Future Dental Journal 4 (2018) 72–75

Contents lists available at ScienceDirect

Future Dental Journal

journal homepage: http://www.journals.elsevier.com/locate/fdj

Correlation of salivary characteristics with high risk of dental caries; A clinical investigation

Anum Khan [a, *], Badar Qureshi [a], Amir Qureshi [a], Yaqoot Imtiaz [b], Sidra Qadeer [a]

[a] Islamic International Dental College and Hospital, Islamabad, Pakistan
[b] National University of Science and Technology, Pakistan

ARTICLE INFO

Article history:
Received 8 June 2017
Accepted 12 October 2017
Available online 20 October 2017

Keywords:
Dental caries
pH
Consistency
Salivary flow rate

1. Introduction

Dental caries is one of the most prevalent and alarming oral health problems encountered in people regardless of age. It is a chronic, multifactorial disease resulting in the destruction of tooth structure and may lead to tooth loss if not treated promptly. Furthermore, it has a significant impact on individuals and on the community as a whole [1] (in the form of discomfort, pain, functional impairment, aesthetic concerns and financial burden for treatment [2]). This makes it a prime public health concern that should be addressed immediately.

Patients considered to have a high risk of dental caries exhibit active carious lesions that have cavitated smooth surfaces of two or more teeth at one time. Also at a high risk are those who show signs of recurrent caries or have a history of smooth surface caries in the past.

Several external and internal host factors contribute to the development and progression of dental caries. The development of carious lesions in teeth is highly dependent upon lifestyle and diet [3]. It is a complex process in which bacterial metabolism produces acid by fermentation of carbohydrates [4]. Demineralization of hard tissue occurs as a result of this pronounced acid attack.

Amongst the external host factors, dietary sugars play an imperative role. Sugars provide a substrate for bacteria to ferment and Streptococcus Mutans is majorly involved [5]. The amount, frequency, concentration, and form of sugars are strongly related to the prevalence of dental caries [6]. In addition, dietary routine of low fiber, sugared/carbonated beverages and refined food can result in reduced clearance and an overall acidic environment. Other factors include inadequate oral hygiene [7] and irregular dental recall. Poor oral hygiene leads to increased plaque accumulation on the surfaces of teeth. This leads to increased bacterial load, lower pH of the mouth and eventually demineralization [8].

Internal host factors contributing to dental caries are tooth surface and saliva. The surfaces not accessible to cleaning aids are more prone to bacterial attack and thus, caries. Saliva plays a fundamental role in the maintenance of oral homeostasis [9]. Saliva has been used as a diagnostic tool for more than two thousand years, utilized as a marker of health or disease states [10]. Various functions of saliva include buffering, lubrication, antibacterial properties, antiviral action, and digestion. Being a complex aggregate of proteins, enzymes, regulating hormones, essential vitamins, immunoglobulins, a reservoir of electrolytes and metabolites makes saliva an important defense mechanism of the body [11]. This natural defense mechanism counteracts the acidic effect of bacteria by washing away debris, neutralizing pH and establishing equilibrium in the remineralization and demineralization cycle. Remineralization of hard tissue relies on saliva being a reservoir of calcium, phosphate and fluoride ions [4]. Therefore, saliva plays an extremely vital role in safeguarding and maintaining the integrity of oral soft and hard tissues in the mouth.

Salivary characteristics such as pH, flow rate, consistency and buffering capacity have been associated with dental caries. The flow rate is the quantitative measure of salivary secretion in milliliters per minute. A greater flow rate leads to increase in clearance of debris and bacteria. Xerostomia caused by decreased salivary production or secretion results in increased caries incidence, compromised periodontal health and functional impairment.

* Corresponding author. Department of Restorative Dentistry/ Endodontics, Islamic International Dental College and Hospital, Islamabad, Pakistan.
E-mail addresses: anumk@outlook.com (A. Khan), badaraq@gmail.com (B. Qureshi), dr.amir28792@gmail.com (A. Qureshi), yaqootimtiaz@hotmail.com (Y. Imtiaz), sidraqadeer07@gmail.com (S. Qadeer).

Peer review under responsibility of Faculty of Oral & Dental Medicine, Future University.

https://doi.org/10.1016/j.fdj.2017.10.002

Altered salivary production or secretion can be caused by medical conditions, medications or salivary gland disorders. Resting salivary flow rate (unstimulated) ranges from 0.25 to 0.35 ml/min, whereas stimulated salivary flow rate ranges from 1 to 3 ml/min [12]. Flow rate can be considered abnormal if in the resting state, it is < 0.1 ml/min and when stimulated, is < 0.5 ml/min.

The normal range of salivary pH is 6.2–7.6. Cariogenic bacteria ferment carbohydrates, releasing hydrogen ions. Increased H+ ion concentrations account for the acidic pH. Saliva maintains the pH of the mouth by clearing away food debris and microorganisms, as well as by its buffering capacity. A lower pH (<6.2), corresponding to an acidic environment means increased bacterial activity and lower mineral reservoir. Inversely, an elevated pH (>7.6) may lead to increased plaque accumulation and provides an environment for anaerobes to thrive. Therefore, a neutral salivary pH is essential for the health of oral soft and hard tissues. Bicarbonate ions in saliva have a buffering effect on the lower pH. They help in neutralizing the acidic effects caused by an increase in the hydrogen ion concentration [13].

Lastly, depending upon the protein and mucin content in saliva, it can be watery (clear) or thick (sticky or frothy). Parotid gland produces most of the saliva when stimulated, being more watery and serous in nature. On the other hand, submandibular gland produces 60% of the saliva at rest (both mucous and serous secretion in nature). Minor salivary glands do not affect the flow rate, as the major salivary glands do. The mucous content of saliva produced by minor salivary glands provides lubrication and protection. More mucins and proteins in saliva mean more lubrication and less plaque accumulation.

The aim of this study is 1) to evaluate the association of certain salivary characteristics (Flow rate, pH, consistency) in high-risk caries patients and 2) their efficacy as clinical tests to determine the risk of developing dental caries.

2. Materials and methods

This research was carried out in the Department of Restorative Dentistry at Islamic International Dental College and Hospital, Islamabad, Pakistan. After taking consent, a sample of saliva was taken from 303 patients and evaluated for flow rate (normal resting 0.25–0.35 ml/min, normal stimulated 1–3 ml/min), pH and consistency.

The inclusion criterions were set as healthy patients with more than 2 active carious lesions in the mouth and were above 9 years of age. Patients taking medications that cause hypo-salivation were excluded. In addition, patients with a history of metabolic disease, previous radiation therapy, salivary gland inflammation or disorder were also excluded from being sampled.

The unstimulated salivary flow rate was measured passively by asking the patient to spit in a plastic cup provided after 60 seconds (Fig. 1a). Patients were instructed to lower their heads facing forward, not to talk nor swallow the collecting saliva. The stimulated salivary flow rate was measured by requesting the patients to chew on paraffin wax pellets (Fig. 1b) for 60 seconds and spitting the saliva collected in a separate cup provided. The flow rate was measured by aspirating from a graduated syringe [14] (Fig. 1c and d). Universal indicator pH paper strips were placed in both cups and dipped in the salivary sample for 10 seconds (Fig. 2a). The color change on the pH strip was noted corresponding to the pH of the saliva, for samples with a very limited quantity of the salivary sample [15] (Fig. 2b). Where salivary content was sufficient, an electronic pH meter was used (Fig. 2c). Salivary consistency was observed subjectively as watery and clear or thick, frothy and stringy (Fig. 1a). The above-mentioned parameters were recorded along with patient's name, age and DMFT scores. The collected data was analyzed using SPSS software estimating the rate ratio using linear regression to relate the above mentioned salivary characteristics with dental caries in different age groups.

3. Results

The data was collected at random and totalled out to 303 patients. The data was analyzed and the mean calculated for the salivary characteristics individually. The mean decayed count was 4.34 with a standard deviation of 3.55. Salivary consistency was denoted as 1 or 2, being watery or thick respectively. The mean flow rate (standard deviation) was recorded to be 0.32 (0.34) ml/min unstimulated and 0.98 (0.77) ml/min stimulated. The mean pH (standard deviation) was documented to be 6.55 (0.92) for unstimulated and 7.21 (0.89) for stimulated salivary samples as shown in Table 1. Table 2 shows the linear regression model summary.

Age is the only factor which is significantly affecting dental

Fig. 1. a) pH strip in thick consistency frothy salivary sample. b) Paraffin wax pellets. c) Saliva sample in a graduated syringe (0.3 ml/min). d) saliva sample in a graduated syringe (0.7 ml/min).

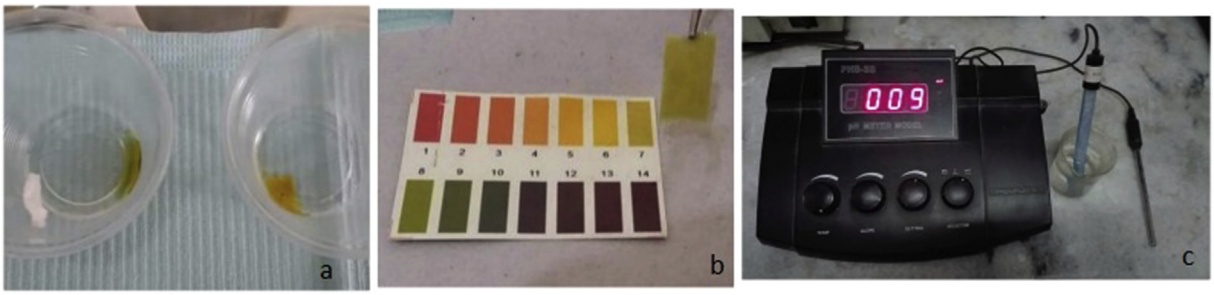

Fig. 2. a) pH strips in stimulated and unstimulated salivary sample (left cup pH 7, right cup pH 6). b) Universal indicator pH paper strip. c) Electronic pH meter.

Table 1
Mean and standard deviation of all the factors.

	Mean	Std. Deviation	N
Decayed	4.34	3.555	303
Flow rate (Unstimulated)	0.3287	0.34123	303
Flow rate (stimulated)	0.9884	0.77372	303
pH (Unstimulated)	6.55	0.923	303
pH (stimulated)	7.21	0.890	303
Consistency	1.37	0.484	303

Table 2
Linear regression model summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.236[a]	0.056	0.037	3.489

Predictors: (Constant), FR.US, FR.S, pH.US, pH.S, Consistency, Age.
[a] These salivary characteristics account for only 23.6% (Table 2) of all the factors that contribute to Dental caries (R = 0.236).

caries (p = 0.007). According to these results, with progressing age the risk of dental caries increases. All other factors are insignificant in relation to the risk of dental caries (pH stimulated p = 0.287, pH unstimulated p = 0.484, Flow rate stimulated p = 0.400, Flow rate unstimulated p = 0.700, consistency p = 0.396).

4. Discussion

This research was conducted to determine salivary characteristics and their effect on dental caries. The results of this research indicate that salivary tests alone cannot indicate a high risk of caries in patients and thus, salivary characteristics do not have a significant outcome on dental caries.

The result of this prospective study indicates that salivary characteristics show a weak association with caries risk. Hence, it disagrees with the concept that low flow rate, pH or watery consistency of saliva would lead to dental caries. In this study, cases with high salivary flow rate (>1 ml/min unstimulated and >2 ml/min stimulated), neutral pH and thick frothy consistency presented with multiple carious lesions in the teeth. Alternatively, cases with flow rate as low as 0.05 ml/min (unstimulated and stimulated), low pH and watery consistency presented with fewer dental caries.

The above-mentioned examples reinforce the definition of dental caries being a multifactorial disease. Dental caries can be prevented if all the contributing factors are in harmony with each other and equilibrium between demineralization and remineralization is maintained. One factor cannot be solely relied upon to assess the risk for high or low dental caries. All the factors responsible for the destruction of tooth structure have to be taken into account to determine the risk.

These results coincide with the results of a prospective study 'salivary characteristics and dental caries' by Cunha-Cruz J. et al., according to which, salivary characteristics are poorly associated with previous dental caries experience [12]. The factors that constituted to increase the incidence of caries were low resting pH, low flow rate and watery saliva of low viscosity, but these results were not consistent amongst various age groups.

In a Case-control study by Erdem V et al., assessing DMFT in 40 healthy and 40 patients with Behcet disease, it was established that there was no statistical significance between salivary pH, flow rate, buffering capacity and bacterial count [16]. Aljerf L. et al., studied the relationship of various salivary characteristics (pH, buffering capacity, flow rate, glucose, levels of calcium and magnesium) in healthy males and males with diabetes and Behcet disease [17]. The results showed a lower pH and flow rate but higher DMFT in type 1 diabetes mellitus, while in type 2 diabetes mellitus, an increase in both flow rate and DMFT was reported. This reinforces the results of our study; that these salivary characteristics cannot be solely accountable for high risk or incidence of dental caries in patients.

In a critical review by Tonetti MS et al., it is concluded that with increasing age, an increase in caries rate and periodontal disease is noted [18]. This also coincides with the result of our study, which documents that age is the only significant factor that correlates with dental caries.

However, there are various studies that contradict the findings of our study. In a study by Hegde AM. et al., evaluating the oral health status in a sample size of 120 leukemic children, evidence of higher caries risk and deteriorating gingival status was documented as a result of decreased salivary flow rate and pH [19].

In a prospective study by Aminabadi NA. et al., investigating the linear interaction between dental caries and salivary characteristics, it was concluded that the relationship is reciprocal [20]. Once dental caries was treated and saliva sample analyzed, pH and buffering capacity of the saliva were increased, but the flow rate did not change.

Shimazaki Y et al. studied the effect of salivary flow rate and oral health status in 2110 Japanese patients [21]. The study concluded that reduced salivary flow rate resulted in an increase in caries risk and periodontal disease.

A large sample size was the strength of this study. The pH was measured by both pH strips and an electronic pH meter which gives more accurate readings. The limitations of the study were the lack of resources for the measurement of salivary flow rate. Salivary flow rate can be measured by more sensitive equipment and techniques. A modified Lashley cup or Carlson-Crittenden collector can be used to measure the flow rate by placing it directly adjacent to Stenson duct to measure flow rate from the parotid gland. A custom-made Wolff saliva collector can be used to measure flow rate for individual submandibular gland by positioning it with the Wharton's duct at the floor of the mouth [22].

5. Conclusion

Salivary tests alone cannot be relied upon to determine the caries risk of a patient. There are several other factors (dietary sugars, oral hygiene, tooth surface and bacteria) that may contribute to dental caries. Therefore other factors need to be considered before making any decision. A more in-depth and successful research is required on this subject to make further progress.

Authors contribution

Dr. Anum Khan: conception, design, acquisition of data, statistical analysis, initial drafting and final review of the manuscript.

Dr. Badar Qureshi and Dr. Amir Qureshi were responsible for data collection and referencing of the manuscript.

Ms. Yaqoot Imtiaz and Dr. Sidra Qadeer: analysis and interpretation of data, review and final approval of the manuscript.

Grant support & financial disclosures

None.

Conflict of interest

None.

References

[1] Pitts N, Amaechi B, Niederman R, Acevedo AM, Vianna R, Ganss C, et al. Global oral health inequalities: dental caries task group–research agenda. Adv Dent Res. 2011;23(2):211–20. https://doi.org/10.1177/0022034511402016.

[2] Hooley M, Skouteris H, Boganin C, Satur J, Kilpatrick N. Body mass index and dental caries in children and adolescents: a systematic review of literature published 2004 to 2011. Syst Rev. 2012;1:57. https://doi.org/10.1186/2046-4053-1-57.

[3] Watanabe M, Wang DH, Ijichi A, Shirai C, Zou Y, Kubo M, et al. The influence of lifestyle on the incidence of dental caries among 3-year-old Japanese children. Int J Environ Res Public Health 2014;11(12):12611–22. https://doi.org/10.3390/ijerph111212611.

[4] Featherstone JD. Dental caries: a dynamic disease process. Aust Dent J 2008;53(3):286–91. https://doi.org/10.1111/j.1834-7819.2008.00064.x.

[5] Forssten SD, Bjorklund M, Ouwehand AC. Streptococcus mutans, caries and simulation models. Nutrients 2010;2(3):290–8. https://doi.org/10.3390/nu2030290.

[6] Rugg-Gunn AJ, Hackett AF, Appleton DR, Jenkins GN, Eastoe JE. Relationship between dietary habits and caries increment assessed over two years in 405 English adolescent school children. Arch Oral Biol. 1984;29(12):983–92.

[7] Stecksen-Blicks C, Gustafsson L. Impact of oral hygiene and use of fluorides on caries increment in children during one year. Community Dent Oral Epidemiol 1986;14(4):185–9.

[8] Mulu W, Demilie T, Yimer M, Meshesha K, Abera B. Dental caries and associated factors among primary school children in Bahir Dar city: a cross-sectional study. BMC Res Notes 2014;7:949. https://doi.org/10.1186/1756-0500-7-949.

[9] Epstein JB, Scully C. The role of saliva in oral health and the causes and effects of xerostomia. J Can Dent Assoc. 1992;58(3):217–21.

[10] Greabu M, Battino M, Mohora M, Totan A, Didilescu A, Spinu T, et al. Saliva–a diagnostic window to the body, both in health and in disease. J Med Life 2009;2(2):124–32.

[11] Nunes LA, Mussavira S, Bindhu OS. Clinical and diagnostic utility of saliva as a non-invasive diagnostic fluid: a systematic review. Biochem Med Zagreb 2015;25(2):177–92. https://doi.org/10.11613/BM.2015.018.

[12] Cunha-Cruz J, Scott J, Rothen M, Mancl L, Lawhorn T, Brossel K, et al. Salivary characteristics and dental caries: evidence from general dental practices. J Am Dent Assoc. 2013;144(5):e31–40.

[13] Khemiss M, Ben Khelifa M, Ben Saad H. Preliminary findings on the correlation of saliva pH, buffering capacity, flow rate and consistency in relation to waterpipe tobacco smoking. Libyan J Med 2017;12(1). https://doi.org/10.1080/19932820.2017.1289651.

[14] Alves C, Brandão M, Andion J, Menezes R. Use of graduated syringes for measuring salivary flow rate: a pilot study. Braz Dent J 2010;21:401–4.

[15] Naveen S, Asha ML, Shubha G, Bajoria A, Jose A. Salivary flow rate, pH and buffering capacity in pregnant and non-pregnant women - a comparative study. JMED Res 2014;2014:1–8. https://doi.org/10.5171/2014.50694.

[16] Erdem V, Yildiz M, Erdem T. The evaluation of saliva flow rate, pH, buffer capacity, microbiological content and indice of decayed, missing and filled teeth in Behcet's patients. Balk Med J 2013;30(2):211–4. https://doi.org/10.5152/balkanmedj.2013.7932.

[17] Aljerf L, Alhaffar I. Salivary distinctiveness and modifications in males with diabetes and Behcet's disease. Biochem Res Int 2017;2017:9596202.

[18] Tonetti MS, Bottenberg P, Conrads G, Eickholz P, Heasman P, Huysmans MC, et al. Dental caries and periodontal diseases in the ageing population: call to action to protect and enhance oral health and well-being as an essential component of healthy ageing - consensus report of group 4 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. J Clin Periodontol 2017;44(Suppl 18):S135–44. https://doi.org/10.1111/jcpe.12681.

[19] Hegde AM, Joshi S, Rai K, Shetty S. Evaluation of oral hygiene status, salivary characteristics and dental caries experience in acute lymphoblastic leukemic (ALL) children. J Clin Pediatr Dent 2011;35(3):319–23. https://doi.org/10.17796/jcpd.35.3.u5kx28q33m760834.

[20] Aminabadi NA, Najafpour E, Razavi Rohani Z, Sighari Deljavan A, Ghojazadeh M, Jamali Z. Linear reciprocal interaction between dental caries and salivary characteristics. J Oral Sci. 2013;55(4):337–42.

[21] Shimazaki Y, Fu B, Yonemoto K, Akifusa S, Shibata Y, Takeshita T, et al. Stimulated Salivary flow rate and oral health status. J Oral Sci. 2017;59(1):55–62.

[22] Navazesh M, Kumar SKS. Measuring salivary flow Challenges and opportunities. JADA 2008;139(2):35–40. https://doi.org/10.14219/jada.archive.2008.0353.