The Effect of Xylitol on *Streptococcus Mutans* in Children

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ABSTRACT

A study was performed on 91 second-grade students from the Los Angeles Unified School District to test the effects of xylitol chewing gum on *Streptococcus mutans* in the saliva. Saliva was collected from students and tested for the first time using the new University of California, Los Angeles, monoclonal antibody testing method. Students found to have moderate or high levels of salivary *S. mutans* were administered four tablets/day of xylitol gum for three weeks. The levels of *S. mutans* in the saliva of children in the high caries index subgroup decreased by 61.7 percent. Xylitol can be dispensed in a public school setting by school nurses and can be a very safe, efficient and inexpensive preventative measure for children at high risk for dental caries.

Streptococcus mutans was first isolated by J.K. Clark in 1924 and has long been considered as the primary etiologic agent in the development of dental caries.[1-5] Many other studies have verified the correlation between the proportion of *S. mutans* in saliva and the incidence of tooth decay.[6-9] W. Shi and his group at the University of California, Los Angeles, first described a rapid and quantitative detection of *S. mutans* in 1998.[6] This method used fluorescence labeled monoclonal antibodies specific against *S. mutans*, thus avoiding the pitfalls of earlier studies using inherently inaccurate culture assay detection methods.[10-12] This method was further refined and developed into a simple and inexpensive saliva test distributed by the Department of Oral Biology at the

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Disclosure / Dominique and Gabrielle Massoth received a grant from the California Dental Association Foundation for this work.

UCLA School of Dentistry. This simple test made it possible to assess the beneficial effect of xylitol in reducing caries risks in schoolchildren in a convenient and cost-effective manner.

Xylitol is a naturally occurring five-carbon sugar alcohol commercially made from xylan hemicelluloses, which include corn cobs and hardwood trees. Clinical studies have shown it to be both noncariogenic and cariostatic.[13-16] Hays reviewed 14 clinical studies from 1966 to 2001 and found a consistent decrease in dental caries ranging from 30 percent to 60 percent among subjects using sugar substitutes as compared to subjects in a control group.[16] Since xylitol is virtually nonfermentable by dental plaque, consumption of xylitol can result in a decreased production of lactic acid and glucans that make the plaque sticky. It may also enhance ammonia formation in plaque, which may neutralize the lactic acid.

Based on these clinical findings, the authors hypothesized that upon identification of children with high levels of *S. mutans*, the administration of xylitol four or five times a day may likely lower the levels of *S. mutans*. Additionally, data was to be collected for the first time using the UCLA antibody assay method. Finally, the efficacy of administration by school nurses and parental compliance would be tested.

Materials and Methods

Patients' recruitment. One-hundred fifty-eight second-grade students from Sunny Brae Elementary School in Canoga Park, Calif., were eligible to be tested. A flier was printed in English and Spanish languages so the parents of each student would be fully educated about the experiment. Ninety-six parents gave consent for an equal number of children to participate in the study. The children were categorized in one of three caries index levels. Seventeen children with less than 10,000 *S. mutans*/ml of saliva were placed in the low-caries-risk subgroup; 51 children with 10,000 to 150,000 *S. mutans*/ml of saliva were categorized into the moderate-caries index subgroup; and 23 children above 150,000 *S. mutans*/ml of saliva became the high-caries-risk subgroup. These categories were quite similar to those used in the UCLA study of salivary *S. mutans* levels counted by the monoclonal antibody testing method of more than 5,000 children.[7] The parents of the 17 children in the low-caries-risk group risk were notified that they did not need to participate further in the study.

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Saliva collection and testing. A pipette was used to collect 0.45 mL of the saliva and to transfer it to a 1.5 mL Eppendorf test tube containing 0.05 mL of formaldehyde. Students did not consume food within two hours of saliva collection and these samples were collected around 11 a.m. Ninety-one samples were sent to the UCLA oral microbiology laboratory for processing within 24 hours. The UCLA lab used the monoclonal antibody-based detection method with fluorescence microscopy to determine the numbers of *S. mutans* cells per mL of saliva.

The experimental design and testing scheme. A large supply of xylitol chewing gum was purchased at Epic Dental in Provo, Utah. Each piece of gum weighed 1.08 grams and was 67 percent xylitol. The 74 parents of the children in the moderate- and high-caries-risk subgroups were sent a bilingual notice detailing the instructions for the experiment. Each of these parents also received a 21-day supply of xylitol chewing gum and a compliance checklist. Every time the parents dispensed the xylitol chewing gum to their child, the child was expected to chew it for five minutes. The parents then checked off the appropriate box on the checklist. After 21 days, the checklists were collected and examined for compliance. Students who did not bring in their checklist were omitted from the compliance mean calculation. Sixty-nine children were retested at 2:30 p.m. after the 21st day of chewing xylitol gum.

Human subjects consent. This project was approved in its entirety by Steven M. Cantrell, PhD, chief research scientist at the Los Angeles Unified School District. Each participating child returned a signed, written informed consent from their parents. All instructions and consents were printed in English and Spanish.

Results

Twenty-two of the 23 high-caries-risk children showed decreases in their salivary levels of *S. mutans* after chewing xylitol gum for 21 days. The statistical analysis to compare *S. mutans* counts before and after xylitol chewing was performed using statistical software STATA version 9. For the high-risk group, after log transforma-

tion, the data was checked by a normality test to make sure it followed the normal distribution. A paired t test procedure was then applied. The result showed the decrease in the salivary *S. mutans* counts in the high-risk group after the application of xylitol was statistically significant (P <0.0001). The mean decrease (**Table 1**) for the 23 high-caries-risk students was 16,491 cells/ml of saliva or 61.7 percent. The 46 children tested in the moderate-caries index subgroup showed a 44.2 percent or a 29,630 cells/ml increase (**Table 1**) in salivary *S. mutans* after the xylitol chewing. This result was not statistically significant (P<0.0001).

The compliance rates were calculated by having each parent count and report the number of tablets left after 21 days. These results were verified by collecting the compliance sheets. Only 76.8 percent of the students returned their compliance sheets. The compliance rates ranged from a low of 19 percent to a high of 100 percent. This was calculated for each student by dividing the gum tablets chewed by the 84 tablets dispensed. The mean compliance rate for the 76.8 percent that returned their checklists was 90.7 percent. Therefore, the average number of tablets chewed was 76 out of the possible 84 dispensed for those that returned the compliance sheets.

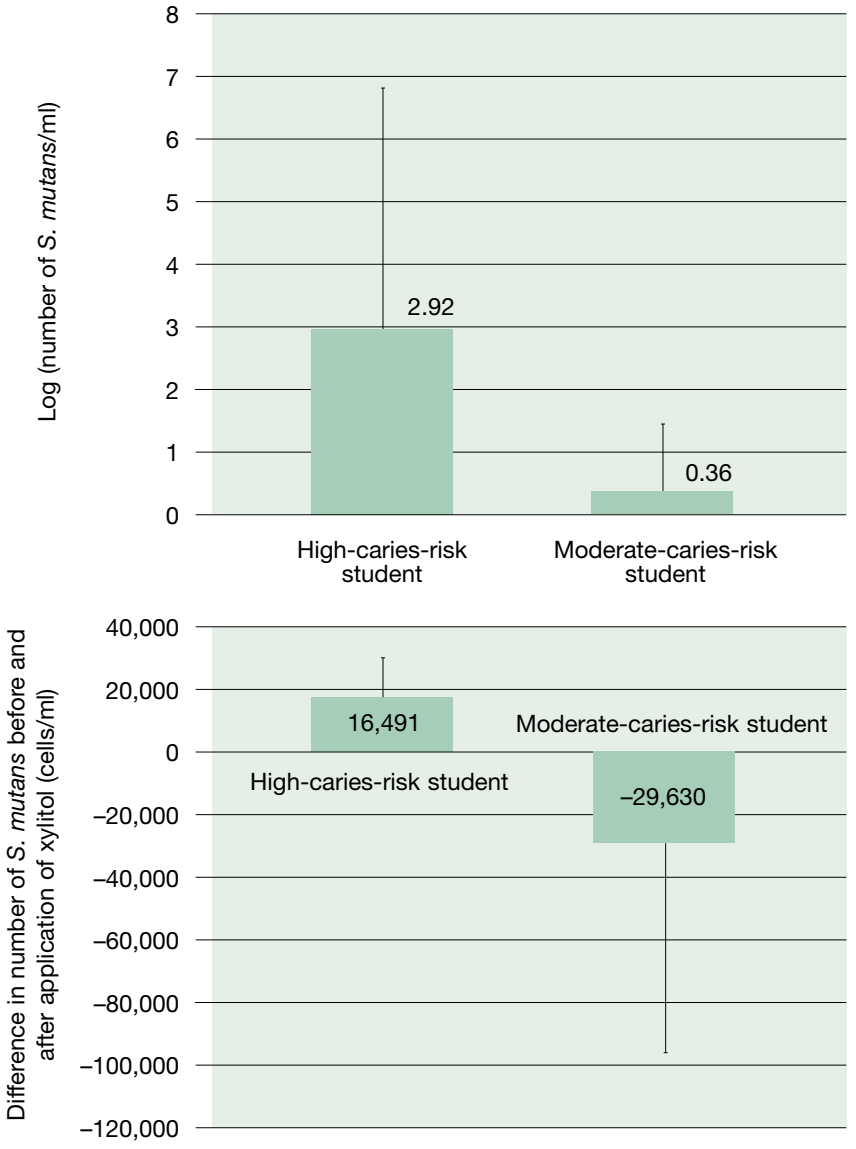
Discussion

Since 95.6 percent of the children in the high-caries index subgroup showed decreases in their levels of *S. mutans* after xylitol chewing, it seems that this gum was quite helpful to those at high-caries risk. In fact, the 61.7 percent reduction in *S. mutans* indicates xylitol may inhibit *S. mutans* much more than expected.

The xylitol was far less impressive

Table 1

The graph was plotted based on the mean of the differences of *S. mutans* counts in each subject between before and after the application of xylitol for 21 days. There were 23 students in high-caries risk group and 46 students in moderate-caries risk group. The error bar showed the standard deviation (SD) of the differences in *S. mutans* counts. Statistical analysis was performed with statistical software STATA (version 9). The data of *S. mutans* counts was log transformed to fulfill the normality requirement before the application of a paired t test to examine whether there was any statistically significant difference in the salivary *S. mutans* counts before and after the application of xylitol. The results showed a significant decrease in the salivary *S. mutans* counts in the high-risk group before and after the application of xylitol (P < 0.0001).



in reducing *S. mutans* in the moderate-caries index subgroup. In fact, this subgroup showed a 44.2 percent increase in salivary *S. mutans* that was not statistically significant. The result from one student in this subgroup was eliminated since his saliva was contaminated. It was found that there was great variability in salivary *S. mutans* counts when they were collected at different times during the day. School scheduling constraints permitted initial sampling at 11 a.m. and testing after xylitol administration at 2:30 p.m. This may explain the extreme variability and high error bar (**Table 1**) in the counts from the moderate-caries index subgroup.

The average compliance rate was 90.7 percent of the dispensed tablets over the 21 days for the 76.8 percent of the children who returned their compliance sheets. Since almost one-quarter of the parents did not return the compliance sheets, it appears that initial communications and instructions need to be improved to establish a more effective program for testing in a public school setting.

Some of the limitations of this study were the lack of a control group and the possibilities of sampling errors. It was extremely difficult to get approval for this project from the chief research scientist of the Los Angeles school district. Approval was not granted to use any students for a control group. Previous studies have shown that regular chewing gum has a very limited effect on *S. mutans*, which would serve as a negative control in this case.[14] Nevertheless, the reductions of *S. mutans* were dramatic in the high-caries risk group and this mirrors the results found in the UCLA study with more than 5,000 children.[7] Contamination could have occurred in collecting the saliva into the cups and then transferring it to the test tubes as the nurses were inexperienced in carrying out this procedure. However, the improved accuracy of monoclonal antibody testing over the previous standard of selective culture assay methods is well documented.[6,7]

One of the main goals of this study was to see if the school nurses could organize the logistics and various stages of the school testing. Once they had received the proper training, they were quite capable of running the program independently. Well-controlled double-blind clinical trials are still needed with more attention to parental compliance. The UCLA antibody assay method was first used and found to yield a more accurate count of *S. mutans* in the saliva than previous, nonspecific culture assay methods.[6,7] It appears that xylitol can be a very safe, efficient and inexpensive protective measure for children at high risk for dental caries. CDA

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