

Prevalence and Species Distribution of Oral *Candida* among Individuals with Type 2 Diabetes Mellitus

Suja C

Reader and Head, Department of Microbiology, Rajas Dental College and Hospital, Tirunelveli, Tamil Nadu, India

Abstract: Background: Type 2 diabetes mellitus is associated with impaired immune function, altered salivary composition, and changes in the oral environment that favor the colonization of *Candida* species. Although *Candida albicans* remains the predominant oral fungal pathogen, the emergence of non-*albicans* *Candida* species has raised concerns because of their potential resistance to commonly used antifungal agents. This study aimed to compare the prevalence and species distribution of oral *Candida* among individuals with type 2 diabetes mellitus and healthy controls. Methods: This cross-sectional study included 30 participants, comprising 15 patients with type 2 diabetes mellitus and 15 age- and gender-matched healthy controls. Unstimulated saliva samples were collected under aseptic conditions and cultured on SDA. Yeast isolates were identified by Gram staining and speciated using CHROMagar™ *Candida* based on colony colour characteristics. Results: Oral *Candida* was isolated from 11 of 15 diabetic participants (73.3%) compared with 6 of 15 non-diabetic controls (40.0%). *Candida albicans*/*Candida dubliniensis* was the predominant isolate in both groups. However, diabetic participants demonstrated a higher proportion of non-*albicans* *Candida* species, particularly *Candida glabrata*. Overall, individuals with diabetes exhibited greater oral *Candida* carriage and increased species diversity than healthy controls. Conclusion: Type 2 diabetes mellitus is associated with increased oral *Candida* colonization and a higher prevalence of non-*albicans* *Candida* species. Routine species-level identification may facilitate early diagnosis, and support preventive strategies for oral candidal infections in diabetic patients. Further studies with antifungal susceptibility testing are recommended to validate these findings.

Keywords: Type 2 diabetes mellitus, Oral *Candida* colonization, *Candida albicans*

1. Introduction

The human oral cavity is a unique biological niche that hosts an extensive range of microorganisms known as the oral microbiome¹. Bacteria, viruses, protozoa, and fungi make up this complex ecology, with *Candida* species playing a key role as commensal organisms. *Candida spp.* are routinely isolated from healthy people's oral mucosa, where they reside in low quantities and do not cause disease². Their capacity to cling to epithelial surfaces, create biofilms, and switch between yeast and hyphal forms allows them to thrive in the changing oral environment³.

Candida albicans is the most common and virulent species, owing to its morphological plasticity, production of hydrolytic enzymes, and competitive fitness⁴. However, in recent years, the epidemiology of oral candidiasis has shifted, with non-*albicans* *Candida* (NAC) species such as *C. tropicalis*, *C. glabrata*, and *C. krusei* emerging as important colonizers and opportunistic infections. These NAC species frequently have decreased susceptibility to commonly used antifungal agents, complicating treatment and contributing to persistent or recurring infection. Their rising recovery from the oral cavities of immunocompetent and immunocompromised persons emphasizes the importance of accurate species identification and epidemiological surveillance⁵.

Diabetes mellitus is one of the most significant risk factors for oral candidal colonization and infection. Chronic hyperglycemia affects the oral environment in several ways that promote fungal development⁶. Elevated salivary glucose levels provide a better nutrition supply for *Candida* species, whereas decreased salivary flow rate, changed salivary pH, and impaired innate and adaptive immune responses all

contribute to higher vulnerability. Diabetics also have lower neutrophil activity, phagocytic function, and delayed healing responses, all of which promote *Candida* colonization and persistence in the oral cavity⁷. As a result, several studies have consistently found a higher prevalence of oral *Candida* carriage among diabetic patients compared to healthy people.

Despite this evident interaction, *Candida* distribution and speciation patterns vary between populations, determined by geographical factors, lifestyle behaviors, glycemic management, dental hygiene practices, and local environmental circumstances⁸. Some places indicate a high prevalence of *C. albicans* even among diabetics, whilst others have seen an increase in NAC species isolation rates. These variations highlight the significance of doing region-specific research to better understand local epidemiological trends, antifungal susceptibility patterns, and associated risk factors⁹.

Given the worldwide increase in diabetes mellitus and the medical implications of new NAC species, it is critical to study the relative prevalence and species distribution of oral *Candida* in diabetic and non-diabetic persons¹⁰. Such data can help improve early detection, guide suitable antifungal therapy, and establish preventative initiatives for high-risk groups.

2. Materials and Methods

A cross-sectional study included 30 participants, 15 with type 2 diabetes mellitus (duration ≥ 3 years) and 15 age- and gender-matched healthy non-diabetic controls.

Participants aged 30 to 60 were eligible for inclusion.

Individuals who had taken antibiotics or antifungal treatments during the previous four weeks were excluded, as were tobacco or alcohol users, denture wearers, xerostomia patients, and those with systemic illnesses other than diabetes.

Saliva Sample Collection

Two milliliters of unstimulated whole saliva were taken from each participant. Participants were advised to abstain from eating, drinking, and practicing good dental hygiene for at least an hour before samples were collected in the morning. Sterile, screw-capped containers were used to collect and process saliva instantly.

Microbiological Processing

Saliva samples were vortexed and inoculated onto Sabourauds Dextrose Agar (SDA) supplemented with chloramphenicol using a calibrated loop. The plates were incubated at 37°C for 48 hours.

3. Results

After 48hrs of incubation, Yeast colonies were assessed for growth characteristics including colour, surface texture, and morphology. Gram staining was performed for the morphological identification of *Candida*, Gram positive oval budding yeast cells were seen under microscope. Representative colonies were sub cultured onto CHROMagar™ *Candida* (HiMedia, India) and incubated at

37°C for 48 hours. Species identification was based on colony colour as per manufacturer guidelines:

- *C. albicans* / *C. dubliniensis* – green colonies
- *C. glabrata* – pale pink to lavender colonies



Figure 1: Colony morphology of *Candida* on SDA plate

Oral *Candida* colonization was more prevalent among diabetic participants compared to non-diabetic controls. Out of 15 diabetic individuals, 11 (73.3%) showed positive *Candida* growth, whereas 6 (40%) of the 15 non-diabetic participants demonstrated yeast isolation.

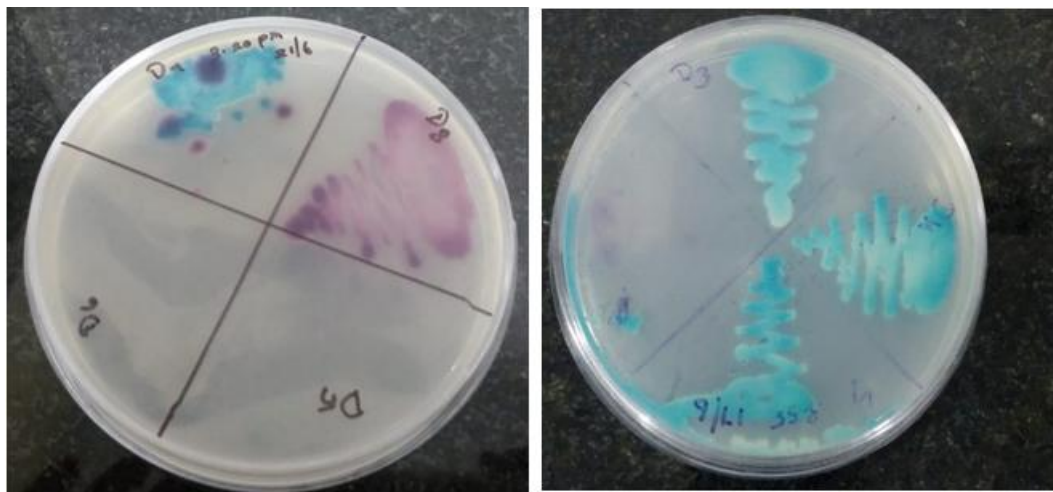


Figure 2: *Candida albicans* and *Candida glabrata* in Hichrome differential media

4. Discussion and Conclusion

In comparison to healthy non-diabetic controls, the current study showed that people with type 2 diabetes mellitus had a higher prevalence of oral *Candida* colonization. Additionally, the diabetic group had a higher species diversity. These results are consistent with recent research showing that diabetes mellitus is a major risk factor for increased oral candidal carriage because of immunological and metabolic changes.^{11,12.}

The most common species found in both subjects with and without diabetes was *Candida albicans*. Due to its great adhesion capacity, biofilm production, and morphological plasticity, *Candida albicans* is the most prevalent commensal and opportunistic fungus species in the oral cavity, based on recent studies^{13, 14}. Nonetheless, a changing epidemiological trend that has been extensively documented in recent years is reflected in the higher isolation of *non-albicans Candida* (NAC) species, especially *Candida glabrata*, among diabetes individuals in this investigation.^{15,16.}

Table 1

Study Group	Total Samples (n)	Candida n (%)	<i>C. albicans</i> / <i>C. dubliniensis</i> n (%)	<i>C. glabrata</i> n (%)
Diabetic	15	11 (73.3%)	8 (53.3%)	3 (20.0%)
Non-diabetic	15	6 (40.0%)	5 (33.3%)	1 (6.7%)
Total	30	17 (56.7%)	13 (43.3%)	4 (13.3%)

Comparative Distribution of Candida Species in Diabetic and Non-Diabetic Subjects

Chronic hyperglycemia in diabetes mellitus promotes fungal colonization by increasing salivary glucose levels, decreasing salivary flow, and changing salivary pH¹⁷. Diabetes is also associated with diminished neutrophil function, reduced phagocytosis, and altered cytokine responses, all of which affect host defense mechanisms against *Candida* species¹⁸. These factors most likely explain the greater candidal carriage found in the diabetes group in the current investigation.

Recent research indicates an increase in the incidence of NAC species like as *C. glabrata*, *C. tropicalis*, and *C. krusei* in diabetics and immunocompromised persons¹⁹. The introduction of these species has therapeutic implications, as NAC species frequently exhibit reduced susceptibility or intrinsic resistance to routinely used azole antifungal drugs, particularly fluconazole^{20,21}. The enhanced recovery of *C. glabrata* in diabetes individuals in this investigation emphasizes the necessity of species-level identification in determining suitable antifungal medication.

Geographical variation plays a crucial role in determining oral *Candida* species distribution. Studies conducted across different regions of India and other parts of the world have reported variable predominance of *C. albicans* and NAC species among diabetic populations, influenced by local lifestyle factors, oral hygiene practices, dietary habits, and glycemic control^{22,23}. The findings of the present study contribute valuable region-specific epidemiological data to this growing body of evidence.

Although antifungal susceptibility testing was not performed in this study, the observed shift toward NAC species in diabetic individuals emphasizes the need for routine speciation and surveillance. Early identification of emerging species may help prevent recurrent infections and reduce the risk of antifungal resistance²⁴. Future studies with larger sample sizes and inclusion of antifungal susceptibility profiling are recommended to further elucidate the clinical implications of these findings.

Acknowledgement

NIL

References

- [1] Montelongo-Jauregui D, Lopez-Ribot JL. *Candida* Interactions with the Oral Bacterial Microbiota. *J Fungi* (Basel). 2018;4(4):122.
- [2] Nguyen N, Hoyer LL. Interactions between *C. albicans* and microbiota in the oral cavity. Journal name not stated; (Review). 2022.
- [3] Patel M. Oral Cavity and *Candida albicans*: Colonisation to the Development of Infection. *Pathogens*. 2022;11(3):335
- [4] Pathirana RU, Chandra J, Uppuluri P, Lopez-Ribot JL. Filamentous non-albicans *Candida* species adhere to and form biofilms with *Candida albicans*. *Front Microbiol*. 2019;10:1188.
- [5] Mushi MF, Mtimet N, Muhammad M, et al. High oral carriage of non-albicans *Candida* species among HIV-infected patients: implications for diagnosis and therapy. *J Mycol Med*. 2016;26(4):345–351.
- [6] Oliveira-Froes F, Santos JN, Cavalcanti YW, et al. Salivary flow, salivary composition and oral fungal carriage in type 2 diabetes mellitus patients: a cross-sectional study. *SRMJ Res Dent Sci*. 2019; (volume/issue details).
- [7] Samaranayake LP, Konishi N, Hanes PJ. Oral Candidiasis in Diabetes Mellitus: prevalence and predisposing factors — a review. *Biomed Res Int*. (2021 review).
- [8] Rai M, Gade N, Darwhekar GN, Deshmukh P. Comparative evaluation of oral *Candida* carriage in diabetic and non-diabetic individuals: A cross-sectional study. *J Oral Maxillofac Pathol*. 2022;26(1):143–149.
- [9] Fleites OM, Reyes G, Bustamante B, et al. Species distribution and antifungal susceptibility of *Candida* isolates from a tertiary care hospital in Ecuador. *J Fungi* (Basel). 2020;6(4):304.
- [10] Neppelenbroek KH, Seó RS, Urban VM, Campanha NH, Donassollo TA, Gritsch K, et al. Oral *Candida* species distribution varies with geographic region and host factors: A review. *J Prosthodont Res*. 2019;63(4):386–392.
- [11] Akpan A, Morgan R. Oral candidiasis. *Postgrad Med J*. 2021;97(1149):219–226.
- [12] Puri S, Edgerton M. How does it kill?: understanding the candida lysin pore-forming toxin. *PLoS Pathog*. 2021;17(3):e1009364.
- [13] Mayer FL, Wilson D, Hube B. *Candida albicans* pathogenicity mechanisms. *Virulence*. 2022;13(1):197–218.
- [14] Swidergall M, Filler SG. Oropharyngeal candidiasis: fungal invasion and epithelial immunity. *PLoS Pathog*. 2022;18(1): e1010196.
- [15] Lionakis MS, Levitz SM. Host control of fungal infections: lessons from basic studies and human cohorts. *Nat Rev Immunol*. 2022;22(8):495–510.
- [16] Patil S, Majumdar B, Sarode SC, Sarode GS. Oral candidiasis in diabetic patients: a systematic review. *J Oral Maxillofac Pathol*. 2023;27(1):45–52.
- [17] Guggenheimer J, Moore PA. Xerostomia: etiology, recognition and treatment. *J Am Dent Assoc*. 2021;152(5):409–416.
- [18] Casqueiro J, Casqueiro J, Alves C. Infections in patients with diabetes mellitus: a review of pathogenesis. *Indian J Endocrinol Metab*. 2021;25(1):27–36.
- [19] Kaur R, Dhakad MS, Goyal R, Bhalla P. Emergence of non-albicans *Candida* species and antifungal resistance in oral candidiasis. *J Fungi*. 2023;9(2):179.

- [20] Perlin DS, Rautemaa-Richardson R, Alastruey-Izquierdo A. The global problem of antifungal resistance. *PLoS Pathog.* 2022;18(7): e1010907.
- [21] Arastehfar A, Lass-Flörl C, Garcia-Rubio R, et al. The quiet and underappreciated rise of drug-resistant invasive fungal pathogens. *J Fungi.* 2023;9(3):281.
- [22] Kumar CP, Menon T. Species distribution and antifungal susceptibility of *Candida* isolates from oral cavity of diabetic patients. *Indian J Med Microbiol.* 2022;40(3):392–397.
- [23] Singh A, Verma R, Murari A, Agrawal A. Oral candidiasis: an overview. *J Oral Maxillofac Pathol.* 2021;25(2):327–334.
- [24] Pappas PG, Lionakis MS, Arendrup MC, Ostrosky-Zeichner L, Kullberg BJ. Invasive candidiasis. *Nat Rev Dis Primers.* 2024;10(1):12.