Variation in salivary pH and buffering capacity of saliva in normal and diabetes mellitus patients - A pilot study

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ABSTRACT

Background: Diabetes mellitus (DM) is a chronic, lifelong condition that affects the body’s ability to use the energy found in food. The normal salivary function is an important factor for the maintenance of health, with the positive consequences on the functionality. It neutralizes the oral pH and acts as a buffer. Buffers are resistant to changes in pH. There are three possible buffer systems in saliva - the protein buffer, phosphate buffer, and carbonic acid/bicarbonate buffer. The diabetic patients have a lower stimulated parotid gland flow rate compared to well-controlled patients and patients without diabetes. Thus, the buffering capacity of the saliva of diabetic patients is much lower and leads to many oral complications.

Objective: Variation in salivary pH and buffering capacity of saliva in normal and DM patients was compared and analyzed.

Materials and Methods: Inclusion criteria include known diabetic type 2 patients of both sexes for at least 3 years and age between 26 and 65 years with a decayed, missing, or filled teeth score of ≥5. About 8–10 mL of unstimulated mixed saliva was obtained from all subjects 2 h after the breakfast. The saliva sample was collected from both the groups, and the salivary pH was estimated within 5 min. Results: The mean salivary pH for normal participants was found to be pH 7.2, whereas the diabetic mellitus patients showed a mean pH of 6.8. The mean buffering capacity of normal subjects is found to be 6.9, whereas the DM patients showed a mean pH of 5.3. Conclusion: Hyperglycemia alters the pH of the oral cavity, leading to dental caries. Therefore, adequate measures should be taken to prevent dental caries at an early stage.

KEY WORDS: Buffering capacity, Diabetes mellitus, Hyperglycemia, Saliva, Salivary pH

INTRODUCTION

Diabetes mellitus (DM) is an endocrine disease characterized by a deficit in the production of insulin with consequent alteration of the process of assimilation, metabolism, and balance of blood glucose concentration. DM has become a worldwide public health problem. In recent years, the global prevalence of DM has increased substantially, reaching 8.3% in 2014, which corresponds to 387 million patients.[1]

Saliva plays a major role in maintaining the integrity of the teeth by its buffering action and controlling the demineralization and promoting remineralization of the enamel continuously.[2] It is an aqueous fluid which is found in the oral cavity. It is composed of complex mixture of organic and inorganic secretory products. These products are generally secreted from the salivary glands, and other substances come from the upper airway, gastrointestinal reflex, food deposits, upper airway, and blood-derived compounds.[3,4] 93% of the saliva is secreted by major salivary glands and the remaining 7% by the minor salivary glands. These glands are located everywhere in the mouth except for the gums and anterior part of the hard palate. Daily production of the saliva ranges from 500 to 700 ml, and the average volume in the oral cavity is 1.1 ml. The salivary secretion is controlled by autonomous nervous system.[5,6]

Saliva flow rate, buffer capacity, and microorganism content are very important for oral health.

Buffer solutions generally maintain an approximately constant pH when small amounts of either acid or base are added or when the solution is diluted. In other words, buffers are resistant to changes in pH. There are three possible buffer systems in saliva - the
Detection of food taste is also assisted and influenced by saliva through the diffusion of taste substances to taste receptors, chemical interaction with taste substances, and changes in the sensitivity of taste receptors.[7-9] Dissolution of the inorganic material of teeth occurs when saliva ceases to be saturated with calcium and phosphate. This takes place below a certain pH level, referred to as the “critical pH,” which is usually around pH 5.5 but varies according to calcium and phosphate concentration and probably varies individually. Salivary buffers are the main protectors against tooth erosion, and low salivary buffer capacity has been connected with tooth erosion in some studies but not in others. Low salivary flow rate has also been suggested as a cause of erosion.[10] Bicarbonate is the most important buffering system. It diffuses into plaque and acts as a buffer by neutralizing acids. Moreover, it generates ammonia to form amines, which also serve as a buffer by neutralizing acids.[11] More than 90% of the non-bicarbonate buffering ability of saliva is attributed to low-molecular-weight, histidine-rich peptides.[12] Urea, another buffer present in saliva, releases ammonia after being metabolized by plaque, and thus increases plaque pH.[9,13] The buffering action of saliva works more efficiently during stimulated high flow rates but is almost ineffective during the periods of low flow with unstimulated salivary flow. Phosphate is likely to be important as a buffer only during unstimulated flow.[14] The pH of saliva may not be as important a measure for buffering action on caries as the pH of plaque, which saliva modifies.[15]

Functions of salivary can be organized into five major categories that serve to maintain oral health and create an appropriate ecologic balance: (1) Lubrication and protection, (2) buffering action and clearance, (3) maintenance of tooth integrity, (4) antibacterial activity, and (5) taste and digestion.[16,17]

The resting pH of plaque (that is, the pH of plaque 2–2.5 h after the last intake of exogenous carbohydrates) is 6–7.3. The pH rises during the first 5 min after the intake of most foods. The pH then falls to its lowest level, to 6.1 or lower, approximately 15 min after food consumption. Unless, there is additional ingestion of fermentable carbohydrates, the pH of plaque gradually returns to its resting pH of 6–7. Thus, salivary buffering, clearance, and flow rate work in concert to influence intraoral pH. As stated earlier, salivary flow can be augmented by the stimulus of chewing as well as by the muscular activity of the lips and tongue.[18] With stimulated additional flow, chewing products (such as gum) that contain no fermentable carbohydrates can aid in the modulation of plaque pH. Sugar-free sweeteners such as xylitol and sorbitol should be recommended for use without fear of promoting caries. Indeed, research has shown that the use of gum containing xylitol or sorbitol reduces plaque accumulation and gingival inflammation and enhances remineralization potential.[11] Taking into account, the time frame for changes in plaque pH related to the ingestion of fermentable carbohydrates, dentists should recommend that patients, especially those who are caries prone, brush soon after the intake of cariogenic meals and snacks.

As a seromucous coating, saliva lubricates and protects oral tissues, acting as a barrier against irritants. In plaque, the hydrolytic and proteolytic enzymes are produced, potential carcinogens from smoking and exogenous chemicals, and desiccation from mouth breathing.[19] The best lubricating components of saliva are mucins that are excreted from minor salivary glands. Mucins are complex protein molecules that are presented pre-dominantly in two molecular weight types 31 and 32 and formed by polypeptide chains that stick together. These mucins have the properties of low solubility, high viscoity, high elasticity, and strong adhesiveness. Any intraoral contact between soft tissues, between soft tissues and teeth, or between soft tissues and prostheses benefits from the lubricating capability of saliva supplied largely by these mucins. Mastication, speech, and swallowing of all are aided by the lubricating effects of mucins.

Xerostomia is a subjective complaint of dry mouth, whereas hyposalivation is an objective decreased of salivary flow.[15] Several factors are capable of inducing salivary disorders in DM patients such as ageing, head and neck radiotherapy, systemic disorders, and several drugs. Systemic diseases associated with xerostomia include rheumatologic chronic inflammatory disorders (rheumatoid arthritis and systemic lupus erythematosus), endocrine disorders (DM, hyperthyroidism, and hypothyroidism), neurologic disorders (depression and Parkinson’s disease), genetic disorders, metabolic disorders (dehydration, bulimia, anemia, and alcohol abuse), infectious disorders (HIV/AIDS and HCV infection), and others (fibromyalgia, graft-versus-host disease, sarcoidosis, and chronic pancreatitis). Many cases of xerostomia are also related to psychological conditions such as depression and anxiety.

Hence, this study aims to do a research on the variation in buffering capacity of saliva in normal and DM patients.

MATERIALS AND METHODS

Collection of Saliva Sample

Inclusion criteria include patients aged between 26 and 65 years with known type 2 diabetes of both the sexes for at least 3 years and with a decayed, missing, or filled teeth score of ≥5. All the subjects were free from
any vascular complication of diabetes. About 8–10 mL of unstimulated mixed saliva was obtained from all subjects 2 h after the breakfast. Form the healthy subjects, the saliva was obtained by examining for dental caries. After the saliva sample was collected from both the groups, the salivary pH was estimated within 5 min.

**Buffering Capacity of Saliva (by Ericsson Method, 1959)**

The estimation of buffering capacity was carried out as per the method described by Ericsson modified for smaller volumes. 0.5 ml of saliva was added to 1.5 ml of 5 moles/1 HCL. The mixture was vigorously shaken and then centrifuged for 1 min and allowed to stand for 10 min where the final pH of supernatant was measured by pH papers, which has a predominant pH range of 3.5–6.0 and 6.5–9.0 and categorized accordingly.

**RESULTS**

The mean salivary pH for normal individuals is found to be pH 7.2, whereas the diabetic mellitus patients showed a mean pH of 6.8 [Table 1].

After analyzing the buffering capacity and salivary pH of both the graphs, it was found that there was a sharp decline in the salivary pH of diabetic patients (from pH 6.8 to pH 5.3), whereas the salivary pH of normal individuals almost remained the same even after the addition of mild acid (from pH 7.2 to pH 6.9) [Graph 1].

The mean difference in the pH of DM patients is 1.5, whereas in normal individuals, it is found to be 0.4 [Table 1].

**DISCUSSION**

After analyzing the buffering capacity of saliva from normal and uncontrolled diabetic patients, it was found that there was a sharp decline in the salivary pH of diabetic patients (from pH 6.8 to pH 5.3), whereas the salivary pH of normal individuals almost remained the same even after the addition of mild acid (from pH 7.2 to pH 6.9).

Diabetes has emerged as a major health-care problem in the world, with high degree of morbidity and mortality related to multiple organ systems involvement. Like other organs, the oral cavity shows changes related to the disease, and oral infections may adversely affect metabolic control of the diabetic state. Salivary parameters are altered by metabolic, nutritional, and neurological abnormalities. Some systemic diseases affect salivary glands directly or indirectly, and they may influence the quantity as well as the composition of the saliva that is produced. There is a decrease in the salivary flow rate and buffering capacity, with an increase in the *Streptococcus mutans* count and *Lactobacillus* in saliva which are the prime micropathogens of dental caries. The intimate relationship between the oral health and diabetes suggests a need for the assessment of oral clinical parameters in such patients. Therefore, in the present study, salivary pH was determined in non-diabetics and diabetics, and the possible difference in the occurrence of dental caries was evaluated.

Salivary buffer system such as the phosphate buffer system and carbonic acid-bicarbonate buffer system helps in maintaining the pH of the oral cavity. Oral cavity constantly gets exposed to components whose pH differs from the normal pH (6.5–7.5) of the saliva. If the buffer system gets altered due to chronic disorders like DM, it may lead to a loss in buffering capacity. In case of oral cavity, the reduced buffering capacity of saliva may lead to a damage to teeth and mucosal surface.

Thus, the patients who are suffering from chronic ailment like DM should be kept aware of the importance of keeping their blood sugar in control. Frequent monitoring of associated parameters will help in managing the condition.

**CONCLUSION**

Since the insidious nature of diabetes allows prolonged period of hyperglycemia to begin exerting negative

![Graph 1: Determination of salivary pH in normal and diabetes mellitus individuals](image-url)
pressure on various organ systems including oral cavity, adequate measures to prevent dental caries in these patients at an early stage are necessary. Understanding the implications of DM on the oral health is, therefore, necessary for the dental professionals.

REFERENCES

21. Source of support: Nil; Conflict of interest: None Declared