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Study of Fungal infections in type 2 Diabetes: A cross-sectional, hospital-based study

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A B S T R A C T

Background: Fungal infections are increasingly recognized as a significant complication among patients with type 2 diabetes mellitus (T2DM), largely due to impaired immunity and poor glycemic control. This study aimed to evaluate the prevalence, clinical spectrum, and associated risk factors of fungal infections in patients with T2DM.

Materials and Methods: A cross-sectional, hospital-based study was conducted among 345 patients with T2DM. Demographic data, clinical history, glycemic status (HbA1c), and risk factors such as obesity, recent antibiotic use, hospitalization, and immunosuppressive therapy were recorded. Fungal infections were diagnosed clinically and confirmed through microbiological methods. Statistical analysis was performed to identify associations between fungal infections and potential risk factors.

Results: Among the 345 participants, the majority were aged 50–59 years (32.5%), and 54.2% were male. Fungal infections were present in 42.9% of cases, with candidiasis (25.8%) being most common, followed by dermatophytosis (17.7%) and onychomycosis (12.2%). Invasive infections included aspergillosis (5.2%) and mucormycosis (2.0%). Fungal infections were significantly more prevalent in patients with poor glycemic control—66.7% in those with HbA1c ≥9% versus 23.5% with HbA1c <7%. Significant risk factors included poor glycemic control ($p<0.001$), obesity ($p=0.032$), recent antibiotic use ($p=0.016$), and hospitalization history ($p=0.004$); immunosuppressive therapy was not statistically significant ($p=0.072$). The genital region (32.4%) and oral cavity (27.7%) were the most affected sites, followed by nails (28.4%) and interdigital feet (22.3%); 16.2% had multiple site involvement.

Conclusion: Fungal infections are prevalent in over 40% of patients with T2DM, particularly those with poor glycemic control, obesity, recent antibiotic use, and hospitalization. Early identification and appropriate management are essential to prevent complications and improve quality of life in diabetic patients.

Key Words: Type 2 diabetes mellitus, fungal infection, candidiasis, dermatophytosis, glycemic control.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is increasingly acknowledged as a major predisposing factor for a broad spectrum of fungal infections, primarily due to the multifactorial immune dysregulation induced by chronic hyperglycemia. Elevated blood glucose levels impair various components of the innate and adaptive immune system, including neutrophil chemotaxis, oxidative burst activity, and phagocytic function, thereby weakening the host's defense against fungal pathogens [1]. Additionally, diabetes-induced microangiopathy and peripheral neuropathy further compromise cutaneous and mucosal barrier integrity, facilitating fungal colonization and invasion [1].

Emerging literature underscores that sustained hyperglycemia alters the functional responsiveness of neutrophils and macrophages, thereby diminishing the clearance of fungal elements such as Candida and Aspergillus species [2]. This immunological vulnerability is compounded by reduced skin barrier function, xerosis, and impaired wound healing in diabetic individuals, collectively creating an environment conducive to fungal proliferation [2].

Epidemiological investigations have consistently demonstrated a heightened burden of superficial fungal infections among patients with T2DM. Conditions such as candidiasis, dermatophytosis, and onychomycosis are significantly more prevalent in diabetic cohorts compared to non-diabetic populations [3,4]. Notably, cutaneous and nail involvement are frequently observed, with onychomycosis often serving as a clinical marker for undiagnosed or poorly controlled diabetes [3,4]. A comprehensive meta-analysis involving over 1,300 individuals with T2DM reported a pooled prevalence of cutaneous Candida albicans infection of 11.4%, a figure that remained consistent across multiple geographic and healthcare settings [4]. Regional studies from South Asia and sub-Saharan Africa have further corroborated these findings, with fungal infection prevalence rates reaching nearly 30–35% among diabetic individuals, in contrast to less than 5% in non-diabetic controls [5].

Although superficial infections predominate, systemic fungal diseases pose a serious and sometimes fatal risk in T2DM patients, particularly when glycemic control is poor. Opportunistic pathogens such as Candida spp., Cryptococcus neoformans, and Aspergillus fumigatus have been implicated in bloodstream and pulmonary infections among diabetic patients, often presenting with high morbidity and mortality [6]. Of special concern is mucormycosis, an aggressive and angioinvasive fungal disease that has shown a disproportionately high incidence in individuals with uncontrolled diabetes, especially during and after COVID-19 outbreaks in tropical countries like India [7]. The thermophilic nature of mucorales, combined with diabetes-induced ketoacidosis, creates an optimal niche for rapid fungal proliferation and vascular invasion [7].

Given these significant clinical implications, the present study was undertaken to evaluate the prevalence, fungal species distribution, and associated clinical and demographic risk factors for fungal infections among patients with type 2 diabetes mellitus in a tertiary care hospital in India.

MATERIAL AND METHODS

Study Design and Setting: This hospital-based cross-sectional observational study was conducted in a tertiary care teaching hospital in India.

Study Population: A total of 345 patients diagnosed with Type 2 Diabetes Mellitus (T2DM), either attending outpatient departments or admitted to inpatient wards, were enrolled in the study. Inclusion was irrespective of gender. All patients were aged 18 years and above and gave informed consent.

Inclusion Criteria

- Patients with established diagnosis of Type 2 Diabetes Mellitus (as per ADA 2023 guidelines).
- Willingness to participate and provide informed written consent.

Exclusion Criteria

- Patients with known immunosuppressive conditions such as HIV/AIDS or malignancy.
- Patients receiving immunosuppressive therapy, corticosteroids, or chemotherapy.
- Pregnant women.

Sample Collection and Processing

Relevant clinical samples were collected from patients showing signs or symptoms of fungal infections. These included:

- **Oral swabs** for suspected oral candidiasis
- **Skin scrapings or nail clippings** for dermatomycoses
- **Urine samples** for candiduria
- **Vaginal swabs** in female patients with suspected vulvovaginal candidiasis

Samples were processed according to standard microbiological procedures. Direct microscopic examination using 10% KOH mount and Gram stain was performed. Culture was done on Sabouraud Dextrose Agar (SDA) with and without antibiotics and incubated at 25°C and 37°C for up to 14 days.

Identification of Fungal Isolates: Fungal growth was identified based on colony morphology, microscopy (Lactophenol Cotton Blue stain), and biochemical tests (e.g., germ tube test for Candida albicans, urease test). Further speciation of Candida was done using CHROMagar Candida and sugar assimilation tests where necessary.

Glycemic Control Assessment: Glycemic control was evaluated by measuring HbA1c levels. Based on HbA1c, patients were categorized into:

- Good control (HbA1c <7%)
- Poor control (HbA1c ≥7%)

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 25.0. Categorical variables were expressed as frequencies and percentages. Associations between glycemic control and occurrence of fungal infections were tested using Chi-square test. A p-value of <0.05 was considered statistically significant.

RESULTS

The present study analyzed 345 patients with type 2 diabetes mellitus to assess the prevalence and patterns of fungal infections. As shown in Table 1, the majority of participants were in the 50–59-year age group, accounting for 32.5%, followed by the 40–49 and 60–69 age groups. Males constituted 54.2% of the study population. Regarding the duration of diabetes, 40% had been diagnosed for 5–10 years, while nearly one-third (32.8%) had diabetes for more than 10 years.

Table 1: Demographic Characteristics of Study Participants (N=345)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
30–39	38	11.0
40–49	79	22.9
50–59	112	32.5
60–69	77	22.3
≥70	39	11.3
Sex		
Male	187	54.2
Female	158	45.8
Duration of Diabetes		
<5 years	94	27.2
5–10 years	138	40.0
>10 years	113	32.8

The overall prevalence of fungal infections among the participants was 42.9% (Table 2). Among the different fungal infections, candidiasis was the most frequently observed, affecting 25.8% of participants, followed by dermatophytosis (17.7%) and onychomycosis (12.2%). Invasive fungal infections, such as aspergillosis and mucormycosis, were less common, affecting 5.2% and 2.0% of the study population, respectively.

Table 2: Prevalence of Fungal Infections among Type 2 Diabetes Patients

Fungal Infection Type	Number of Cases (n)	Prevalence (%)
Candidiasis (oral/genital)	89	25.8
Dermatophytosis (skin/nails)	61	17.7
Onychomycosis	42	12.2
Aspergillosis (pulmonary)	18	5.2
Mucormycosis	7	2.0
Total with Fungal Infection	148	42.9

A significant association was observed between poor glycemic control and fungal infection prevalence (Table 3). The frequency of fungal infections increased progressively with rising HbA1c levels. Patients with HbA1c ≥9% had the highest infection rate at 66.7%, compared to 23.5% among those with HbA1c <7%. This trend indicates a strong correlation between poor glycemic control and susceptibility to fungal infections.

Table 3: Glycemic Control and Fungal Infection

HbA1c Level	Total Patients (n)	Fungal Infection Present (n, %)
<7%	102	24 (23.5%)
7–8.9%	156	66 (42.3%)
≥9%	87	58 (66.7%)
Total	**345**	**148 (42.9%)**

Risk factor analysis demonstrated statistically significant associations between fungal infections and several parameters (Table 4). Patients with poor glycemic control (HbA1c ≥8%), obesity, recent antibiotic use, and a history of hospitalization were significantly more likely to develop fungal infections. Although patients on immunosuppressive medications showed a higher infection rate, the association did not reach statistical significance (p=0.072).

Table 4: Association of Risk Factors with Fungal Infections

Risk Factor	With Fungal Infection (n=148)	Without Infection (n=197)	p-value
Poor Glycemic Control (HbA1c ≥8%)	102	59	<0.001
Obesity (BMI ≥30)	61	47	0.032

Recent Antibiotic Use	47	31	0.016
History of Hospitalization	39	18	0.004
Immunosuppressive Medications	12	5	0.072

The anatomical distribution of fungal infections is detailed in Table 5 and Figure 1. The genital area and oral cavity were the most commonly affected sites, involved in 32.4% and 27.7% of infected patients, respectively. Nail and interdigital foot infections were also frequent. Additionally, 16.2% of affected individuals had fungal infections involving multiple sites.

Table 5: Sites of Fungal Infection in Affected Patients (n=148)

Site of Infection	Frequency (n)	Percentage (%)
Oral cavity	41	27.7
Genital area	48	32.4
Feet (interdigital)	33	22.3
Nails	42	28.4
Lungs	18	12.2
Nasal/Sinuses	6	4.1
Multiple sites	24	16.2

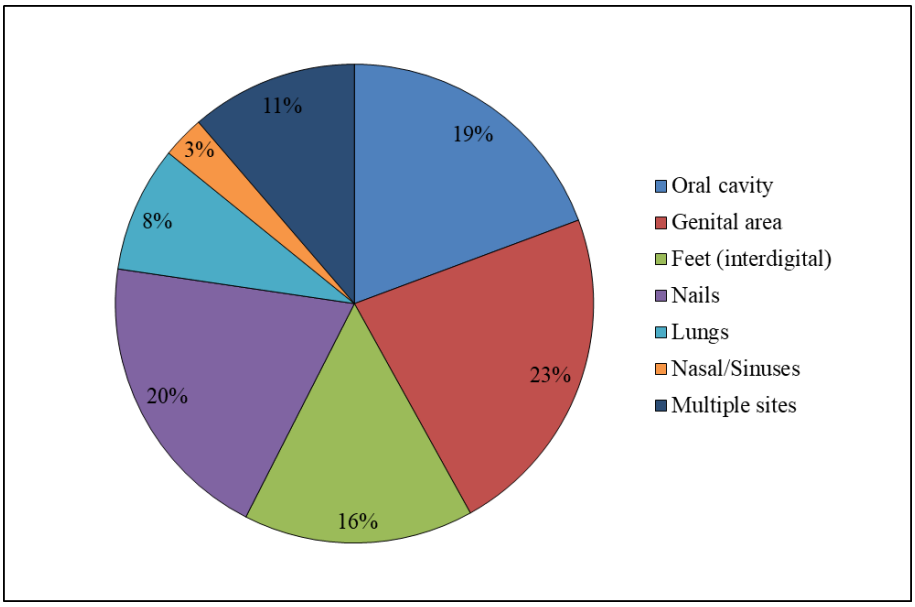

Figure 1: Percentage distribution of sites of Fungal Infection in T2DM patients

DISCUSSION

In this cross-sectional analysis of 345 patients with type 2 diabetes mellitus, over 40% were found to harbor a fungal infection, underscoring the high burden of mycoses in this population (Table 2). These findings align with prior reports describing elevated prevalence among diabetics compared to non-diabetic controls, with candidiasis predominating as the leading clinical presentation (Table 2). For example, a Nepalese case–control study documented fungal infection in 34% of diabetic patients versus under 5% in non-diabetic subjects [3]. Similarly, global reviews estimate that Candida albicans skin infection in type 2 diabetes has a pooled prevalence around 11%, affirming the higher vulnerability among this demographic [4].

The strong correlation observed between higher HbA1c levels and increased infection prevalence (Table 3) supports mechanistic insights that chronic hyperglycemia impairs innate immunity, specifically neutrophil function, and promotes fungal colonization across mucocutaneous sites [8]. A meta-analysis likewise reported that poor glycemic control significantly elevates risk for candidal and dermatophytic infections in diabetic individuals [8].

The observed associations with obesity, antibiotic use, and hospitalization further corroborate established risk models whereby compromised host barriers, prior antimicrobial therapy that disrupts microbiota, and healthcare exposure increase fungal susceptibility (Table 4). Use of antibiotics has been repeatedly linked to fungal overgrowth, whereas hospitalization can introduce nosocomial pathogens including Candida spp. and Aspergillus [9].

Distribution of infection across anatomical sites revealed highest frequencies in genital, oral, and nail locations (Table 5). This pattern reflects typical localization reported in diabetic cohorts, where moist or intertriginous areas and poorly vascularized nail beds are particularly predisposed to fungus-related lesions [10-13].

The study's strengths include a sizable sample with comprehensive evaluation of clinical and glycemic factors. However, limitations such as a single-center design and lack of species-level microbiological confirmation should be acknowledged. Future prospective studies including fungal identification, antifungal resistance profiling, and host immune analysis would help clarify causal pathways and inform targeted prevention or treatment strategies.

CONCLUSION

Fungal infections were found to be notably prevalent among individuals with type 2 diabetes mellitus, with candidiasis being the most commonly encountered pathogen. The incidence of fungal infections was significantly higher in patients with poor glycemic control and a longer duration of diabetes. Genitourinary and cutaneous mycoses represented the most frequent clinical manifestations. The results emphasize the importance of routine screening for fungal infections in diabetic patients, especially those with uncontrolled blood sugar levels. Early diagnosis and timely antifungal therapy can significantly reduce complications and improve overall quality of life in this high-risk group.

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