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The effect of oral acidity imbalance on the growth of pathogenic bacteria in diabetic patients

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Abstract

Background: It is well-established that diabetes alters the oral environme particularly the composition and acidity of saliva, which can affect the microb balance in the oral cavity. This study investigates the impact of oral acid disturbances on the growth of pathogenic bacteria in diabetic patients. Sal samples were collected and analyzed to measure pH levels, acid neutralizati capacity, and microbial composition. The results indicate that: diabetic patie exhibit a lower saliva pH compared to non-diabetic individuals, creating favora conditions for the proliferation of pathogenic bacteria such as Streptococ mutans, Candida albicans, and Porphyromonas gingivalis. Oral acidity disturban were positively correlated with increased bacterial colonization and a higher risk oral infections. Conclution :These findings highlight the importance of monitori oral health in diabetic patients and suggest that maintaining oral acid balance m play a crucial role in preventing the growth of pathogenic bacteria and th associated complications.

1. Introduction

Elevated blood glucose levels brought on by an absolute or relative insulin insufficiency are the hallmark of diabetes mellitus, a clinical condition (1). It is a common chronic disease that leads to high blood sugar (2). Research over the past few decades has focused on alternative diagnostic procedures using different body fluids instead of blood, with saliva being one of the most important. Several previous studies have shown changes in saliva flow and composition in diabetic patients, although the results have often been inconclusive (1). Decreased insulin secretion, decreased glucose uptake, or increased gluconeogenesis ultimately lead to elevated blood glucose levels and detrimental changes in various organs (3).

Diabetes comes in two primary forms: type 1 and type 2. Pancreatic beta cells are attacked and destroyed by lymphocytes and other immune cells in type 1, an autoimmune illness that affects only one organ and causes insulin insufficiency(2, 4) Environmental aspects are also important in susceptibility to type 1 (4). Gestational diabetes, which is defined as any degree of glucose intolerance that starts or is initially identified during pregnancy; type 2 diabetes, which requires either a deficiency in beta cells or a decrease in tissue sensitivity to insulin for the illness to develop; and some types of diabetes resulting from other causes (2) .

There is contradictory data in published studies about the qualitative and quantitative features of saliva in diabetes individuals (5). Another contentious issue is the connection between tooth caries and diabetes. Prior research has shown a link between diabetes and a higher incidence of dental caries in adults, especially when glycemic control is inadequate (5). Diabetes patients may develop dental cavities as a result of decreased salivary flow and higher glucose levels, which encourage the growth of bacteria that cause cavities (3). These patients may also experience oral complications, such as impaired taste, where their ability to distinguish taste sensations is diminished (3)(Figure 1).

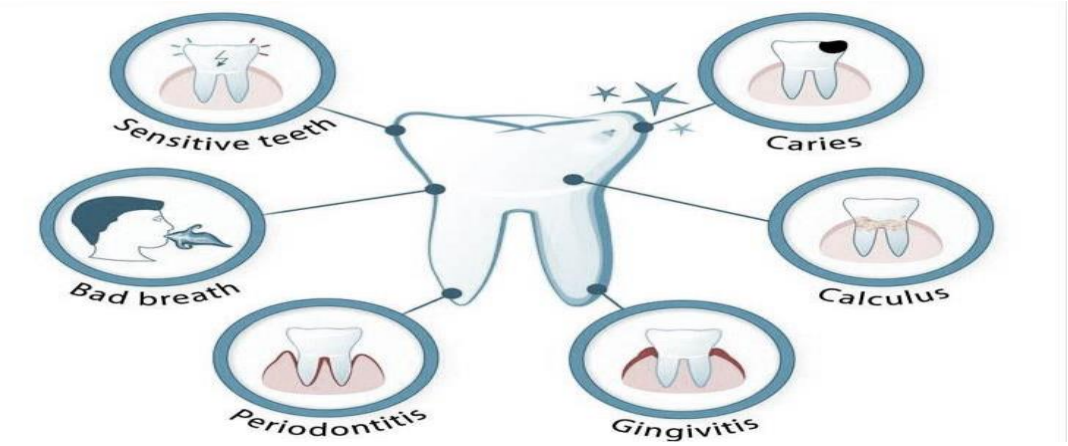


Fig. 1 : Complications and oral health problems associated with diabetes

1.1. The risk of developing diabetes is linked to Periodontal disease.

Untreated periodontitis is a chronic inflammatory disease with multiple contributing factors, can cause irreversible harm to the cementum, alveolar bone, and periodontal ligament that surround the teeth, resulting in tooth loss **(6, 7).**The relationship between periodontitis and diabetes has also been studied. Several studies indicate that this relationship is bidirectional. In fact, Diabetes increases the risk of periodontitis in individuals, and those with both periodontitis and diabetes often have poorer blood sugar control **(6).**

The American Diabetes Association classified periodontitis as a diabetic complication in 2008 (8). It is currently believed that oral disorders arise from a detrimental disturbance of the typically stable balance of the oral microbiota. As previously explained, there is an epidemiological link between periodontitis and diabetes, and treatment of periodontitis may reduce the level of glycated hemoglobin (HbA1c) by up to 0.4% in patients with type 2 diabetes (9).

Diabetes manifests itself in changes in the composition and function of saliva (10). The change in the oral environment leads to the appearance of pathogenic bacteria, which damages the hard and soft tissues in the oral cavity, and leads to increased tooth decay activity and the appearance of gum lesions (11).

Numerous studies indicate a strong epidemiological link between metabolic diseases and oral infections, such as periodontitis (9), which is the sixth leading complication of diabetes. Periodontitis is a chronic, multifactorial oral infection characterized by an inflammatory response associated with microbial imbalance in the mouth (9, 12).

Diabetes-related chronically high blood sugar is linked to long-term harm, organ failure, and overall frailty .The functions of the salivary glands lead to changes in the composition of saliva (13).

1.2. Diabetes's impact on oral microbiome

The mouth cavity's natural environment, saliva, is crucial to preserving its equilibrium. It lubricates and coats tissues, shielding mucous membranes and tooth surfaces from chemical, mechanical, and biological irritants(14). The pathophysiology of oral disorders is significantly influenced by the interplay between the oral ecology and the body's tissue resistance. Variations in the microbiological makeup could make the mouth microbiome more capable of causing illness (14).

Although there is conflicting evidence, Diabetes may be impacted by oral bacteria. Thus, it has been proposed that oral microorganisms cause intermittent bacterial presence in the bloodstream, which in turn causes systemic inflammation, insulin resistance, and high blood sugar (4) .

Several studies have shown that certain indicators of dental caries, such as reduced saliva flow and the number of Streptococcus mutans bacteria, may be related to metabolic control in diabetes and thus could affect the caries process.. Reduced saliva flow resulting from elevated blood glucose is a hallmark of periods of impaired metabolic control in diabetes (15, 16). During these periods, glucose may leak into the oral cavity, facilitating the growth of acid-producing bacteria and the development of caries lesions (15). The kidneys, retina, nerves, and other organs and tissues with a high capillary density are among the major problems of diabetes. The emergence of microangiopathy is the cause of these issues (15, 17). Similar changes in the small blood vessels of oral tissues can be observed (15).

The relationship between diabetes and bacterial infection is clinically known and increases the incidence of diabetes-related diseases and complications (18).

Patients with diabetes are twice as likely to develop community-acquired bacterial infections, such as pneumococci, streptococci, and enterococci, compared to patients without diabetes (18). Impaired innate and adaptive immune responses in a hyperglycemic setting have been connected to the higher frequency and severity of bacterial infections in diabetic patients (18).

1.3. Diabetes and saliva pH

Saliva is always present in the oral cavity, which plays a vital role in lubricating and cleaning the mouth. Diabetes can cause changes in the salivary glands, leading to a decrease in saliva flow and other alterations (19). The flow rate of saliva determines its composition and function. Saliva's capacity to neutralize acidity grows along with its levels of sodium, calcium, chloride, bicarbonate, and protein (19, 20). This buffering effect in saliva helps maintain a stable pH in dental plaque, thus preventing demineralization of tooth enamel. Diabetes can affect the oral cavity, potentially leading to various complications, including tooth decay, gum disease, oral mucosal diseases, and impaired salivary gland function, which significantly impact patients' quality of life (19). Insulin deficiency in diabetic patients can lead to decreased saliva and elevated glucose levels, putting them at increased risk of developing tooth decay (19).

The pH of saliva is an important physical property, responsible for its ability to neutralize acidity. Maintaining the acidity of the oral environment, in addition to its acid-neutralizing properties, is one of saliva's most important functions in protecting teeth. Viscosity is another important physical property of saliva that also contributes to protecting the oral cavity (21).

With advancing age, blood sugar levels, diabetes markers, and tooth decay increase in diabetic patients. Saliva production also decreases due to changes in its composition (22). The pH of their saliva decreases due to metabolic changes that produce an acidic environment (22).

2. Methodology

The total sample consisted of 100 samples who were divided into two groups. 50 patients with diabetes were included in the first group, whereas 50 samples without diabetes served as the control group in the second group, ranging in age from 12 to 75 years. They were clearly informed of the research objective and were free to accept or refuse to undergo the examination. They were all selected from among the people who visit the Diabetes and Endocrinology Center in Nasiriyah.

Every participant had unstimulated saliva samples taken under controlled circumstances. An hour before saliva was collected, participants were not allowed to eat or drink anything but water. Samples were collected between 9:00 AM and 12:00 PM, with each collection taking five minutes. The pH of the saliva was then measured using a pH test strip. The strip was immersed in the saliva for thirty seconds, and the resulting color was compared to the manufacturer's standard color chart.

The activity of the bacteria in the laboratory was studied by activating them using nutrient agar and detecting the Gram stain for bacterial infection: Gram-positive or Gram-negative bacteria were identified by MacConkey agar.

3. Results

3.1. Levels of PH in patients with diabetics and healthy control subject.

Table (1) and Figure (2) show the findings of a comparison of PH between individuals with diabetes and healthy control subjects. Patients with diabetes had mean PH levels of 6.0±0.81 and 6.98±0.136, respectively; the difference was very significant (P <0.001) and the level was lower in diabetic patients than in healthy control subjects.

Table 1. Average pH indicator levels in diabetic patients and healthy individuals as a control group.

			P
	Patients n = 50	Healthy control n = 50	
PH			
Mean± SD	6.0± 0.81	6.98 ± 0.136	< 0.001 † HS
Range	5.0 -7.0	6.0-7.0	

n: number of instances; SD: standard deviation; t-test for independent samples; Chi-square test; HS: P < 0.001 indicates high significance.

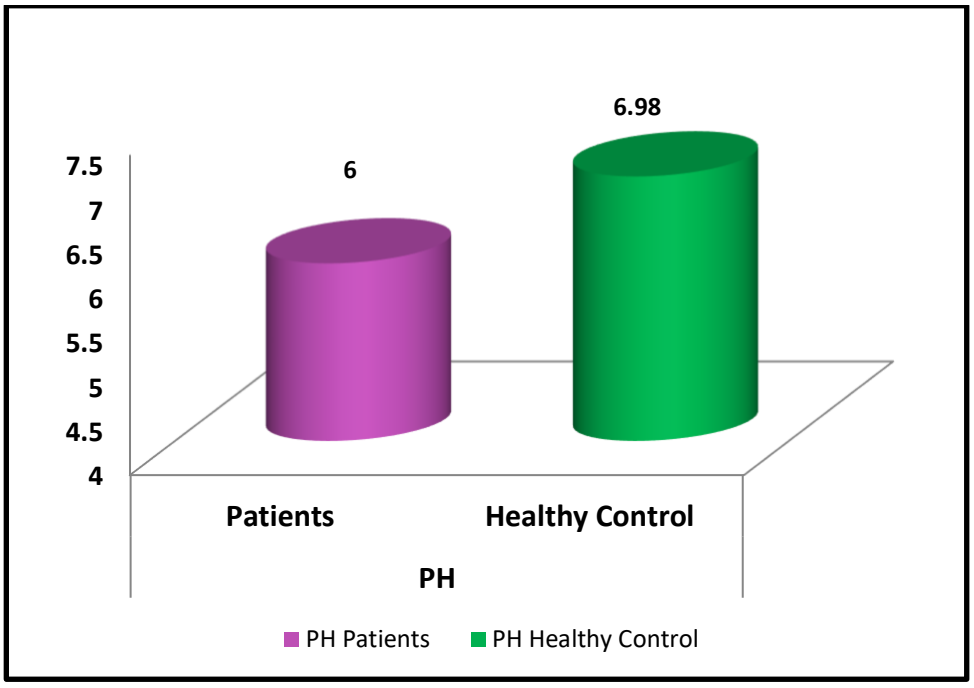


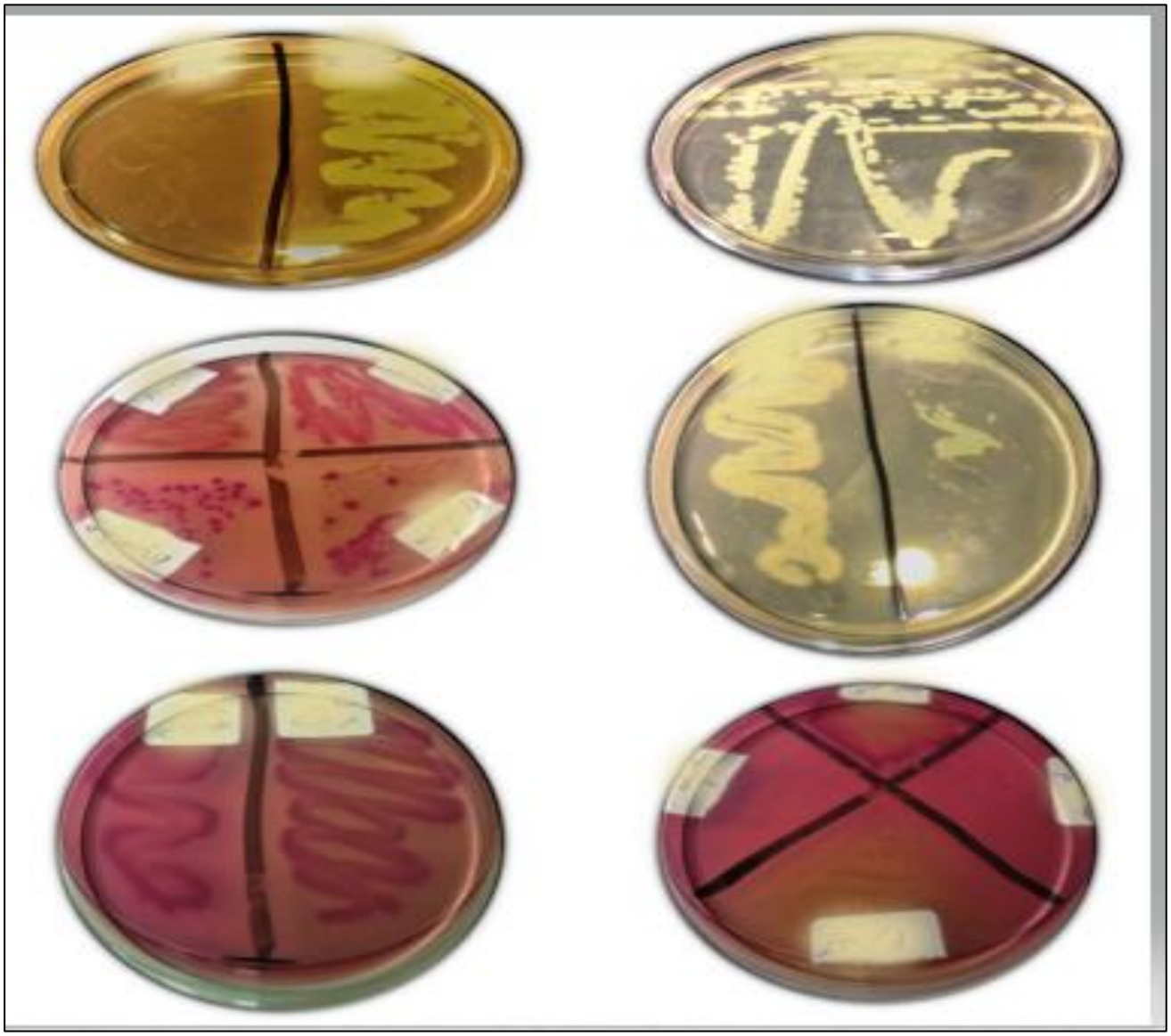
Fig 2. Distribution of patients and control according to PH level

3.2. Percentages of oral bacteria in diabetic patients

The results of the oral microbiome in the laboratory in 33 samples showed that 33 smears were culture-positive; 23.52% and 68.75% were Gram-positive and 76% and 68.75% were Gram-negative in the patients and control group respectively, as shown in Table (2) and Figure (3).

Table 2. Percentage of microbes in the samples

Present bacteria	Patients n= 17	Percentage %	Control N=16	Percentage %
Negative -	13	76%	11	68.75%
Positive +	4	23.52%	5	31.25%



4. Discussion

In their investigation, Sri Kenneth et al. discovered that individuals with uncontrolled diabetes had lower salivary pH and more dental caries than the control group (15). This permits the equilibrium of the oral environment to change in favor of cariogenic microorganisms, which reduces the pH of saliva even more and perpetuates the cycle (15).

The results showed a shift in the gut microbiome of diabetic patients towards an increased relative abundance of Gram-negative bacteria (23). Numerous studies show how antimicrobial treatment for periodontal disease affects patients with type 2 diabetes' blood levels of glycated hemoglobin (HbA1c) and tumor necrosis factor-alpha (TNF-α). Thus, patients with type 2 diabetes benefit from both antibiotics and alternative treatments for periodontitis (9). Growing evidence suggests that oral microbiota plays a significant role in the pathophysiological processes of obesity and its associated metabolic symptoms (9).The study by Janim et al. showed that the microbiological features of saliva in diabetic patients did not differ statistically significantly from healthy individuals (24, 25).The most relevant aspect of oral bacterial resistance is that the continued formation of plaque leads to a change in its composition, with an increase in the levels of Gram-negative bacteria (26). Also, the decrease in saliva pH promotes the growth of acid-loving bacteria, allowing acid-producing (Gram-negative) bacteria to multiply, creating an unfavorable environment for protective oral bacteria (15).

Oral infections caused by diabetes are primarily due to an imbalance between different types of oral microbes. Some types of oral microbes may be positively or negatively associated with diabetes, Others might not be impacted at all (27).

In diabetes, high blood sugar levels lead to decreased saliva production, especially when blood sugar is poorly controlled. Saliva plays a vital protective role in the oral cavity, cleaning away food particles that feed the bacteria that cause tooth decay. Saliva also removes acidic residues from food, thus neutralizing the acids in the mouth that erode tooth enamel. During this period, glucose is present in the oral cavity, allowing bacteria to grow and tooth decay to develop (28).

5. conclusion

In the modern world, diabetes has become a major epidemic. The oral cavity is one of the difficulties caused by this metabolic condition. One of the main effects of diabetes is oral problems, which can have a detrimental effect on a patient's quality of life. There is evidence that these patients' blood sugar levels are adversely affected by long-term oral problems. Therefore, preventing and managing oral complications resulting from diabetes is crucial.

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