Effect of Xylitol on Dental Caries and Salivary *Streptococcus Mutans* Levels among a Group of Mother-Child Pairs

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Recent researches have focused on xylitol as convenient and effective method to inhibit cariogenic bacteria. The purpose of the present study is to assess the effect of xylitol on plaque accumulation, caries activity and salivary Streptococcus Mutans in a group of Saudi mother-child pairs. ***Materials and Methods:*** *The study sample included 60 mother and child pairs selected on the basis of having high salivary streptococcus mutans levels. The study sample was randomly divided into experimental group (30 pairs) and control group (30 pairs). The experimental group was given xylitol treatment and the controls received fluoride varnish. Both groups were examined to assess caries, plaque and salivary streptococcus mutans levels. Xylitol treatment in the form of chewing gum for mothers and tablets for children was consumed three times/day for three months. All subjects received oral hygiene instructions, dietary counseling and restorative treatment. The* ***results*** *showed that the number of mothers and children with high streptococcus levels in the experimental group decreased to a statistically significant level at the end of the three month period, similarly, the control mothers showed the same trend. A statistically significant decrease in plaque scores was evident only among the children's experimental group. The caries level of children and mothers showed no statistically significant differences between the experimental and control groups. The factors which significantly affected the streptococcus mutans count in children after three months were the child's dmft at baseline the preventive method used and the mother' salivary streptococcus mutans level.*

Keywords: *Xylitol, Streptotcoccus mutans, caries, saliva, plaque, mother- child pairs.*
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INTRODUCTION

Dental caries is a significant public health problem for a large proportion, of the Saudi population, especially the child segment.[1,2]

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Preventive strategies tend to focus on dietary modification and the use of fluoride and pit and fissure sealants to increase the host resistance. *Mutans streptococci* (MS) in particular *Streptococcus mutans* is a major causative bacteria that are involved in dental carie.[3,4] Accordingly, a new strategy based on the suppression of MS levels on the dentition is recently addressed in clinical practice.

Substitution therapy replacing harmful habit (excessive sucrose consumption) with a more positive practice (ingestion of non-fermentable sugar substitutes) can lead to a promising caries control strategy. Xylitol which is a polyol-a pentatol that occurs widely in nature is used originally to sweeten a number of sugar-free products and is most frequently used in chewing gum.[5] Recent caries researches showed that xylitol, has a well documented inhibitory effect against dental caries.[6-12] The caries inhibitory effect of xylitol is related to the inability of cariogenic bacteria to ferment it, therefore plaque bacteria do not proliferate, enamel demineralization is prevented and remineralization is enhanced.[5] Some studies suggest that xylitol reduces the ability of MS to adhere, making it more easily removed from plaque.[13,14] In addition to its antibacterial effect, chewing gum containing xylitol has also a salivary stimulating effect that leads to an increased salivary buffering capacity and clearance of

fermentable carbohydrates. Its inhibitory effect is also related to the enhancement of remineralization capabilities.[15]

Recent bacteriological studies on the transmission of MS in the mother and child pair, revealed a relation between salivary MS levels in mothers and initial acquisition of MS by their infants.[16,17] Once MS have colonized on the teeth of a child, their presence is rather stable and establishment of other bacteria on tooth surfaces is impaired.[18] Children whose teeth are colonized earlier by MS show higher caries experience than those colonized later or not at all.[19-21] Based on the potential promising results of xylitol, xylitol-containing chewing gums are being studied to assess their caries preventive action among mothers and their potential influence on MS acquisition in children during tooth eruption period.[18,22,24] The dental literature revealed impressive clinical data concerning xylitol; however, results regarding the mechanism of action as well as regimens used for caries prevention in children are still inconclusive. The preventive role of this sweetening agent when used by the mother-child pair has not proved to be sufficiently effective to trigger its widespread use in dental practice. Therefore, this study was initiated to assess the effect of xylitol on salivary *Streptococcus Mutans* and plaque levels as well as on caries activity in a group of Saudi mother-child pairs.

MATERIALS AND METHODS

The present report is the first of a 3 article series representing a cohort investigation planned to investigate the effect of xylitol treatment on caries experience, plaque levels and streptococcal level in mothers and children with an initial high salivar*y streptococcus mutans* (SM) levels over a period of 24 months.

Sixty pairs of mothers and children aged 2-5years (120 subjects) were selected out of a total group of 96 mother-child pairs. The sample was selected from patients attending the dental clinics in King Abdul-Aziz University Hospital (KAUH), Well Baby Clinics and the Faculty of Dentistry Pediatric dental clinics. Base line examination was carried out by one calibrated examiner to assess caries, plaque and SM levels in saliva.

Criteria for subject's selection: (a) having a high count of salivary SM ($\geq 10^5$), (b) for the children's group, the presence of 1 or more deciduous tooth decayed, filled or missed due to caries (c) for the mothers' group, the presence of 1 or more carious, filled or missed permanent tooth due to caries.

Exclusion criteria were: (a) having systemic disorders such as diabetes, hypertension or sleeping disorders or being on regular medication, (b) wearing removable dental prostheses or prone to tempro-mandibular joint complaints, (c) children attending the clinic without their mothers, or reared by nannies.

Informed consents were obtained from mothers after they were provided with verbal and written information concerning the importance and the procedures of the study.

Equal numbers of mother-child pairs were randomly allocated to the experimental and control groups. The experimental group received xylitol for a treatment period of 3 months. Xylitol chewing gums were given to the mothers while children received xylitol chewable tablets. The pair was instructed to participate in three 5 minutes chewing sessions; after breakfast (8:00 am), after lunch (1:00 pm), and as a snack (6:00 pm). Detailed instructions on administration and monitoring the use of tablets were given to the mothers. Chewing gums and tablets contained xylitol as the only sweetener (100% w/w). Each chewing gum pellet (1.8g) contains 66% xylitol by weight, providing a total daily dose of 3.64g. A xylitol tablet (1.2g) contains 84% xylitol by weight, making up a total daily dose of 3g. The experimental group received also oral hygiene instructions, dietary counseling, amalgam and composite restorations as well as fixed dental prosthetics when needed.

The control group received fluoride varnish (Durafat 5% Na F), oral hygiene instructions, dietary counseling, and restorative treatment including amalgam, composite restorations as well as fixed dental prosthetics when needed.

Clinical examination

A comprehensive dental examination for each subject was conducted by one calibrated examiner to collect the baseline data on caries and plaque levels. Examinations were performed in optimal light using mouth mirror and explorer. The diagnosis of dental caries was based on the WHO criteria 1987.[24] Bitewing radiographs for each subject were taken after clinical examination to detect proximal caries. Dental caries level was expressed using the DMFT index for permanent teeth and dmft for deciduous teeth. Plaque levels were assessed using the by Green and Vermillion OHI simplified (plaque component) (Green and Vermillion1964).[25] Clinical examination was repeated after 3 months to assess dental caries and plaque levels.

Streptococcus mutans level in stimulated saliva sample was determined using the (CRT) (Vivadent-Ivoclar, Lichenstein) bacteriological screening method. According to the manufacturer's instructions agar surface was wetted with saliva, and then placed in the test vial which was incubated at 37 C for 48 hours. The density of the SM colonies was compared with the corresponding evaluation figure in the enclosed model chart. Based on the manufacturer's criteria, findings of 10^5 CFU or more of SM indicated a high caries risk, whereas findings less than 10^5 CFU were considered low caries risk.

Stimulated saliva samples were collected from each participant for salivary bacterial level assessment. Saliva sampling was performed before conducting the clinical examination between 9- 11 am for a period of 15 minutes. Subjects were instructed not to eat or drink or chew gum for 2 hours before sampling. On the morning of saliva sampling, mothers and children refrained from tooth brushing. Each subject was asked to chew a pellet of paraffin wax (1g) and to expectorate the stimulated saliva into a calibrated cylinder (15 ml). Chewing was carried out under close supervision of the examiner and children were asked to imitate their

mother's action. If expectorations were found to be difficult with younger children, saliva was collected with the pipette supplied by the CRT kit. Saliva was not taken if the child has received antibiotics within month prior the examination. Saliva sampling was repeated at the end of xylitol treatment (after 3 months) to assess changes in salivary SM levels.

To reach good intra-examiner reliability, calibration of the examiner was conducted prior to baseline registration. Ten children and their mothers were examined by one examiner to assess their caries, plaque and salivary SM levels. They were re-examined the second day and the level of agreement between corresponding readings was assessed using the Kappa method.

Statistical analysis was carried out using SPSS. Student t-test was used to evaluate differences between baselines and follow up measurements for dmft and DMFT scores. For SM counts and plaque score, the Chi square test of significance was used.

RESULTS

Kappa statistics for permanent and primary teeth were 0.88 and 1.00 respectively (excellent agreement).

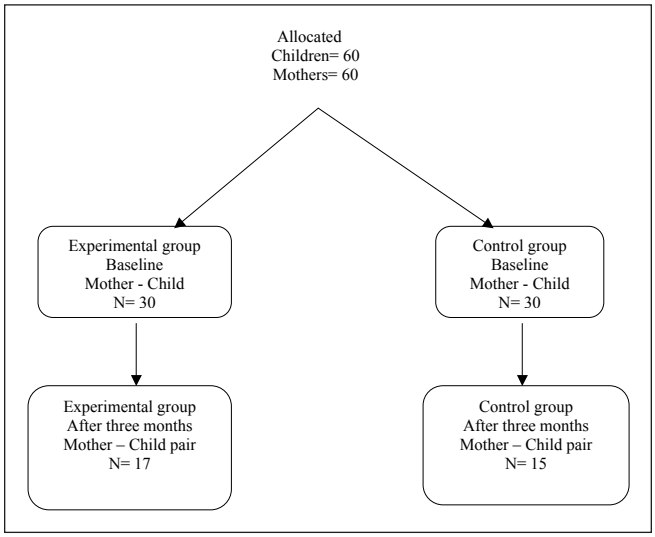

Figure 1. Flow chart showing the dropout of subjects in the experimental and control groups throughout the study period.

This study was conducted over a three month period to compare the effect of xylitol in a group of mother-child pairs. There has been an attrition of the original sample size to 17 in the experimental group and 15 in the control group. Data was only obtained from subjects who complied with the experimental measure and attended the final examination. Those who reported irregular use of xylitol or failed to attend at the end of study period were excluded and the study ended up with a total sample of 32 mother-child pairs.

Table 1. Frequency distribution and percentage of children with high *streptococcus mutans* level (≥10^5)

	High level/ total N (%)		Z test P value
	Experimental (N=17)	Control (N=15)	
Baseline	17/ 17 (100)	15/ 15 (100)	0.11 0.74
Three months	8/ 17 (47.1)	11/ 15 (73.3)	0.10 0.75
P value of McNemar test (baseline- 3 months)	0.002*	0.11	

*Statistically significant at P≤0.05

There was a statistically significant decrease in the number of children with high streptococcus level in the experimental group only.

Table 2. Frequency distribution and percentage of mothers with high *streptococcus mutans* level (≥10^5)

	High level/ total N (%)		Z test P value
	Experimental (N=17)	Control (N=15)	
Baseline	17/ 17 (100)	15/ 15 (100)	0.11 0.74
Three months	8/ 17 (47.1)	9/ 15 (60)	0.29 0.59
P value of McNemar test (baseline - 3 months)	0.002*	0.02*	

*: Statistically significant at P≤0.05

There was a statistically significant decrease in number of mothers with high streptococcus level in both study groups after three months.

Table 3. Mean plaque scores of children in the experimental and control groups

	Experimental Mean ± SD	Control Mean ± SD	Z of MWU test P value
Baseline	0.94 ± 0.24	1.20 ± 0.68	1.52 0.13
Three months	0.35 ± 0.49	1.07 ± 0.59	3.13 0.002*
WSR test (baseline to 3 months) P value	3.16 0.002*	0.56 0.58	

MWU: Mann Whitney U test
WSR: Wilcoxon signed ranks test
*: Statistically significant at P≤0.05

After 3 months, only the experimental group displayed a significant decrease in the mean plaque score. The mean value was significantly lower than that of the control group.

Table 4. Mean plaque scores of mothers in the experimental and control groups

	Experimental Mean ± SD	Control Mean ± SD	Z of MWU test P value
Baseline	0.94 ± 0.90	1.40 ± 1.06	1.35 0.18
Three months	0.65 ± 1.00	1.13 ± 0.92	1.76 0.08
WSR test (baseline to 3 months) P value	0.88 0.38	0.75 0.46	

MWU: Mann Whitney U test
WSR: Wilcoxon signed ranks test
*: statistically significant at P≤0.05

In the mothers' group, the controls showed a higher mean plaque score compared to the experimental group. A statistically non significant decrease in the mean plaque scores was seen in both study groups after 3 months.

Table 5. Mean dmft scores of children in experimental and control groups

	Experimental Mean ± SD	Control Mean ± SD	T test P value
Baseline	8.78 ± 5.68	10.00 ± 5.67	0.83 0.41
Three months	9.19 ± 5.49	10.55 ± 5.79	0.72 0.47
Paired t (baseline- three months) P value	0.21 0.83	0.26 0.79	

*: Statistically significant at P≤0.05

There was a slight statistically non-significant increase in the mean dmft in both the experimental and control groups.

Table 6. Mean DMFT scores of mothers in experimental and control groups

	Experimental Mean ± SD	Control Mean ± SD	T test P value
Baseline	15.18 ± 6.10	15.40 ± 6.72	0.13 0.89
Three months	15.18 ± 6.10	15.40 ± 6.72	0.13 0.89

There was no change in the DMF scores of mothers after 3 months.

Table 7. Logistic regression model for factors affecting *streptococcus mutans* level after 3 months in children

Variables	Wald X^2	P value
Preventive measure used	4.07	0.04*
Mother streptococcus mutans level after 3 months	3.93	0.05*
Baseline child dmft	5.80	0.02*
Child age	2.49	0.12
Child sex	3.33	0.07
Child nationality	0.59	0.44

Table 7 shows the logistic regression model for factors affecting streptococcus mutans count in children after 3 months. Arranged in an order according to the level of significance, the factors which significantly affected the child salivary MS count were the baseline child dmft, preventive measure used and the mother' salivary MS at the end of the experimental period.

DISCUSSION

The present article is the first report in a series of three articles representing a longitudinal study investigating the preventive action of xylitol in a group of mother- child pairs throughout a period of two years. The study focused primarily on the potential effect of xylitol consumption on high levels of salivary MS, which is considered an indicator of the child's caries risk level.

The regular chewing of xylitol-sweetened gum proved to inhibit growth of MS in the oral cavity[5] suggesting a reduction in caries experience of children adopting this habit. Based on the recommendation of the American Academy of Pediatrics (AAP)[26] which prohibited the use of chewing gum in children less than 4 years because of the risk of choking, xylitol tablets were given to children, whereas, mothers used xylitol chewing gums. A series of prospective studies were conducted to clarify the use and frequency relationship of xylitol to the reduction of MS and dental caries. Reviewed data demonstrated a linear response, where increasing frequency of xylitol consumption was associated with decreasing levels of salivary MS.[6,12,27-30] In our study the decreased number of subjects with high salivary MS levels was used as an indicator of the protracted xylitol effect. The significant decrease of the MS seen at the end of the three month period in the experimental groups supports data from the study.[31] Similarly, the control mothers who were treated with fluoride varnish and received oral hygiene instructions and dietary counseling (positive controls) showed a significant reduction after the 3 month period. Considering the observation of Schaeken et al. that fluoride varnish treatment did not reduce the MS level in the oral cavity,[32] and that its efficacy as a caries preventive agent is related to reversing the progression of non-cavitated lesions, we suggest a confounding effect related to the educational environment to which the adult mothers were exposed. In contrast, the control children showed a statistically non significant decrease, probably because they were less likely to be influenced by the dental health instructions.

The logistic regression model for factors affecting MS counts in children at the end of the 3 month period, revealed a significant relationship between the initial caries experience of the child and his salivary level of MS. The present observation coincides with that of Campus et al. who related the high caries incidence in primary teeth to higher scores of *mutans streptococci* and *lactobacilli*.[33] The intervention method used (xylitol versus fluoride varnish) proved to significantly affect the child' salivary MS count. The result supports the reported preventive potentials of xylitol and its superior effect compared to fluoride varnish application.[22]

Moreover, the mother's salivary MS level significantly affected her child' level, which documents the relationship of maternal cariogenic flora to that of the off springs.

Plaque result supports other studies which have proved the reducing effect of xylitol on plaque accumulation.[34,35] Although plaque scores in mothers and children decreased at the end of study period, the difference was only significant in the children's group. Intergroup comparisons between experimental and control groups showed a trend of higher scores among the controls with differences that reached statistically significant level only among children. Lack of significant difference between experimental and control mothers does not mean lack of efficacy for the xylitol, but instead comparable efficacy with the positive controls that had benefited from the other preventive technique. It could also be related to the compliance level of experimental group. While children found xylitol tablets appealing, they complied better with the treatment regimen. In contrast, their mothers might have found daily frequent chewing of xylitol gums unpleasant practice.

Contrary to what was expected, the caries experience of children showed a slight statistically non significant increase after three months. The xylitol anti-cariogenic effect in reducing dental caries in children was attributed to lasting microbiological changes, different bacterial colonization patterns on erupting teeth and enamel maturation under favorable circumstances.[36] According to the study of Hujoel *et al* [12] the effect of chewing xylitol is maximized if it started at least one year before eruption of teeth. Their recommendation supports the present result regarding the lack of clinical significance of xylitol on caries during this short period of time (3 months). The inability to observe clinical effect on dental caries may also be related to the selection of high caries risk children, who most of their teeth are already affected by caries and had longstanding cariogenic feeding habits. In this regard, the finding supports the notion that children who are heavily colonized by MS and have feeding habits characterized by frequent and prolonged oral exposure to cariogenic substrates, are more likely to show progressive increase in dental caries and are not likely to experience an abrupt change in caries incidence. However, the preliminary finding of xylitol effect on salivary MS levels provides a potential clinical significance and proved that xylitol may be a good alternative to fluoride varnishes, especially for young children. This finding underscores the rationale for extending the present study into a larger and more in-depth investigation in which the present short-term result will serve as baseline data.

The revealed beneficial effect of xylitol on salivary SM and plaque levels supports its use as a safe preventive agent particularly when intensive and longer treatment regimen is used. The only disadvantage of this preventive practice is that they necessitate high level of compliance.

Further longitudinal studies are needed to investigate treatment variations (such as repeated xylitol consumption with different doses).

CONCLUSIONS

Based on the results of 3 month post xylitol consumption, the study presents the following conclusions:

1. Xylitol tablets proved to be appealing to children, which suggest their use as an effective vehicle for providing xylitol to children.
2. The three month use of xylitol significantly decreased salivary *streptococcus mutans* level in mothers and children.
3. The use of xylitol proved to reduce plaque accumulation on tooth surface and thus it can be used as a safe, efficacious and feasible prevention method for high-risk children.
4. The three month use of xylitol showed non significant effect on caries experience, which suggests longer follow up periods as well as long term xylitol consumption.

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