OPEN ACCESS

Saudi Journal of Oral and Dental Research
Abbreviated Key Title: Saudi J Oral Dent Res
ISSN 2518-1300 (Print) | ISSN 2518-1297 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article **Dentistry**

Correlation of Salivary pH, Incidence of Dental Caries and Periodontal Status among Diabetic and Non-Diabetic Subjects-A Cross Sectional Study

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DOI: https://doi.org/10.36348/sjodr.2024.v09i11.002 | **Received:** 08.10.2024 | **Accepted:** 13.11.2024 | **Published:** 16.11.2024

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Abstract

***Aim*:** To evaluate the salivary pH and incidence of dental caries and periodontal status in Diabetes Mellitus and non-diabetic subjects. ***Materials and methods*:** A cross-sectional study was conducted which included 40 subjects. 20 Type 2 Diabetic Mellitus subjects and 20 non diabetic subjects. The pH of saliva was determined using a digital pH meter. For dental and periodontal Status, clinical examination was performed and Modified WHO Oral Health Assessment Form for Adults, 2013 was measured. The data collected was statistically analyzed and interpreted. ***Results*:** There was a decrease in the mean salivary pH of (6.59±0.10) in diabetic group, compared to that of non diabetic group (7.49±0.24). The mean number of carious teeth in diabetics (7.2±3.61) was significantly higher than in non diabetic subjects (2.55±1.05). Likewise, periodontal health was worse in diabetic subjects, with a higher prevalence of gingival bleeding and pockets of 4-5 mm depth, emphasizing the association between diabetes and increased oral health risks. ***Conclusion*:** This study concluded that there was a significant relationship between diabetes mellitus and increased incidence of dental caries and periodontitis. The salivary pH was significantly lower, hence the evaluation of salivary parameters can be a cost effective and a non invasive alternative for screening, diagnosis and monitoring of diabetes.

Keywords: Salivary pH, Diabetes Mellitus, Periodontitis, Dental Caries, Salivary biomarkers.

INTRODUCTION

Diabetes mellitus (DM) is a clinical syndrome characterized by hyperglycemia because of absolute or relative deficiency of insulin [1]. Diabetes is documented as the chronic disease with highest prevalence in the century by the World Health Organization and the International Diabetes Federation [2].

Diabetic Mellitus can be of two types - Type 1 and Type 2. Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder caused by insulin resistance or insufficient insulin secretion and is mainly characterized by elevated blood glucose levels [3].

A number of oral diseases have been associated with diabetes mellitus with an increased risk of dental caries and periodontal disease [4].

Diabetes mellitus manifests in altering the salivary composition and its functions. Change in oral environment initiates pathogenic bacteria, damaging hard and soft tissues of the oral cavity leading to an increased cariogenic activity and periodontal lesions. Since, saliva provides a protective effect; there can be development of dental caries when there is clinically significant decrease in salivary functions [4].

There is often a correlation between pH changes in plaque and sugar clearance from saliva. The low salivary pH provides an acidogenic environment for the

growth of aciduric bacteria leading to dental caries which again further lowers the salivary pH leading to a vicious cycle. Diabetes promotes periodontitis through an exaggerated inflammatory response to the periodontal microflora [4].

In patients with type 2 diabetes and periodontitis, intensive treatment of periodontitis improved glycemic control to a certain extent. Although the mechanisms underlying the bidirectional relationship between periodontal diseases and T2DM remain unknown, hyperglycemia has been shown to increase the expression of innate immunity receptors and potentially affect immune reactions in periodontal tissues [3].

The diagnosis of DM is based on blood glucose estimations. Blood collection is an invasive procedure, and may be traumatizing, especially in diabetic patients who require routine daily monitoring of blood glucose levels. Ongoing research in the past few decades has focussed on alternative methodologies that involve incorporating various other body fluids that could be used as a substitute for blood for diagnostic purposes. One of the most important among these is saliva [1].

Compelling reasons exist to use saliva as a diagnostic fluid. It meets the demands for being inexpensive, noninvasive and easy-to-use diagnostic methods. As a clinical tool, saliva has many advantages over serum, including ease of collection, storing and shipping and it can be obtained at low cost in sufficient quantities for analysis. For patients, the non-invasive collection techniques dramatically reduce anxiety and discomfort and simplify procurement of repeated samples for monitoring over time and is easier to handle for diagnostic procedures because it does not clot, thus lessening the manipulations required [5]. Hence, this study aims at using salivary pH as a diagnostic biomarker for diabetic subjects.

METHODOLOGY

This cross-sectional study was conducted in the MA Rangoonwala College of Dental Sciences and Research Centre, Pune, India over a period of 6 months where a total of 40 subjects with the age range of 18 to 60 years were included in the study using simple convenience sampling method after taking the institutional ethical clearance (EC/MCES/972/2024). All subjects were verbally explained the nature and purpose of the study and an informed written consent was obtained as per Helsinki declaration [1] (refer Annexure 1).

The inclusion criteria included subjects with 18 to 60 years of age diagnosed with Type 2 Diabetes Mellitus since 2 years and are free of any other systemic disease or under the influence of any drug which could alter the salivary composition and pH and were giving their consent to participate in the study as well as gave sample of their saliva.

The exclusion criteria included subjects who did not give written informed consent, gestational diabetic patients, Type I diabetic patients and patients with diseases, conditions and medication which can alter salivary composition and pH. Patients with any other pathology/disease that could affect salivary glands function and patients who were completely edentulous were also not selected for the study.

The selected subjects were divided into two groups. Group I (study group) comprised of 20 known diabetic subjects (16 males and 4 females), with minimum of two years of disease duration. Only Type II diabetic patients were included in this group. Group II (control group) comprised of 20 non diabetic subjects (16 males and 4 females), who were age and gender matched as that of the previous group.

A detailed history of the subjects was taken including personal history, drug history, allergies. The subjects were clinically examined and assessed for dental caries and periodontal status using the Modified WHO Oral Health Assessment Form for Adults, 2013 (refer Annexure 2).

The unstimulated whole salivary samples were collected from subjects in both the groups using spitting method. Subjects were requested not to drink any beverages except water and then to rinse their oral cavity with water before giving a sample of their saliva. After a waiting period of 10 minutes, so as to avoid sample dilution subjects were asked to bend the head forward and accumulate the saliva in the floor of the mouth. They were asked to refrain from talking and coughing during this period and then to expectorate the saliva in a sterile container, every 1 minute for a total of 10 minutes. 5 ml of saliva was collected in sterile 10 ml beakers.

The pH of the samples was immediately analyzed using a digital pH meter as shown in the (Figure 1). The pH meter was calibrated daily with freshly prepared pH 6.8 and pH 9.0 buffer solutions. After calibration, the electrode was placed in double-distilled water. Before measuring each sample, the electrode was gently dried with fresh, sterile filter paper. After measuring the pH, the electrode tip was rinsed with a gentle stream of distilled water and then placed back in double-distilled water. All solutions and reagents were prepared fresh each day. The digital pH meter readings were recorded, and the data was entered into Microsoft Excel for statistical analysis, with results presented in tables and graphs.

Figure 1: Digital pH meter (Model EQ-610)

RESULTS

In this study, 20 Diabetic and 20 Non-diabetic subjects consisting of 10 males & 10 females in each group with the age range of 18 to 60 years from Pune city participated.

1. Dentition Status:

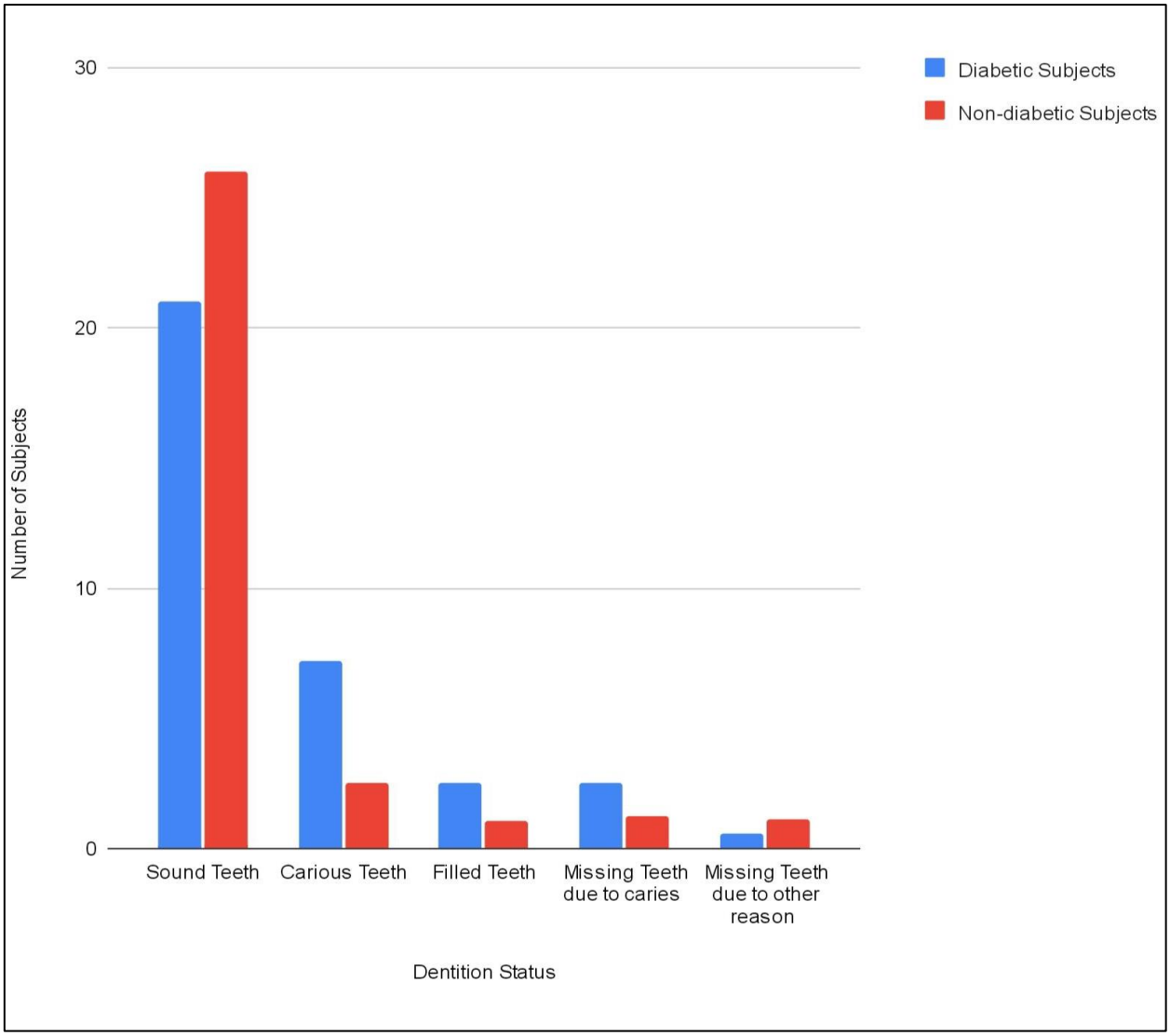
Table 1: Comparison of mean dentition status among diabetic and non-Diabetic subjects

Dentition Status	Groups	Mean	Std. Deviation	P Value
Sound 0	Diabetic	20.85	5.23	**<0.001****
	Non Diabetic	26.20	1.64	
Caries 1	Diabetic	7.20	3.61	**<0.001****
	Non Diabetic	2.55	1.05	
Filled w Caries 2	Diabetic	1.00	2.45	0.076
	Non Diabetic	0.00	0.00	
Filled, No caries 3	Diabetic	2.55	2.72	**0.025***
	Non Diabetic	1.05	0.88	
Missing due to caries 4	Diabetic	2.50	2.21	**0.033***
	Non Diabetic	1.25	1.20	
Missing due to other reason 5	Diabetic	0.55	0.94	**0.038***
	Non Diabetic	1.15	0.81	
Fissure Sealant 6	Diabetic	0.00	3.28	0.00
	Non Diabetic	0.00	0.00	
Fixed prosthesis 7	Diabetic	0.40	0.82	**0.036***
	Non Diabetic	0.00	0.00	
Unerupted 8	Diabetic	0.00	0.00	0.00
	Non Diabetic	0.00	0.00	
Not recorded 9	Diabetic	0.00	0.00	0.00
	Non Diabetic	0.00	0.00	

**p Value < 0.001 is highly significant

Table 1 shows that diabetic subjects has significantly lower number of sound teeth (mean 20.85 ± 5.23) than non-diabetic subjects whereas non-diabetic subjects show lower number of carious teeth than diabetic-subjects s (mean 26.20 ± 1.64) which is statistically significant (p<0.001).

Moreover diabetics had more number of filled (p=0.025) & missing teeth (p=0.033) due to caries compared to non-diabetics which is statistically significant. Non-diabetic subjects had overall better dental health than diabetics.



Graph 1: Graphical representation of dentition Status of diabetic and non-diabetic subjects

2. Gingival and Periodontal Status:

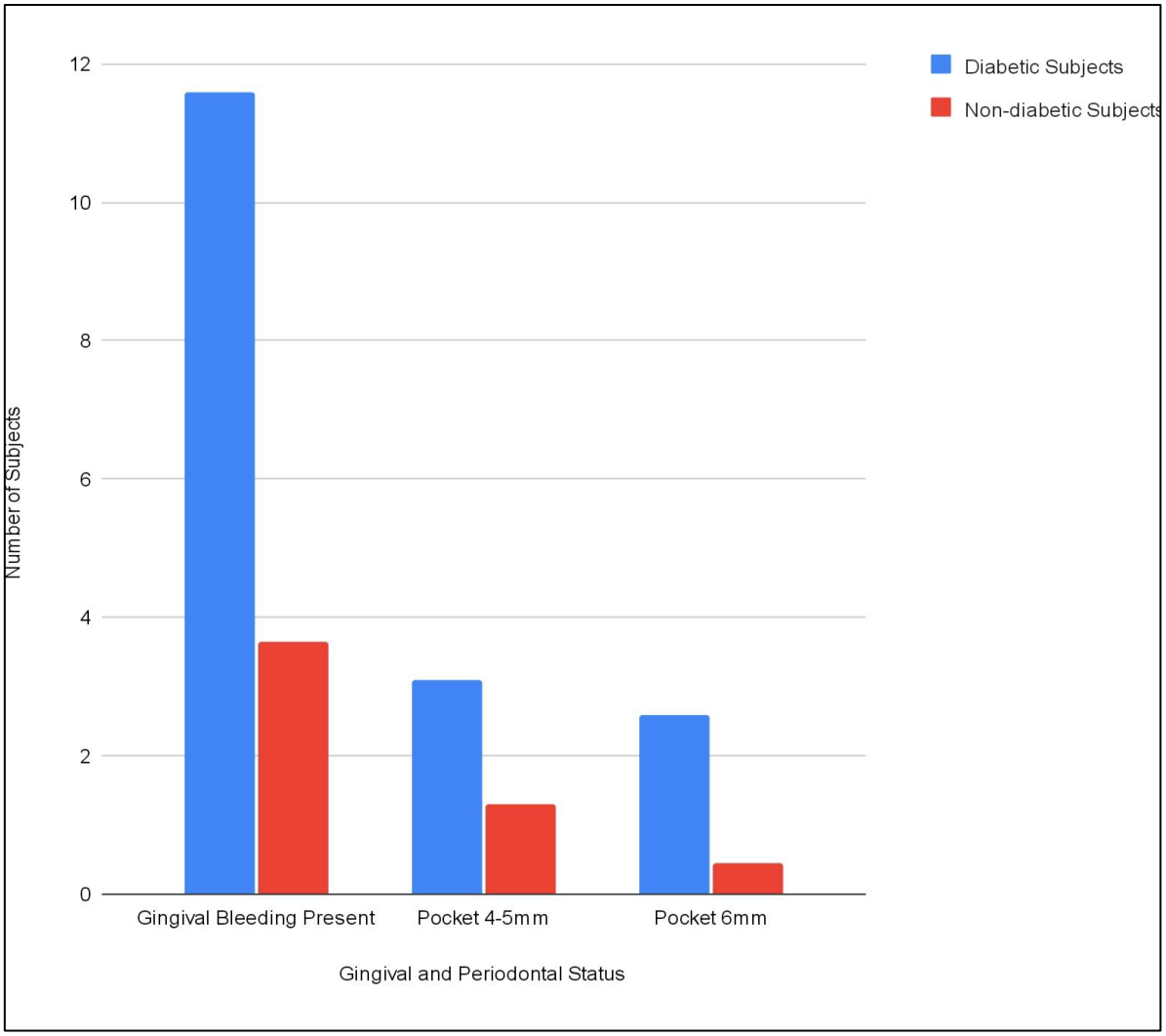
Table 2: Comparison of mean periodontal status among diabetic and non-Diabetic subjects

	Groups	Mean	Std. Deviation	P value
Gingival Bleeding Absent	Diabetic	17.55	7.25	**<0.001****
	Non Diabetic	25.95	2.58	
Gingival Bleeding Present	Diabetic	11.60	7.98	**<0.001****
	Non Diabetic	3.65	2.45	
Pocket Absent	Diabetic	23.40	4.53	**<0.001****
	Non Diabetic	27.85	2.06	
Pocket 4-5mm	Diabetic	3.10	1.86	**0.001***
	Non Diabetic	1.30	1.13	
Pocket 6mm	Diabetic	2.60	3.16	**<0.001****
	Non Diabetic	0.45	0.94	

**p Value < 0.001 is highly significant

Diabetic subjects had higher gingival bleeding (mean 11.6 ± 7.98) and a higher occurrence of periodontal pockets of 4-5mm (mean 3.10 ± 1.86) and pockets greater than 6mm (mean 2.60 ± 3.16) which is statistically significant (p<0.001).

Non-diabetic subjects showed significantly better periodontal health overall, with fewer gingival and periodontal problems.



Graph 2: Graphical representation of Gingival and Periodontal Status of Diabetic and Non-Diabetic subjects

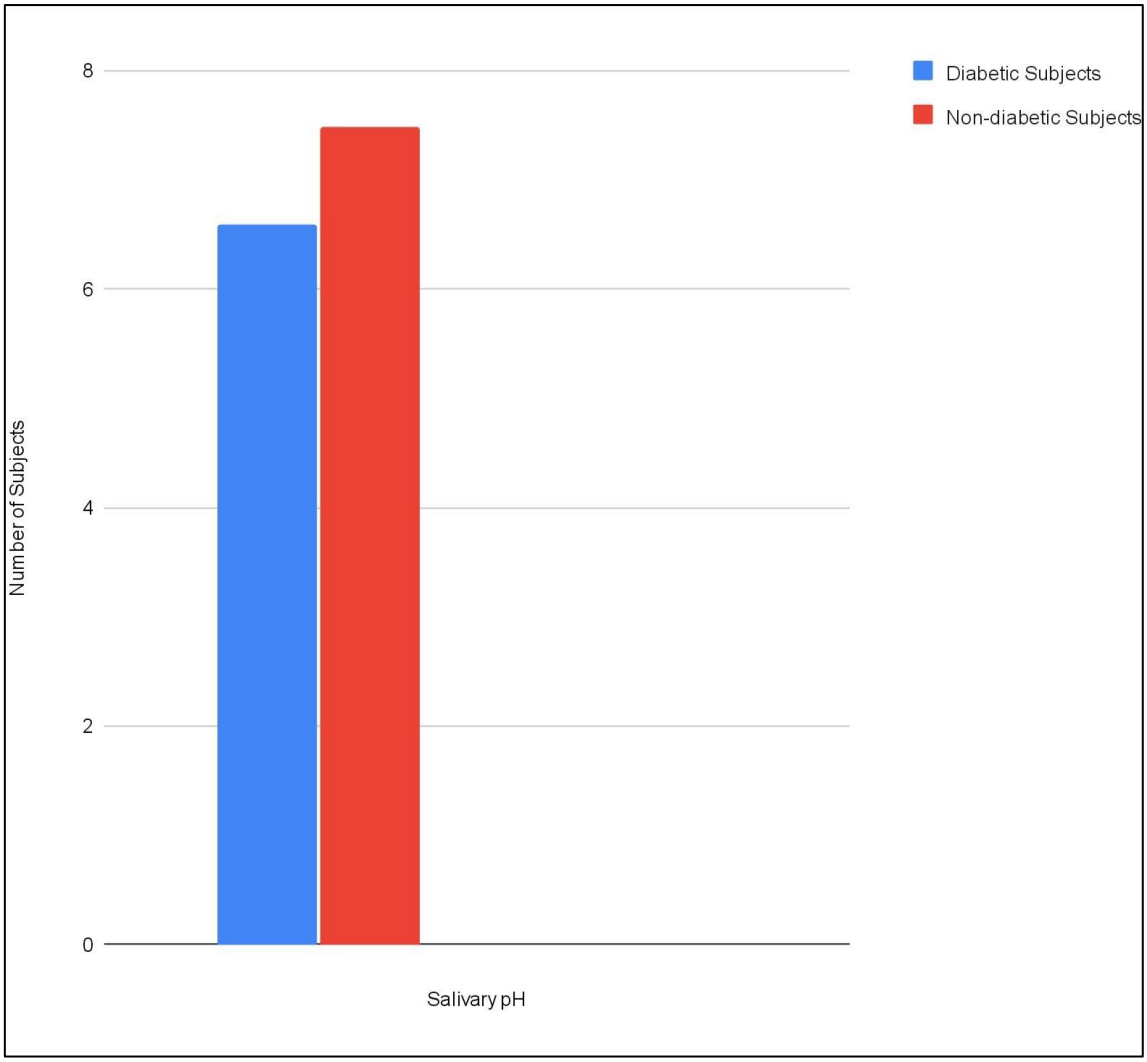
3. Salivary pH:

Table 3: Comparison of mean Salivary pH among Diabetic and Non-Diabetic Subjects

	Groups	Mean	Std. Deviation	P value
pH	Diabetic	6.59	0.10	**<0.001****
	Non Diabetic	7.49	0.24	

**p Value < 0.001 is significant

Diabetic subjects had a lower mean salivary pH (6.59 ± 0.10) compared to non-diabetic subjects (mean 7.49 ± 0.24), suggesting a more acidic oral environment in diabetic subjects which is statistically significant ($p<0.001$).



Graph 3: Graphical representation of Salivary pH of Diabetic and Non-Diabetic subjects

The differences in these metrics between the two groups were statistically significant, indicating that diabetes is associated with poorer oral health outcomes in terms of both dental and periodontal health, as well as salivary pH.

DISCUSSION

The relationship between diabetes and oral health has long been established, but this study provides a detailed comparison of the dentition status, periodontal health, and salivary pH between diabetic and non-diabetic individuals. The results clearly indicate that diabetes significantly impacts oral health, leading to worse outcomes across multiple dental and periodontal conditions.

The analysis of dentition status in this study revealed that diabetic subjects had significantly greater carious teeth (mean 7.2 ± 3.61) compared to non-diabetic individuals (mean 2.55 ± 1.05) and a greater number of missing teeth due to caries which is in accordance with de Lima *et al*., [6], Malvania EA *et al*., [7], Wang Y *et al*., [8], Ling *et al*., [9] who in their study have reported increased dental caries in diabetic subjects than Non-diabetic subjects. These results can be attributed to several factors associated with diabetes. One of the most prominent is xerostomia, or dry mouth, which is commonly seen in individuals with diabetes.

As reflected in the results, the level of gingival bleeding (mean 11.60 ± 7.98) and above 6mm periodontal pocket formation (mean 2.60 ± 3.16) was greater in diabetic subjects. This association between diabetes and periodontal disease is well-documented in the literature, with several mechanisms explaining the increased susceptibility of diabetics to periodontal issues and aligns with Zambon JJ *et al*., [10], N. Sayeeganesh *et al*., [11], Ervasti T *et al*., [12], Reuterving CO *et al*., [13], Taylor GW *et al*., [14] who in their study have reported increased gingival Bleeding and periodontal pockets in diabetic subjects than Non-diabetic subjects.

One of the unique aspects of this study was its focus on salivary pH levels. The results showed that diabetic subjects (mean 6.69 ± 0.10) had a significantly lower mean salivary pH compared to non-diabetic

subjects (mean 7.49 ± 0.24). A lower pH indicates a more acidic environment, which can contribute to dental caries by weakening the enamel and making it more susceptible to demineralization.

The results of this study is in harmony with Prathibha K. M *et al*., [15], Lima-Aragão *et al*., [16], Arul A *et al*., [17], Kao CH *et al*., [18], Jawanda *et al*., [19], Mascarenhas P *et al*., [20], Bernardi *et al.*, [21], Maya S. Indurkar *et al*., [22] who in their study have reported a decreased Salivary pH in diabetic subjects than Non-diabetic subjects.

Clinical Implications

The findings of this study have important clinical implications for both dental practitioners and healthcare providers managing diabetic subjects. Given the increased risk of dental caries, periodontal disease, and a more acidic oral environment in diabetics, integrated care is crucial. Dental professionals should emphasize the use of Salivary pH as a diagnostic marker and collaborate with endocrinologists and primary care physicians to ensure that diabetic subjects receive comprehensive care that addresses both their systemic condition and oral health [23].

Healthcare providers managing diabetic subjects should also be aware of the impact of oral health on glycemic control. By improving periodontal health, it may be possible to reduce systemic inflammation and improve insulin sensitivity, thereby helping subjects manage their diabetes more effectively [24-26].

Finally, educating diabetic subjects about the importance of hydration and the use of saliva substitutes or mouthwashes to combat xerostomia is essential for maintaining a healthy oral environment. Proper management of salivary flow and pH levels can reduce the risk of caries and other oral health complications.

Limitations of the study

The study's small sample size of 20 diabetic and 20 non-diabetic subjects limits the generalizability of the results. Additionally, confounding factors such as smoking, oral hygiene practices, and diet were not controlled, which could influence outcomes. The absence of glycemic control data further weakens the findings, as blood glucose levels can impact the severity of oral health issues in diabetics. Lastly, if the study only included Type 2 diabetics, the results may not apply to individuals with Type 1 diabetes.

CONCLUSION

In conclusion, this study highlights the significant impact of diabetes on oral health, with diabetic subjects exhibiting worse dentition status, periodontal health, and salivary pH levels compared to non-diabetic individuals. These findings underscore the importance of early and proactive dental care and using Salivary pH as a diagnostic biomarker for diabetic subjects. By addressing both oral health and glycemic control, healthcare providers can help improve the quality of life for diabetic subjects and reduce the burden of diabetes-related complications by integrating oral health into diabetes management for preventing the long-term consequences of both conditions.

Conflict of Interest: The authors had no conflict of interest to declare.

Financial Disclosure: The authors declare that they have not received financial support.

Ethics approval: The study was approved by the Ethics Committee of the M. C. E. Society, Pune. The reference number for the ethical clearance is EC/MCES/972/2024.

ACKNOWLEDGEMENTS

We, Namra Mirza and Shifa Patel, are immensely grateful to our guides, Dr. Neetu Kadu ma'am & Dr. Renukka Nagarale ma'am, for their constant guidance and support in making this study a success. We are also grateful to our Dean, Dr. Duggal ma'am, Vice- Principal, Dr. Salika Sheikh ma'am, the Secretary of the Ethics Committee, Dr. Farha Rizwan, & all members of the research committee. We would also like to thank our President, Shri P. A. Inamdar sir, for giving us an opportunity to conduct this study. We are particularly grateful to all the administrative staff of the colleges who have helped us & allowed us to conduct this study. Last but not least, we would like to thank all the subjects for participating enthusiastically in this study.

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