Impact of Maternal Xylitol Consumption on *Mutans Streptococci*, Plaque and Caries Levels in Children

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Aim: *The present study was designed to determine whether maternal xylitol consumption through regular chewing of xylitol gums can affect the salivary mutans streptococci (MS), dental caries, and dental plaque levels of their children.* ***Method:*** *Study sample included 60 mother and child pairs with high salivary mutans streptococcus (MS) levels. Samples were randomly divided into experimental group (30 pairs) and control group (30 pairs). Mothers in the experimental group received xylitol chewing gum treatment three times/ day for three months, whereas the controls received fluoride varnish. Both groups received oral hygiene instructions, dietary counseling and restorative treatment. All children were examined after 6, 12 and 18 months from the initiation of the study to assess caries, plaque and salivary mutans streptococcus (MS) levels.* ***Results*** *showed that at 18 month the percent of children with high streptococcus levels in the control significantly increased when compared to the increase in the experimental group. Throughout the study, dmft scores of experimental children showed marginal non significant increase compared to controls that showed higher scores. Plaque scores revealed statistically non significant decrease among both groups.* ***Conclusions:*** *maternal xylitol consumption provided better preventive outcomes on salivary (MS) levels compared to fluoride varnish treatments.*

Keywords: *Xylitol, Sterptotcoccus mutans, caries, saliva, plaque*

INTRODUCTION

Increasing evidences focus on dental caries as a health problem among the Saudi population indicating the emergence of a potential economic burden that necessitates the adoption of strategic health policies.[1,2] Dental caries is an infectious transmissible chronic disease caused by the interaction among etiologic risk factors (micro flora), external modifying risk factors (diet), internal modifying risk factors (host), and exposure time.[3] New, easily applied and less costly strategies beyond restoration placement and antibacterial therapy are strongly needed to control dental caries.

Since the early Turku sugar studies,[4,5] attention has been focused on the potential effect of xylitol as a convenient and effective method to inhibit *mutans streptococcus* (MS). The Turku Sugar Studies demonstrated the relationship between dental plaque and xylitol, as well as the safety of xylitol for human consumption. There are claims of specific effects of xylitol on microbial growth and metabolism. An *in vitro* study[6] showed that cells of the cariogenic streptococcus were not able to use xylitol or sorbitol effectively when they were transferred from normal media into media that contained these polyols. The overall metabolism of cells seemed to be retarded.

The consumption of xylitol led to reduction in dental caries incidence in persons receiving a strict xylitol diet for two years, through the increased production of salivary peroxidase activity from fourfold to tenfold level. Lactoperoxidase which belongs to the natural defense mechanisms of the oral cavity is attributed to the possible inhibition of lactobacillus & streptococcus growth.[7]

Several studies have shown xylitol to reduce the amount, adhesiveness and acidogenic potential of dental plaque.[8-10] Xylitol studies suggested that xylitol intake produces positive results with respect to the reduction of the incidence of caries or MS levels.[11-13]

Xylitol currently is available in many forms including gums and chewable tablets. Xylitol chewing gum has been shown to be effective as a preventive agent.[14,15] The effectiveness of other xylitol products such as chewable tablets is being studied at this time.

Recent bacteriological studies on the transmission of MS in the mother-child pair, revealed a relation between salivary MS levels in mothers and initial acquisition of MS by their infants.[16,17] Children whose teeth were colonized earlier by MS showed higher caries experience than those colonized later or not at all.[18-20]

Based on the potential promising results of xylitol, xylitol-containing chewing gums were studied to assess their caries preventive action among mothers and their potential influence on MS acquisition in children during tooth eruption period.[21-23] However, the role

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of maternal xylitol consumption in reducing the initial acquisition of MS by their infants has not yet proved to be effective to trigger its widespread use in dental practice. The frequency of use, and the optimal dosage to produce a significant impact on the child oral health still need to be documented. Therefore, the present study was initiated to assess the effect of xylitol on salivary SM level, plaque accumulation and caries activity in relation to maternal xylitol consumption in a group of Saudi mother-child pairs.

MATERIALS AND METHOD

The present study was planned to assess the potential effect of xylitol on the vertical transmission of *mutans streptococcus* (MS) from mother to child., plaque accumulation and caries activity in a group of Saudi mother-child pairs.

The study sample comprised sixty pairs of mothers and their children selected from King Abdul-Aziz University Hospital, Well Baby clinic and Faculty of Dentistry Pediatric Dentistry Dental clinic. Mothers were selected from a total group of 196 screened for salivary *mutans streptococcus* count to recruit mothers with high salivary counts ($\geq 10^5$) as well as having children at least 10 months of age (10-36months) or having a minimal of 8 primary teeth. The age range of mothers was 20-45 years.

All participants were given verbal and written information concerning the study material and procedures consent forms were signed.

The mothers were randomly assigned into 2 groups; experimental and control groups using the random number table. Mothers in the experimental group were instructed to chew 1 pellet of xylitol chewing gum (Fennobon Oy, Yrittäjäntie, Finneland – chewing gum, tablet), 1.8g and containing 66% xylitol by weight, 3 times *per day* for a period of 3 months. The total dose of xylitol was 3.64g daily. The group also received oral hygiene instructions and restorative treatment when needed. Mothers were 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). The control group participated in a preventive program under the supervision of the Pediatric Dentistry Department. The program activities consisted of oral hygiene instructions, fluoride varnish application (Duraphat 5% Na F ,Ultradent Products, Utah, USA) and restorative treatment when needed.

Children were clinically examined after 6 from the initiation of maternal xylitol consumption, which coincides with the MS window of infectivity. A comprehensive dental base line examination was carried out by one calibrated examiners to assess dmft scores, plaque accumulation and salivary *mutans streptococcus* (MS) levels. Examinations were conducted in optimal light using mouth mirror and explorer. The diagnosis of dental caries was based on the WHO criteria 1987.[24] Dental caries level was expressed using the dmft for deciduous teeth. Plaque levels were assessed using the simplified OH index by Green Vermillion (debris index).[25] Re-examination was carried out after 12 and 18 months to assess longitudinal changes in dmft scores, plaque accumulation and salivary *mutans streptococcus* (MS) levels.

The children did not receive any prophylactic measure before the age of 3 years. Regardless of the study group, all children received oral health care including regular examinations, advice on diet, oral hygiene and restoration treatment.

Saliva sample

Collection of saliva samples was carried out for microbiological screening after 6, 12 and 18 months from the initiation xylitol consumption.

Unstimulated saliva samples were collected from each child for salivary bacterial level screening. Saliva sampling was performed before conducting the clinical examination between 9-11 am. Children were not allowed to eat or drink for 2 hours before sampling. On the morning of saliva sampling, children refrained from tooth brushing. Saliva was collected with the pipette supplied by the dentocult (CRT) kit. (Ivoclar Vivadent, Lichtenstein).

Saliva sample was not taken if the child has received antibiotics within 1 month prior the examination.

Screening of stimulated saliva samples for *mutans streptococcus* (MS) level were carried out using the dentocult method (CRT) .The agar surface was wetted with saliva, and then placed in the test vial which was incubated at 37^0C for 48 hours. The density of the MS colonies was compared with the enclosed corresponding evaluation model chart. According to the manufacturer criteria, findings of 10^5 CFU or more of MS indicates a high caries risk, whereas findings less than 10^5 CFU is considered low caries risk.

Calibration

To reach good intra-examiner reliability, calibration of the examiner was conducted prior to baseline registration. Ten children and their mothers were examined to assess their caries, plaque and salivary *mutans streptococcus* levels. Re-examination of subjects was carried out after 2 days and the level of agreement between two corresponding readings was assessed using the Kappa method which resulted in a score of 1.00.

RESULTS

Table 1 shows Pearson Chi-square test analysis which revealed no significant difference in MS counts between the experimental and control groups at the base line (6 months), and at 12 month examination. proportion of children with high MS counts in the experimental group decreased from baseline to 18 months. A statistical significant difference was recorded only at 18 months (P=0.020). The children's risk of MS colonization was 3.12 fold in the control group when compared with the experimental group (95% CI. 1.316-9.513).

Table 1: The proportion of children with high Mutans Streptococcus ($\geq 10^5$) at the different study phases (6,12 and 18 month).

Study phases	High level/ total N (%)		Pearson chi-square test *P* value
	Experimental *n* = 24	Control *n* = 12	
6 months (base line)	3/24 (12.5%)	2/12 (16.7%)	1.000
12 months	3/24 (12.5%)	3/12 (25.0%)	0.378
18 months	4/24 (16.7%)	7/12 (58.3%)	0.020*

*significant difference at <0.05

To detect longitudinal changes in children due to the experimental intervention of the mother, the McNmar test was applied. Analysis showed no statistical significant differences between 6 months (base line) and 12 as well as 18 months among both groups. (Table 2)

Table 2: Longitudinal changes in salivary MS level of children in experimental and control groups

Study phases	High level/ total N (%) Experimental *n* = 24	McNmar test *P* value	High level/ total N (%) Control *n* = 12	McNmar test *P* value
6 months	3/24 (12.5%)	1.000	2/12 (16.7%)	1.000
12 months	3/24 (12.5%)		3/12 (25.0%)	
6 months	3/24 (12.5%)	1.000	2/12 (16.7%)	0.063
18 months	4/24 (16.7%)		7/12 (58.3%)	

*significant difference at <0.05

Table 3 shows that throughout the study period, children showed no statistically significant differences in the dmft scores between the experimental and control groups, although the controls displayed higher mean scores. Applying paired t test to compare the longitudinal change in dmft from baseline (6 month) to 18 month showed a trend of higher dmft scores throughout the 18 month period, which indicates a positive impact of the maternal xylitol consumption.

Table 3: Comparison of Mean dmft between the experimental and control group at each study phase (6,12 and 18 month).

Study phases	Dmft score Mean ±sd		*t* test *P* value
	Experimental *n* = 24	Control *n* = 12	
6 months (base line)	3.08 ± 4.96 (*n* =24)	4.08 ± 3.70 (*n* =12)	0.542
12 months	3.38 ± 4.60 (*n* =24)	4.58 ± 4.27 (*n* =12)	0.453
18 months	3.62 ± 4.67 (*n* =24)	6.17 ± 3.88 (*n* =12)	0.114
6 / 18 month Paired *t* test value	0.699	0.192	

Table 4 shows that children in the experimental and control groups showed no statistical significant differences in plaque scores at 6, 12 and 18 month follow up visits. Applying the paired t test to assess longitudinal change in plaque score from baseline (6 month) to 18 month in both groups showed no significant change.

Table 4: Comparison of plaque scores between the experimental and control group at each study phase (6,12 and 18 month).

Study phases	Plaque scores Mean ±sd		*t* test *P* value
	Experimental *n* = 24	Control *n* = 12	
6 months (base line)	0.96 ± 0.55 (*n* = 24)	0.83 ± 0.72 (*n* =12)	0.566
12 months	1.04 ± 0.81 (*n* =24)	0.83 ± 0.72 (*n* =12)	0.453
18 months	0.83 ± 0.64 (*n* = 24)	0.75 ± 0.75 (*n* = 12)	0.730
6 / 18 month Paired t test value	0.486	0.784	

*significant difference at <0.05

DISCUSSION

This is the last report of a cohort study investigating the potential effect of the maternal consumption of xylitol on children's future caries level. Mother-child pairs were recruited in this study and monitored longitudinally for evaluation of xylitol as an intervention used to prevent the transmission of MS from mother to child. Maternal xylitol consumption started when children were below the age of window of infectivity (10 months), and had not more than 8 anterior teeth. Three months after the end of xylitol consumption period (3 months), children were examined to assess differences in salivary MS, caries and plaque levels in relation to maternal consumption of xylitol.

Children of mothers having high levels of MS are more likely to exhibit levels of MS corresponding to their mothers' levels.[13,14] The main objective of the present study was to determine the likelihood of reducing MS transmission from mother to child and the potential effect of xylitol on vertical transmission among the pair. The gradual increase in salivary MS level seen in the experimental group from base line to 18 months indicates a positive impact of maternal xylitol consumption on the salivary MS level in children as compared to the opposing trend of increased proportion of control children with high MS level suggests a positive change in children due to the xylitol intervention method used by mothers.

Furthermore, the difference in salivary MS level between the experimental group and the controls reached significant level only after 18 months supports the preventive impact of xylitol. This is in good agreement with the earlier studies of Isokangas *et al* [21] and Soderling[22] where they found a five fold and a three fold risk of MS colonization in children with the use of bi-annual fluoride varnish and chlorhexidine treatment in the mothers', when compared to habitual daily xylitol consumption along the study period (2 years). Although, in The current study xylitol consumption was three times daily for three months, yet we also recorded a 3.2 fold MS colonization risk in the control group (58.3%), when compared to the xylitol consuming group (16.7%) findings, which suggests that maternal use of xylitol may lead to better caries prevention than fluoride varnish treatment even when used for a short period.

Throughout the study phases, children in the experimental group showed lower but statistically non significant dmft mean scores compared to their controls. The experimental group showed marginal and non significant increase from base line to 18 months. Similarly, the control group showed the same trend but the differences were more pronounced. There are two possible explanations for the result that seemed weaker than we expected. The first one is related to the dietary instruction of children, which probably made their dietary habits healthier in the two groups. Second: the losses of subjects in follow-ups might probably introduced a potential bias. Although inter-group differences are not significant, they suggest a potential effect of maternal xylitol consumption. In high caries risk populations such as the Saudi child population, adjunct preventive measures are recommended to achieve considerable outcomes.

Data on plaque accumulation in children showed statistically non significant differences between the two groups with a tendency of less accumulation among the controls. The difference between base line and 18 months were also non significant. This finding suggests that maternal xylitol consumption was less effective on the off spring plaque scores. However, a study with a larger sample would have revealed a better picture concerning the plaque score.

CONCLUSION

The present findings indicate better preventive outcome of xylitol compared to fluoride varnish treatments received by the control mothers. Despite the less pronounced outcome in caries and plaque, the effect of maternal use of xylitol reduced the salivary MS levels in the off springs significantly. This is a favorable impact in children under the age of 3 years using a less costly preventive procedure

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REFERENCES

1. Alamoudi N,Salako N, Masoud I. Prevalence and distribution of dental caries in the primary dentition in a cosmopolitan Saudi Population. Saud Dent J. 7:23-28, 1995.
2. Alamoudi N,Salako N, Masoud I. Caries experience of children aged 6-9 years in Jeddah, Saudi Arabia. Int J Ped Dent. 6:101-5,1996.
3. Gussy MG, Waters EG, Walsh O, Kilpatrick NM. Early childhood caries: Current evidence for etiology and prevention. J Paediatr Child Health. 42:37-43, 2006.
4. Scheinin A, Mäkinen KK, Tammisalo E, Rekola M. Turku sugar studies. XVIII. Incidence of dental caries in relation to 1-year consumption of xylitol chewing gum. Acta Odontol Scand.33(5):269-78, 1975.
5. Scheinin A, Mäkinen KK, Ylitalo K. Turku sugar stud¬ies. V. Final report on the effect of sucrose, fructose and xylitol diets on caries incidence in man. Acta Odontol Scand.34(4):179-216, 1976.
6. Sato Y, Yamamoto Y, Kizaki H. Xylitol-induced elevated expression of the gbpC gene in a population of Streptococcus mutans cells. Eur J Oral Sci 108:538-45, 2000.
7. Makinen KK, Tenovuo J, Sceinin A. Xylitol-induced increase of Lacto-peroxidase activity. J Dent Res. 55:652-60, 1976.
8. Steinberg LM, Odusola F, Mandel ID. Remineralizing potential, antiplaque, and antigingivitis effects of xylitol and sorbitol sweetened chewing gum. Clin Prev Dent. 14:31-34, 1992.
9. Makinen KK, Chen CY, Makinen PL, et al. Properties of whole saliva anddental plaque in relation to 40-month consumption of chewing gums containing xylitol, sorbitol or sucrose. Caries Res. 30:180-88. 1996.
10. Soderling E, Trahan L, Tammiala-Salonen T et al. Effects of xylitol, xylitol-sorbitol, and placebo chewing gums on the plaque of habitual xylitol consumers. Eur J Oral Sci. 105:170-77, 1997.
11. Mäkinen KK, Benett CA, Hujoel PP, et al. Xylitol chew-ing gums and caries rates: A 40-month cohort study. J Dent Res.74(12):1904-13,1995.
12. Mäkinen KK, Hujoel PP, Bennett CA, et al. A descriptive report of the effects of a 16-month xylitol chewing-gum programme subsequent to a 40-month sucrose gum pro¬gramme. Caries Res.32(2):107-12, 1998.
13. Milgrom P, Ly KA, Roberts M, Rothen M, Mueller G, Yamaguchi DK. Mutan Streptococci dose response to Xylitol chewing gum. J Dent Res. 85(2):177-81,2006.
14. Ly KA, Milgrom P, Rothen M. Xylitol, sweeteners, and dental caries. Pediatr Dent. 28(2):154-63, 2006.
15. Lynch H, Milgrom P. Xylitol and dental caries: An over-view for clinicians. J Calif Dent Assoc.31:205-9, 2003.
16. Berkowitz RJ, Turner J, Green P. Maternal salivary levels of streptococcus mutans and primary oral infection of infants. Arch Oral Biol. 26:147-149, 1981.
17. Caufield PW, Cutter GR, Dasanayake AP. Initial acquisition of mutans streptococci by infants: evidence for a discrete window of infectivity. J Dent Res. 72:37-45, 1993.
18. Alaluusua S, Renkonen OV. Streptococcus mutans establishment and dental caries experience in children from 2 to 4 years old. Scand J Dent Res. 91:453-457, 1983.
19. Kohler B, Andréen I, Johnson B. The effect of caries-preventive measures in mothers on dental caries and the oral presence of the bacteria Streptococcus mutans and lactobacilli in their children. Arch Oral Biol. 29:879-883, 1984.
20. Tenovuo J, Lehtonen OP, Aaltonen AS. Caries development in children in relation to the presence of mutans streptococci in dental plaque and of serum antibodies against whole cells and protein antigen I/II of Strptococcus mutans. Caries Res. 24:59-64, 1990.
21. Isokangas P, Söderling K, Pienihäkkinen K, Alanen P. Occurrence of dental decay in children after maternal consumption of xylitol chewing gum, a follow-up from 0to5 years of age. J Dent Res. 79:1885-1889, 2000.
22. Söderling E, Isokangas P, Pienihäkkinen K, Tenovuo J. Influence of maternal xylitol consumption on the acquisition of mutans streptococci by infants. J Dent Res. 79:882-887, 2000.
23. Söderling E, Isokangas P, Pienihäkkinen K, Tenovuo J,Alanen P. Influence of maternal xylitol consumption on mother-child transmission of mutans streptococci: 6-year follow-up. Caries Res. 35:173-177, 2001.
24. Green P, Vermillion J. The simplified oral hygiene index. World Health Organization 1964.
25. WHO. Dental caries levels at 12 years (mimeograph of data from global data bank). World Health Organization, Geneva 1987.