Effectiveness of Xylitol and Polyol Chewing Gum on Salivary Streptococcus mutans in Children: A Randomized Controlled Trial

Abstract

Introduction: Dental caries is a multi-factorial, infectious disease, the prevention of which is based on multifaceted approaches. Chewing sugar-free gum has potential beneficial effects on dental health. Objectives: The aim of this study is to assess and compare the effectiveness of xylitol and polyol chewing gums on salivary Streptococcus mutans in 12–15 years old schoolchildren residing in hostels in Belgaum city. The acceptability of the two chewing gums was also assessed. Materials and Methods: Sixty children of 12–15 year age groups from three hostels, who fulfilled all the inclusion criteria, were included in this triple blind randomized controlled field trial. They were then randomly allocated into one of the three groups using lottery method. Xylitol chewing gum, polyol chewing gum and control group (no chewing gum). Patients were instructed to chew one pellet two times a day after meals for 5 min each for 30 days. Salivary samples were collected at baseline, 30 days after chewing gum use and 30 days after discontinuation, for microbiological analysis. The data were subjected to statistical analysis using SPSS software version 18. Results: Chewing 100% xylitol chewing gum 2 times a day for 5 min for 30 days can successfully reduce salivary S. mutans counts. The xylitol gum has shown a maximum benefit against salivary S. mutans when compared to polyol gum and control group. Conclusion: Xylitol-containing chewing gums can be used as an adjunct to regular home care preventive procedures to prevent dental caries.

Keywords: Chewing gum, polyol, salivary Streptococcus mutans, xylitol

Introduction

It is a well-known fact that dental caries is a widespread, multi-factorial, infectious disease which causes a significant public health problem for a large segment of society both as a disease and as an economic burden.[1] Prevention of dental caries is very important as it has a considerable impact on self-esteem, mastication, nutrition, and health. Hence, the dental healthcare team needs to apply preventive care strategies beyond restoration placement.[2]

Xylitol, five-carbon natural sugar alcohol, is a sugar substitute with sweetness equal to that of table sugar. It is produced commercially from birch trees and other hardwoods containing xylan.[3] About 5–15 g of xylitol may be formed daily in the body, mostly in liver cells. It is not fermented or used as a growth substrate by Streptococcus mutans or by other microorganisms; whereas, it has been shown to reduce S. mutans levels in plaque and saliva and can also promote an ecological shift, to markedly reduce tooth decay.

Sorbitol, mannitol, and maltitol are also naturally occurring substances which are less sweet than xylitol but are widely used in sugar-free products such as chewing gums, candies, and toothpastes because they are cheaper. These polyols including xylitol have been proven to be extremely poorly cariogenic in clinical caries studies by replacing fermentable sugars and reducing the total cariogenic load of the diet. Hayes[4] reviewed 14 clinical studies from 1966 to 2001 and found a consistent decrease in dental caries ranging from 30% to 60% among patients using sugar substitutes as compared to subjects in a control group. However, to be cost-effective, recommendations of agents for use in health improvement should be based on the minimum concentration and frequency required for clinical benefit to be attained.[5]

Sucrose free chewing gums act as a delivery vehicle, which contains appropriate amounts of dental protective substances, which either alone or in combination may be used in preventive health programs to improve health.

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oral health. Chewing gums containing xylitol have received special attention since mechanical cleaning together with saliva stimulation are very likely to benefit further over and above the antibacterial effects of the polyol.\textsuperscript{[6]} No active cariostatic properties of any single polyol has been soundly substantiated in humans to date; although, accumulating data are making it seem more likely in the case of xylitol.

Loesch\textsuperscript{[7]} previously found that children given 5 g xylitol/day for 4 weeks had reduced saliva and plaque \textit{S. mutans} levels compared with baseline. To check whether xylitol alone has a better cariostatic effect, the present study was carried out to assess the antibacterial effectiveness of xylitol and polyol chewing gums on salivary \textit{S. mutans} in children residing in hostels.

**Materials and Methods**

**Subjects and study design**

The present study was a triple-blind randomized controlled field trial in which the subjects consist of schoolchildren aged between 12 and 15 years from three residential hostels in Belgaum city of Karnataka. Accordingly, there were only three private hostels which had subjects of 12–15 years age group and all the children were screened for the study. In total 136 children underwent the screening procedure and 84 children fulfilled the study inclusion and exclusion criteria. Out of these, 60 children were randomly selected by lottery method, 20 children in each group to constitute the sample size. The investigator was blinded about the group allocation and the chewing gums used by the children. Xylitol chewing gum– Group I, polyol chewing gum– Group II and control group (with no chewing gum)– Group III.

Permission to conduct the study was initially obtained from the Block Education Officer and District social welfare association, Belgaum. A written informed consent was obtained from the parents of all the subjects who were selected for the study. Children were free to withdraw from the study at any point during the study. The investigator visited the study site obtaining baseline information and performed the clinical examination and saliva collection from the selected children according to the protocol. The inclusion criteria were subjects having salivary \textit{S. mutans} level equal to or more than 10\textsuperscript{5} colony forming units (CFUs) and decayed-missing-filled-teeth (DMFT) score equal to or more than 3. Any children undergoing any dental treatment, orthodontic treatment, or with extensive intraoral prosthesis or any developmental defects were excluded along with children having any systemic diseases or temporomandibular joint disorders. Ethical clearance before the study was obtained from the Institutional Ethical Committee of KLE University, Belgaum.

**Data collection**

Relevant information of the children regarding the sociodemographic data, diet history, sugar exposure, oral hygiene practices, and compliance were recorded through an interview. The socio-economic status was assessed based on the modified Kuppuswamy’s classification.\textsuperscript{[9]} Dental caries was examined by applying the WHO modified criteria (1986) on DMF-index by Klien \textit{et al.} (1938).\textsuperscript{[9]} Each tooth was wiped with cotton and dried before examination followed by saliva sample collection. Calibration of the investigator to was done under the guidance of a professor to limit the intra-examiner variability (Kappa coefficient - 0.877). The examination was carried out in the classroom by making the patient sit on a chair with backrest and the examiner standing behind the chair. Sterilized instruments were carried to the site to conduct examination and collection of saliva.

**Distribution of chewing gum**

The chewing gum pellets were removed from their respective wrappers and packed in an identical box. Each box consisted of 14 chewing gum pellets; this was the number of chewing gums required by each subject in the study for 1 week (2 \times 7). At the end of every week, the investigator supplied a new box containing the required number of chewing gums for next 1 week. The chewing gum pellets were distributed once every week, a total of four times during the study. In the last distribution time, an additional of four pellets (2 \times 2) was given to complete 30 days cycle. Children were instructed to chew one pellet twice daily for 5 min after breakfast and dinner for 28 days. All children were advised to maintain their routine dietary habits, daily oral hygiene regimens and not to consume any other chewing gum except that which was provided to them during the study period. The wardens of the hostels were also asked to remind the children to chew the chewing gums every day. The investigator visited the hostels every alternate day to check for the compliance. On every visit, the children were instructed to chew the chewing gums as according to the given instructions.

**Saliva collection**

The saliva samples for counting \textit{S. mutans} was collected at the following 3 time intervals, i.e., baseline before giving the chewing gums, 30 days after xylitol and polyol use and 30 days after discontinuation of chewing gums. The children were requested not to have any physical exercise or to eat or drink (except water) 1 h before saliva collection. The saliva was collected between 10.30 and 11.00 am during school hours to diminish the influence of circadian rhythm. Children were asked to chew the wax block to stimulate salivation and collect the saliva for a minute. Stimulated saliva was sucked from the mouth of children, and 0.5 ml of saliva was injected into containers containing thioglycollate broth with hemin and vitamin K transport media. The sample was transported to the laboratory...
immediately after collection and cultured on the same day. The processing was done at Department of Microbiology, Jawaharlal Nehru Medical College, Belgaum.

**Microbial analysis**

The saliva samples were vortexed (15 s, cyclo mixer, CM 101). One loop (1/1000th ml of sample) was inoculated on the Mitis Salivarius Agar with Potassium Tellurite medium (Himedia M259, Lot No Y1100). The plates were incubated for 48 h at 37 C in 5%–10% CO₂ jar for 48 h. After 48 h, colony characteristics were studied and the number of CFU of *S. mutans* (CFU/ml) of saliva was determined.

**Statistical methods**

The obtained data were compiled systematically, and analysis was performed using SPSS software Version 16.0, (SPSS Inc, Chicago, USA). Where appropriate, descriptive statistics, Chi-square test, One-way ANOVA, Kruskal–Wallis test, and Mann–Whitney U-test were used to determine difference among the groups at different intervals. *P* < 0.05 was accepted as indicating statistical significance.

**Results**

Each of the three groups had 20 participants (*n* = 60), with females constituting from 60% to 65% in the groups. The overall mean age of the study population was 13.47 ± 1.11. Mean and standard deviation of DMFT according to the three study groups are given in Graph 1. No statistically significant differences were seen on comparison of three study groups to DMFT by one-way ANOVA (*f* = 0.190, *P* = 0.827). At baseline, there were no statistically significant differences between the groups in the levels of salivary *S. mutans* (*h* = 1.283, *P* = 0.526). The mean values of the salivary *S. mutans* score in the three groups at each time interval are presented in Table 1.

A significant difference was found between the *S. mutans* levels of all the three groups at 30 days (*h* = 12.531, *P* = 0.019) and 60 days (*h* = 11.428, *P* = 0.003) using Kruskal–Wallis ANOVA. Pair-wise comparison using Mann–Whitney U-test showed that a statistically significant difference was seen in *S. mutans* levels at 30 days and 60 days between xylitol group and control group, *P* = 0.004 and *P* = 0.015, respectively [Table 2]. *S. mutans* level at baseline, 30 days and 60 days according to the three study groups is plotted in Graph 2.

No significant difference was observed with respect to socio-economic status, frequency of sugar consumption on previous day or frequency of cleaning teeth in the study population [Table 3]. About 80 to 85% of the children in the three groups used toothbrush and toothpaste to clean the teeth and also changed their brush within 4–6 months (data not shown). Of the 40 children in the study who chewed the gum, 18.3% of children found the taste of the chewing gum as very good, 26.7% of children found it as good, 15% found it as ok, 6.7% found it as bad and none found as it is very bad. The relation between the acceptability of the two chewing gum groups was statistically significant (Chi-square = 23.529, *P* = 0.0006).

**Discussion**

In recent years, chewing gums, which are used by a large proportion of the population, have gained a lot of consideration in caries prevention. This is mainly due to their ability to stimulate salivation and saliva being a “Magical fluid” with multiple protective benefits may prevent oral diseases. Stimulated saliva has an increased bicarbonate concentration resulting in the neutralization of low pH by increasing the buffer capacity of the saliva and by enhancing the clearance of fermentable carbohydrates.

| Groups          | Baseline | Mean±SD          | At the end of 30 days | At the end of 60 days |
|-----------------|----------|------------------|-----------------------|-----------------------|
| Group I         | 3.7 × 10^±2.23 | 5.0 × 10^±4.59 | 6.8 × 10^±4.40 |
| Group II        | 3.2 × 10^±3.99 | 7.3 × 10^±4.23 | 2.2 × 10^±3.34 |
| Group III       | 2.3 × 10^±3.29 | 1.4 × 10^±2.03 | 1.9 × 10^±2.69 |

SD=Standard deviation

Graph 1: Mean and standard deviation of decayed-missing-filled-teeth according to the three study groups. *f* = 0.190, *P* = 0.827

Graph 2: *Streptococcus mutans* level at three intervals according to the three study groups
from the oral cavity.\textsuperscript{[10]} The stimulated saliva is also a state of mineral supersaturation that promotes enamel remineralization.\textsuperscript{[11]}

The product used in the current study contained 1.28 gm of xylitol per pellet. Hence, 2 pellets were advised per day to deliver around 2.56 gm of xylitol per day and this was to see the action of xylitol in lesser concentrations. Previous studies revealed that 5–10 g/day of xylitol was required for its antibacterial effect.\textsuperscript{[6,12]} Sugar-free chewing gums when used after meals is suggested to have a beneficial effect\textsuperscript{[13]} for this reason in the present study children were instructed to chew the gum after meals. Various literature \textsuperscript{[10,14–16]} suggested that chewing gums for 5 min at a time were effective against \textit{S. mutans}. Hence, the subjects were advised to chew the gums for 5 min each time. To see the effect of xylitol and polyol beyond interruption of chewing gum, a follow-up period of 30 days was included in the present study.

The significant variation in salivary \textit{S. mutans} counts between the three groups was strengthened by the nonsignificant distribution of dietary pattern, sugar exposure, and oral hygiene practices among the children. Children in the present study were characterized by low-to-middle socioeconomic level based on the modified Kuppuswamy’s classification and shared a similar educational and cultural environment. The dietary pattern also did not vary much as more than 60% of children had rice as their staple diet from hostels.

A relationship between the percentage of xylitol used and the changes in \textit{S. mutans} levels in saliva has been revealed in the study. A significant reduction in the proportion of \textit{S. mutans} in the xylitol gum group was seen after intervention in contrast to the control group. The design of the present study was similar to the study conducted by Fraga et al. wherein Happydent Xylit chewing gum was given 5 times daily for 30 days.\textsuperscript{[17]} A significant decrease in \textit{S. mutans} levels observed from baseline to the time immediately after 30 days of xylitol usage which coincides with the present study. Wennerhold and Emilson confirmed a significant reduction in salivary \textit{S. mutans} after 2 months of chewing xylitol-containing gum\textsuperscript{[18]} which is in line with the results obtained in the present study. When xylitol group is compared with the polyol group, there was a reduction in the \textit{S. mutans} count, but it was not statistically significant. The reduction of \textit{S. mutans} in polyol group may be attributed to the fact that xylitol was also one of the components in the chewing gum. This finding suggests that the effect observed in xylitol group may be due to the antibacterial action of “XYLITOL” in addition to the salivary stimulation property of chewing gums due to the act of chewing.
The effect obtained by xylitol chewing gum can be due to the following reasons:\[19\] Xylitol is not fermented by cariogenic plaque bacteria and thus, does not lower the pH of plaque. As the plaque pH does not decrease, enamel demineralization is prevented, and plaque bacteria do not proliferate. Xylitol is absorbed and accumulates intracellularly in S. mutans. Xylitol competes with sucrose for its cell-wall transporter and its intracellular metabolic processes. Unlike the metabolism of sucrose, which produces energy and promotes bacterial growth, S. mutans expends energy to break down the accumulated xylitol without yielding energy in return.

In the present study, a “no chewing gum control group” was considered than the placebo chewing gum as studies\[15,20\] have shown that placebo gum does not have an effect on S. mutans counts. It is difficult to motivate the study participants to chew the disagreeable gum base with the same frequency and duration as the sweetened gum, even in short-term studies which was the reason the control group has refrained from chewing any placebo gum in this study.

The limitation could be a small sample size which was based on the effect of xylitol chewing gum observed in previous studies. At the end of the study, all children in the hostels were given health education and motivated for healthy oral hygiene practices. Even though further studies are needed to evaluate the long-term acceptance, compliance and efficacy, xylitol gum chewing should be promoted as it offers an efficacious and cost-effective caries prevention strategy which may greatly improve the quality of oral health for the young children.

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Conflicts of interest

There are no conflicts of interest.

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