Original Article

Quantification of sugar intake and mineralization of teeth in 13–15-year-old subjects – A pilot study

Sona Gajanan Therathil, Prasad V. V. Kakarla[1]

Department of Public Health Dentistry, Coorg Institute of Dental Sciences, Coorg, [1]Department of Public Health Dentistry, SDM College of Dental Sciences and Hospital, Dharwad, Karnataka, India

ABSTRACT

Background: Dental caries begins with the initiation of demineralization which is a reversible process. Diet, especially intake of sugar, is an important aetiological factor for demineralization of enamel which eventually leads to caries. **Aim:** This study aims to understand the quantitative relationship between sugar consumption and mineralization by finding out the change in mineralization of teeth as a result of the change in the sugar score. **Settings and Design:** This interventional study was done among 119 teeth of 19 subjects who were between the ages of 13–15 years in Hubli city. **Materials and Methods:** Sugar score was calculated from a 5-day diet history of the subjects and a DIAGNOdent pen was used to indicate the mineralization value of the teeth before the intervention. Diet counseling was given as an intervention after which sugar score and DIAGNOdent scores were measured again after 14 days and compared with the baseline values. **Statistical Analysis:** Descriptive statistics and a linear regression analysis was done to determine the relationship between the variables. **Results:** Sugar score and DIAGNOdent score after 14 days were found to have reduced significantly by 41.6% and 20.3% respectively from the baseline values. The Linear Regression indicated that a reduction of sugar score by 5 resulted in a decrease of DIAGNOdent score by 0.16. **Conclusion:** The findings of the present study suggest that the modification of sugar consumption brought about a significant improvement in the mineralization of the demineralized teeth thus making diet counseling an effective preventive strategy for caries prevention.

KEYWORDS: Dental caries, DIAGNOdent, diet modification, tooth demineralization

Address for correspondence:
Dr. Sona Gajanan Therathil,
Department of Public Health Dentistry, Coorg Institute of Dental Sciences, Kanjithanda Kushalappa Campus, Maggula, Virajpet, Coorg - 571 218, Karnataka, India.
E-mail: sonagajanan@gmail.com

Access this article online

Quick response code

Website: www.jisppd.com

DOI: 10.4103/jisppd.jisppd_181_21

Introduction

Dental caries is the most widespread noncommunicable disease and is a major global health problem. According to the 2015 Global Burden of Disease Study, it is the most prevalent condition. Permanent teeth decay ranking first affecting 2.3 billion people and decay of deciduous teeth ranking 12th affecting 560 million children.[1] According to Miller's chemoparasitic theory, the acid produced by the metabolism of carbohydrates by oral bacteria dissolves the teeth resulting in caries.[2] The three major factors responsible for caries formation are plaque, tooth, and diet.[3] One of the most significant factors that cause caries in the diet is sugar. It is a fact that a greater amount and frequency of sugar intake is a risk factor for caries formation.[4]

How to cite this article: Therathil SG, Kakarla PV. Quantification of sugar intake and mineralization of teeth in 13–15-year-old subjects – A pilot study. J Indian Soc Pedod Prev Dent 2022;40:30-3.

Submitted: 20-May-2021 **Revised:** 21-Dec-2021
Accepted: 03-Jan-2022 **Published:** 14-Apr-2022

Dental caries is the result of lifelong exposure to caries risk factors one of which is free sugars. This is of particular importance because studies have shown that sugar consumption was very high among teenagers.[5] Therefore, even a small reduction in the risk of dental caries in this age group is of significance in the lifelong risk of dental caries. Hence, population-wide strategies to reduce free sugars consumption especially among children and adolescents are the key public health approach that should be a high and urgent priority.

The discovery of remineralization and demineralization was another breakthrough in the understanding of caries. The critical pH value for enamel dissolution is 5–6 with an average pH of 5.5 which is the generally accepted value. The caries process begins with the loss of minerals (demineralization) when the pH of plaque drops below the critical pH value of 5.5.[2,3] Redeposition of mineral (remineralization) occurs when the pH of plaque rises. The balance between demineralization and remineralization process determines the formation of the carious lesion.

DIAGNOdent Pen (KaVo) is a portable device that is based on a laser fluorescence system that can detect demineralized areas on a tooth using a laser diode. Although the relationship between demineralization and sugar is a fact there is a lack of knowledge in understanding the quantitative relationship between the two.

This study aims to quantify the change in mineralization of teeth as a result of a change in sugar consumption.

Materials and Methods

The present study was an interventional study conducted over a period of 14 days on 20 subjects between 13 and 15 years of age in a school in Karnataka, India. Ethical clearance was obtained for the present study by the Ethical Review Committee, SDM College of Dental Sciences and Hospital (IRB. No. 2018/P/COMM/55).

The sample size of 20 was considered using the rule of thumb of 14–20 as set out by Kieser and Wasserman for sample sizes in a pilot study.[6] Subjects whose teeth showed the beginning of demineralization as indicated by a DIAGNOdent score between 13 and 24 were included in the study. Uncooperative, handicapped subjects, subjects with debilitating diseases, and subjects undergoing orthodontic treatment were excluded from the study.

After obtaining permission from the head of the school, students in 8th, 9th, and 10th grade were screened by one examiner and one recorder. A random sample of 20 students was obtained using a random number table among the subjects who satisfied the inclusion criteria. Informed consent was obtained from the parents of the selected subjects. At baseline 120 teeth among 20 subjects were examined. During follow-up, there was a loss of 1 subject which accounted for 1 tooth (because the subject was absent on the day of examination). Therefore, 19 subjects who accounted for 119 teeth completed the study.

A 5-day food diary was given to the selected subjects and instruction for filling the diary was provided. After a week, the food diaries were collected from the subjects and the mineralization status of their teeth was checked using a DIAGNOdent pen (KaVo). Teeth that showed a DIAGNOdent score between 13 and 24 indicating the beginning of demineralization were noted in a score chart.

After recording the DIAGNOdent scores the selected subjects were given diet counseling based on their food diary with emphasis on limiting the number of eating periods to three regular meals per day, stressing the need to avoid in between meal snacks, weaning the patient from the taste of sweets by restricting the consumption of sugar-containing foods to meals and complete elimination of sticky sweets, especially between meals.[6] The parents were telephonically contacted and given the same information.

Following the counseling, the subjects were given another 5-day food diary. After 2 weeks from the counseling date, the subjects were instructed to submit their completed food diary, and the teeth that showed DIAGNOdent scores between 13 and 24 were checked again using the DIAGNOdent pen, and scores were noted.

The sugar score was calculated by classifying each sweet into liquid, solid, and sticky or slowly dissolving categories. The sweets and sugar-sweetened foods and the frequency with which they were consumed were listed. If the sweets were liquid it was multiplied by 5, if solid multiplied by 10, if slowly dissolving multiplied by 15.[7] The products were written and totaled to obtain the sugar score. The mineralization status score was obtained by calibrating and using the DIAGNOdent pen according to the manufacturer's instructions. The scoring criteria are as given in Table 1.

The data were entered into an Excel datasheet (Microsoft office 360 ProPlus). The data were subjected to statistical analysis using the statistical package, Minitab, Inc. Wilcoxon signed-rank test was used to compare the

Table 1: Scoring criteria for demineralization of teeth according to the KaVo manufacturer's instructions for the DIAGNOdent pen

Value	Demineralization status
0-12	Healthy tooth
13-24	Beginning demineralization
>25	Strong demineralization

mean sugar score and DIAGNOdent score before and after counseling. Linear regression was used to compare the change in sugar score with that of change in DIAGNOdent score.

Results

The mean age of the 19 subjects was 14.1 years as shown in Table 2. Among these 19 subjects, 119 teeth satisfied the inclusion criteria of the DIAGNOdent score between 13 and 21.

Table 3 shows the mean and standard deviations of sugar score and DIAGNOdent score at baseline and after 14 days' follow-up. The mean sugar score showed a 41.6% reduction and the mean DIAGNOdent score showed a 20.3% reduction from baseline to the follow-up examination. Kolmogorov –Smirnov test of normality was used to find the normality of the sugar scores and DIAGNOdent scores and was found not to be normal. Thus, the Wilcoxon signed-rank test was performed to find if there was a significant change in the mean of sugar score and DIAGNOdent score from baseline to follow up. The result of the test showed that there was a significant difference in the mean of sugar score and DIAGNOdent score at baseline and follow-up.

Figure 1 shows a scatter plot comparing the change in sugar score and the change in DIAGNOdent score. The correlation coefficient (R^2) was found to be 0.84 which indicates a strong correlation. Therefore 84% of the variance in the DIAGNOdent score is explained by the change in the sugar score. The Linear Regression equation was found to be $y = 0.0611x - 0.1485$.

Table 2: Demographic distribution of subjects who completed the study and the number of teeth

Gender	Number of subjects	Age (years)	Number of subjects
Male	5	13	2
Female	14	14	3
Total	19	15	14
		Total	19
		Mean age	14.1±0.44

Table 3: Comparison of sugar score and DIAGNOdent score at baseline and at follow-up after 14 days' postdiet counseling

Time	Mean±SD	
	Sugar score	DIAGNOdent score
Baseline	119.3±29.21	15.8±4.4
After 14 days	69.7±17.39	12.6±3.7
Percentage change	41.6	20.3
P	0.00*	0.00*

*$P \leq 0.05$. SD=Standard deviation

Discussion

The present study showed a decrease of 41.6% reduction of sugar score and 20.3% reduction in the DIAGNOdent score from baseline to follow-up. These findings show that the sugar score as well as the DIAGNOdent score showed a reduction as a result of diet counseling. This result is similar to the finding of Zhang *et al*. where there was a decrease of 22.3 g/day added sugar in diet after one year of diet counseling.[8] Similarly, in a study done by Anttonen *et al*. the mean values for laser fluorescence remained the same or decreased slightly, more so in the schools with dietary intervention, which indicates remineralization of initial lesions.[9] This is the result of improvement in knowledge of the subjects as a result of the intervention as shown by Goel *et al*.[10]

The correlation coefficient (R^2) was found to be 0.84 which indicates that 84% of the variance in the DIAGNOdent score is explained by the change in the sugar score. The strong correlation between sugar intake and demineralization is in accordance with the finding of Bibby *et al*. and Rugg-Gunn *et al*.[11,12] In the present study, linear regression showed that when the sugar score decreased by 5, it resulted in the decrease of DIAGNOdent score by 0.16. In a study conducted by Woodward and Walker among 12-year-old of 90 countries, the linear relationship between the logarithm of DMFT and sugar had a slope of 0.021 per kg/year per head of population ($P < 0.0001$), and accounts for 0.28 of the variation in DMFT.[13] Burt *et al*. reported a difference in caries increase in children (initially aged 11–15 y) who consumed on average 109 or 175 g sugar/d that was only 0.45 approximal carious tooth surfaces over 3 years.[14] Using the data from Burt *et al*.'s study, Szpunar *et al*. found that each additional 5-g/d intake of sugars was associated with a 1% increase in the probability of developing caries during a 3-y interval.[15]

The present study proves that diet counseling is an effective public health measure to reduce caries

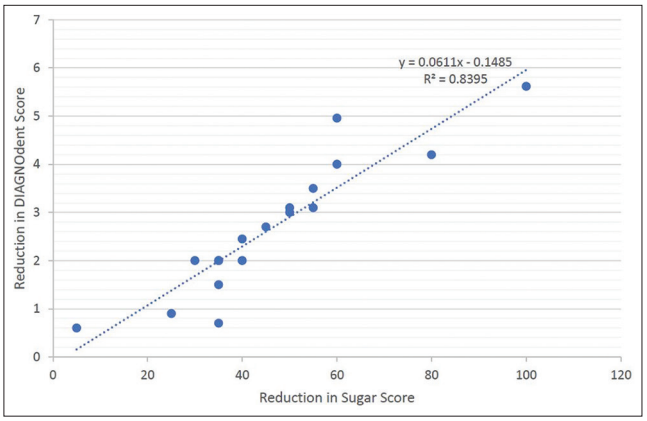

Figure 1: Scatter plot comparing the difference in the sugar score from baseline to follow-up (x-axis) with the difference in the DIAGNOdent score from baseline to follow-up (y-axis)

prevalence. One of the limitations of the present study is the small sample size taken which could make the result inconclusive. Future studies with bigger sample sizes could substantiate it. Another limitation is that the DIAGNOdent pen could be an unreliable measurement for mineralization as has been speculated in some studies. However, few studies including the one by Kamath *et al*. have used DIAGNOdent to successfully measure mineralization.[16] Hence, other methods to measure mineralization could be explored in future studies. Furthermore, similar studies for other public health interventions may help compare the effectiveness of different public health measures directed at preventing dental caries.

From the present study, it can be concluded that quantification of the effectiveness of preventive measures is an important public health tool. DIAGNOdent can be used effectively in measuring the effectiveness of various measures directed at the prevention of caries. This corroborates with the findings of Goel *et al*. and Shwetha *et al*. wherein DIAGNOdent showed higher sensitivity and accuracy as compared with other conventional methods for detection of enamel caries.[17,18] Modification of sugar consumption in the diet through diet counseling resulted in a significant improvement in the mineralization status of the demineralized teeth. Greater the reduction in sugar consumption in the diet, greater was the improvement in the mineralization status of the demineralized teeth. Thus, diet counseling is an important and effective public health strategy in caries prevention.

Conclusion

The findings of the present study suggest that the modification of sugar consumption brought about a significant improvement in the mineralization of the demineralized teeth thus making diet counseling an effective preventive strategy for caries prevention. Thus, incorporating it in public health programs will have wider and significant implications on caries incidence.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. GBD 2015 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: A systematic analysis for the global burden of disease study 2015. Lancet 2016;388:1545-602.
2. Miller WD. In: König KG, editor. The Microorganisms of the Human Mouth. Basel, Switzerland: S Karger; 1973.
3. Keyes PH, Jordan HV. Factors influencing initiation, transmission and inhibition of dental caries. In: Harris RJ, editor. Mechanisms of Hard Tissue Destruction. New York: Academic Press; 1963. p. 261-83.
4. Newbrun E. Sugar and dental caries: A review of human studies. Science 1982;217:418-23.
5. Hegde PP, Ashok Kumar BR, Ankola A. Sugar consumption pattern of 13-year-old school children in Belgaum city, Karnataka. J Indian Soc Pedod Prev Dent 2005;23:165-7.
6. Kieser M, Wasserman G. On the use of the upper confidence limit for the variance from a pilot sample for sample size determination. Biom J 1996;8:941-9.
7. Nizel AE, Papas AS. Dietary counseling for the prevention and control of dental caries. In: Nutrition in Clinical Dentistry. 3rd ed. Philadelphia: WB Saunders; 1989.
8. Zhang L, Pagoto S, May C, Olendzki B, L Tucker K, Ruiz C, *et al.* Effect of AHA dietary counselling on added sugar intake among participants with metabolic syndrome. Eur J Nutr 2018;57:1073-82.
9. Anttonen V, Seppä L, Niinimaa A, Hausen H. Dietary and oral hygiene intervention in secondary school pupils. Int J Paediatr Dent 2011;21:81-8.
10. Goel P, Sehgal M, Mittal R. Evaluating the effectiveness of school-based dental health education program among children of different socioeconomic groups. J Indian Soc Pedod Prev Dent 2005;23:131-3.
11. Bibby BG, Mundorff SA. Enamel demineralization by snack foods. J Dent Res 1975;54:461-70.
12. 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;29:983-92.
13. Woodward M, Walker AR. Sugar consumption and dental caries: Evidence from 90 countries. Br Dent J 1994;176:297-302.
14. Burt BA, Eklund SA, Morgan KJ, Larkin FE, Guire KE, Brown LO, *et al.* The effects of sugars intake and frequency of ingestion on dental caries increment in a three-year longitudinal study. J Dent Res 1988;67:1422-9.
15. Szpunar SM, Eklund SA, Burt BA. Sugar consumption and caries risk in schoolchildren with low caries experience. Community Dent Oral Epidemiol 1995;23:142-6.
16. Kamath P, Nayak R, Kamath SU, Pai D. A comparative evaluation of the remineralization potential of three commercially available remineralizing agents on white spot lesions in primary teeth: An *in vitro* study. J Indian Soc Pedod Prev Dent 2017;35:229-37.
17. Goel A, Chawla HS, Gauba K, Goyal A. Comparison of validity of DIAGNOdent with conventional methods for detection of occlusal caries in primary molars using the histological gold standard: An *in vivo* study. J Indian Soc Pedod Prev Dent 2009;27:227-34.
18. Shwetha G, Chandra P, Anandakrishna L, Dhananjaya G, Shetty AK, Kamath PS. Validation of different diagnostic aids in detection of occlusal caries in primary molars: An *in vitro* study. J Indian Soc Pedod Prev Dent 2017;35:301-6.