-WIfI classification, Wagner-Meggitt classification, and amputation rate in patients with diabetic foot infection. The International Journal of Lower Extremity Wounds, 23(1), 33–42.
7. Bhasin, A., Krueger, K. M., Williams, J., Gulati, R., Sisler, N., & Galvin, S. (2023). Management patterns and outcomes of patients hospitalized with diabetic foot ulcers at one tertiary care hospital. Internal and Emergency Medicine, 18(1), 185–191.
8. Charan, J., & Biswas, T. (2013). How to calculate sample size for different study designs in medical research? Indian Journal of Psychological Medicine, 35(2), 121–126. https://doi.org/10.4103/0253-7176.116232
9. Cobb, L. H., McCabe, E. M., & Priddy, L. B. (2020). Therapeutics and delivery vehicles for local treatment of osteomyelitis. Journal of Orthopaedic Research, 38(10), 2091–2103. https://doi.org/10.1002/jor.24611
10. Feleke, B. E., Sacre, J., Tomic, D., Huynh, Q., Shaw, J. E., & Magliano, D. J. (2024). Hospital admissions among people with diabetes: A systematic review. Diabetic Medicine, 41(1), e15236. https://doi.org/10.1111/dme.15236
11. Gonçalves, J., Guimarães, A. R., Ferreira, H. U., Ribeiro, S., Moreno, T., Borges-Canha, M., et al. (2024). Microbiological characterization of neuropathic diabetic foot infection: A retrospective study at a Portuguese tertiary hospital. BMC Infectious Diseases, 24, 791. https://doi.org/10.1186/s12879-024-09608-0
12. Gong, H., Ren, Y., Li, Z., Zha, P., Bista, R., Li, Y., et al. (2023). Clinical characteristics and risk factors of lower extremity amputation in the diabetic inpatients with foot ulcers. Frontiers in Endocrinology, 14, 1144806. https://doi.org/10.3389/fendo.2023.1144806
13. Jais, S. (2023). Various types of wounds that diabetic patients can develop: A narrative review. Clinical Pathology, 16, 2632010X231205366. https://doi.org/10.1177/2632010X231205366
14. Lazzarini, P. A., et al. (2023). Global trends in the incidence of hospital admissions for diabetes-related foot disease and amputations: A review of national rates in the 21st century. Diabetologia, 66(2), 267–287. https://doi.org/10.1007/s00125-022-05819-1
15. Lipsky, B. A., & Uçkay, İ. (2021). Treating diabetic foot osteomyelitis: A practical state-of-the-art update. Medicina, 57(4), 339. https://doi.org/10.3390/medicina57040339

16. Luo, Y., Liu, C., Li, C., Jin, M., Pi, L., & Jin, Z. (2024). The incidence of lower extremity amputation and its associated risk factors in patients with diabetic foot ulcers: A meta-analysis. International Wound Journal, 21(7), e14931. https://doi.org/10.1111/iwj.14931

17. Masters, E. A., Ricciardi, B. F., Bentley, K. L. D. M., Moriarty, T. F., Schwarz, E. M., & Muthukrishnan, G. (2022). Skeletal infections: Microbial pathogenesis, immunity and clinical management. Nature Reviews Microbiology, 20(7), 385–400. https://doi.org/10.1038/s41579-022-00698-5

18. Prasad, K. (2020). Sample size calculation with simple math for clinical researchers. National Medical Journal of India, 33(6), 372–374. https://doi.org/10.4103/0970-258X.321139

19. Ponirakis, G., Elhadd, T., Al Ozairi, E., et al. (2022). Prevalence and risk factors for diabetic peripheral neuropathy, neuropathic pain and foot ulceration in the Arabian Gulf region. Journal of Diabetes Investigation, 13(9), 1551–1559. https://doi.org/10.1111/jdi.13820

20. Urish, K. L., & Cassat, J. E. (2020). Staphylococcus aureus osteomyelitis: Bone, bugs, and surgery. Infection and Immunity, 88(7), e00932-19. https://doi.org/10.1128/IAI.00932-19

21. Walter, N., Baertl, S., Alt, V., & Rupp, M. (2021). What is the burden of osteomyelitis in Germany? An analysis of inpatient data from 2008 through 2018. BMC Infectious Diseases, 21, 550. https://doi.org/10.1186/s12879-021-06235-7

22. Wang, X., & Ji, X. (2020). Sample size estimation in clinical research: From randomized controlled trials to observational studies. Chest, 158(1S), S12–S20. https://doi.org/10.1016/j.chest.2020.03.010

23. Xu, J., Cheng, F., Li, Y., Zhang, J., Feng, S., & Wang, P. (2021). Erythrocyte sedimentation rate combined with the probe-to-bone test for fast and early diagnosis of diabetic foot osteomyelitis. The International Journal of Lower Extremity Wounds, 20(3), 227–231. https://doi.org/10.1177/1534734620916815