

Long-term effect of xylitol chewing gum on dental caries

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Abstract – About 85% ($n=269$) of the subjects who participated in the Ylivieska follow-up studies on the effect of xylitol chewing gum on dental caries during 1982–84 or 1982–85 were re-examined in 1987 for the analysis of possible long-term preventive effects. Further caries reduction was found 2 or 3 yr after the discontinuation of the use of xylitol. The effect was especially marked in girls; the reduction in caries increment in the post-use years was 60% for the 2-yr users, suggesting that more pronounced caries reduction was associated with the most regular use of xylitol. In teeth erupting during the first year of the use of xylitol gum the long-term preventive effect was greater than in other teeth. Several explanations are suggested: lasting effect of the microbiological changes in the mouth, bacterial colonization on newly erupted teeth by organisms other than *S. mutans*, and/or thorough maturation of the teeth under favorable physico-chemical circumstances. The results suggest that the value of xylitol in caries prevention depends on the timing of the treatment in relation to the development of the dentition.

Key words: cost-effectiveness analysis; dental caries; long-term effects; prevention; xylitol

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The studies available on the long-term effect of caries preventive agents or procedures are few, and have given equivocal results (1–7). However, for the assessment of the value of a preventive program it is important to know whether the effect on dental caries is temporary or lasting and information on the possible long-term effects is also needed for cost-effectiveness analyses (8).

Two longitudinal field studies, one lasting 2 yr and the other 3 yr, were carried out in Ylivieska, Finland, in 1982–85, with subjects initially aged 11–12 yr. The results showed that regular use of a chewing gum containing xylitol further increased the efficacy of the existing preventive measures, which were mainly based on fluorides and which are regularly applied in Finnish Health Centers (9, 10). The results were in line with other studies on xylitol (11–15; for a review, see 16) and indicate the existence of a cariostatic mechanism induced by peroral xylitol (11, 17). In no previous studies, however, has the possible long-term clinical effect of xylitol been analyzed.

The aim of the present study was to analyze the increment of dental caries during three post-experimental years (1984–87) in subjects who used xylitol

chewing gum for 2 yr, and during two post-use years (1985–87) in high-risk subjects who used xylitol for 3 yr.

Subjects and methods

The original Ylivieska xylitol study was a field trial, in which the experimental group and control group consisted of parallel classes at school. The detailed arrangement of the study has been published earlier (9, 10). The original 2-yr study consisted of 172 children initially aged 11–12 yr (mean age 11.5 yr) who used xylitol chewing gum two to three times per day, and 152 children of the same age (mean 11.5 yr) who formed the control (no-gum) group. All the children received the same basic fluoride prevention. On the basis of the total caries experience recorded at the beginning of the study in 1982, 30 of the original 172 children were classified as high-risk subjects for dental caries, and they continued the daily use of xylitol chewing gum for one more year. Using similar criteria, 36 children in the control group were chosen as controls for the 3-yr study. The criteria for allocating subjects to high-risk groups and the evaluation of the method used have been published elsewhere (9).

A total of 147 children (85%) of the

original xylitol group and 122 children (80%) of the original control group were clinically re-examined in 1987, i.e. 3 yr after the discontinuation of the daily use of xylitol gum in the main experimental group (2 yr after discontinuation in the high-risk groups). A blind study design was applied, and the re-examinations were carried out by two dentists who had participated in the original studies (9). Of the re-examined children 120 had used xylitol chewing gum for 2 yr (1982–84) and 27 belonged to the high-risk subjects who had used xylitol for 3 yr (1982–85), while in the re-examined control group, 31 children had originally (1982) been classified as high-risk subjects (Fig. 1).

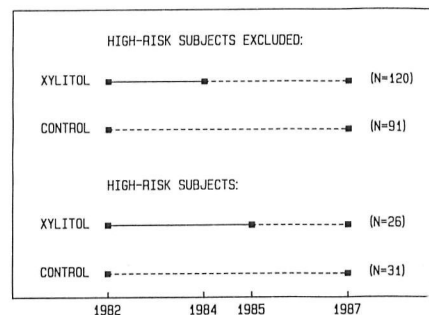


Fig. 1. Overall schedule of the study. Solid line refers to the use of xylitol chewing gum in the original 2- and 3-yr trials.

The criteria for dental decay were the same as those used during the original studies (9). However, enamel caries (D_1) was not registered for the present analysis. Detailed information on the criteria, which are in accordance with WHO guidelines (18), has been given by ISO-KANGAS (9). For comparison in the present study, the results of the original 2- and 3-yr trials were recalculated for the participants in the re-examination according to the design presented in Fig. 1. The use of xylitol gum and other sweets during the intervening years 1984-87 (1985-87 for the high-risk subjects) in both the xylitol and control groups was checked by a questionnaire.

Results

Subjects who used xylitol chewing gum for 2 yr (1982-84)

In boys, the reduction in dental caries, measured as ΔD_2MFS , was 33% in the xylitol (X) group during the original 2-yr study in 1982-84, and 31% during the years 1984-87 as compared to the control (C) group. In the X-group girls, the corresponding figures were 46% and 60% (Fig. 2). The caries increment values for 1984-87 were 2.1 in the X-group boys (95% confidence limits 1.2, 3.0), 3.2 in the C-group boys (1.8, 4.6), 1.0 in the X-group girls (0.6, 1.4), and 2.5 in the C-group girls (1.3, 3.7), respectively. In view of the differences in total caries experience at the baseline examination, the caries increment was also analyzed after stratification by baseline DMF. In those for whom baseline DMF=0, xylitol users did not differ from control group children with respect to 2-yr or 5-yr caries increment. In the two other strata, however, both for boys and girls, the reduc-

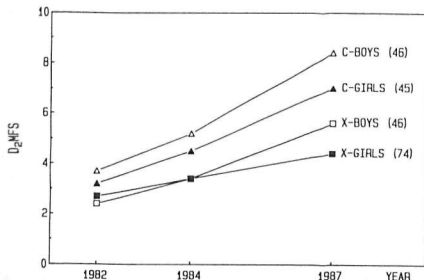


Fig. 2. Dental caries increment during 1982-84 and 1984-87 in all teeth in subjects who used xylitol gum for 2 yr in 1982-84 (X), and in the control subjects (C), boys and girls separately.

Table 1. Caries increment (ΔD_2MFS) during experimental and post-experimental years in xylitol (X) and control (C) groups expressed by baseline DMF and by sex, and caries reduction in the X-subgroups as compared to the corresponding C-subgroups

Baseline DMF	Subgroup	n	ΔD_2MFS_{82-84}			ΔD_2MFS_{84-87}		
			Mean	SD	Reduction%	Mean	SD	Reduction%
0	X-boys	16	0.7	2.0	13	2.4	3.9	-20
	C-boys	10	0.8	1.6		2.0	2.2	
	X-girls	23	0.4	0.6	20	1.0	1.5	0
	C-girls	8	0.5	0.8		1.0	1.1	
1-2	X-boys	17	1.1	1.6	27	2.1	2.9	51
	C-boys	15	1.5	2.0		4.3	4.7	
	X-girls	26	0.7	1.4	42	0.6	1.0	63
	C-girls	17	1.2	1.3		1.6	1.8	
3-	X-boys	13	1.5	2.3	21	1.9	2.2	37
	C-boys	21	1.9	2.0		3.0	5.3	
	X-girls	25	1.0	2.3	44	1.4	2.6	64
	C-girls	20	1.8	2.1		3.9	5.5	

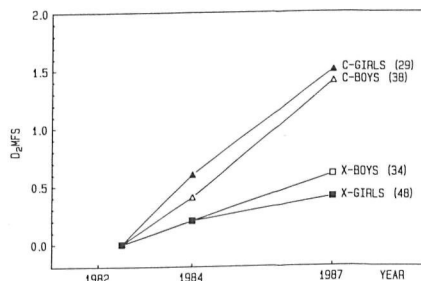


Fig. 3. Dental caries increment during 1982-84 and 1984-87 in those teeth that erupted during the first year of the use of xylitol gum in the xylitol group (X), and in the control group (C), boys and girls separately.

tion was greater during the post-experiment years 1984-87 than during the actual field trial in 1982-84 (Table 1).

In those teeth that erupted during the first year of using xylitol, the long-term effect was greater than in teeth overall: the reduction was 50% for boys during the original study, and 60% during the post-use years of 1984-87. In girls the corresponding figures were 67% and 79% (Fig. 3). The increment values for

erupted teeth were 0.4 for X-boys (95% confidence limits 0.1, 0.7), 1.0 for C-boys (0.4, 1.6), 0.2 for X-girls (0.1, 0.3), and 1.0 for C-girls (0.4, 1.6).

High-risk subjects who used xylitol chewing gum for 3 yr (1982-85)

The mean caries increment for the high-risk children during the experimental period 1982-85 was 2.9 in the xylitol group and 6.6 in the control group, representing a reduction of 55% in the X-group as compared to the C-group. During the follow-up period the mean increment was 1.4 in the X-group and 2.4 in the C-group, representing a corresponding reduction of 39% (Table 2). In those teeth which erupted during the first year of using xylitol, the reduction was 76% in the original study, and 14% in the follow-up years 1985-87 (Table 2).

Use of xylitol chewing gum

Distribution of xylitol chewing gum to the children ended in 1984 (1985 to high-

Table 2. Mean caries increment with 95% confidence limits in the high-risk subjects in the xylitol and the control group during the experimental years 1982-85 and follow-up years 1985-87, separately for all teeth and for teeth erupting during the first experimental year

	n	\bar{x}	ΔD_2MFS_{82-85}		ΔD_2MFS_{85-87}	
			95% confidence limits	\bar{x}	95% confidence limits	
All teeth						
Xylitol	26	2.9	1.8, 4.0	1.4	0.3, 2.5	
Control	31	6.6	4.9, 8.3	2.4	0.4, 4.4	
Erupted teeth						
Xylitol	12	0.4	-0.2, 1.0	0.6	0.0, 1.2	
Control	16	1.7	0.9, 2.5	0.8	-0.3, 1.9	

risk subjects). The questionnaire survey revealed that 10 children in the xylitol group had daily used commercially available xylitol gums during post-experimental years. One of these children belonged to the high-risk group. In the control group, 10 children had also used xylitol chewing gum regularly after the termination of the original 2- or 3-yr studies. Three of these children were classified as high-risk subjects.

Discussion

The participation of the children in the re-examination can be regarded as satisfactory. The essential reason for losing 17% of the subjects was their moving from the community. Because of the loss, the results from the 2- and 3-yr studies were recalculated for the re-examined subjects; but since the caries increment values were practically identical with the original ones (9), we consider that the dropouts did not affect the comparisons.

Inter- and intra-examiner analyses for caries registration were carried out in the original studies (9). Due to practical reasons such as difficulties in contacting the subjects, it was not possible to arrange a new reproducibility analysis for the observations in the present study. However, the two examiners involved were experienced clinicians who had showed good repeatability during the original study (9). In view of this and of the blind study design, there is no reason to suspect biased observations.

The 2- and 3-yr Ylivieska xylitol studies showed that only regular use of xylitol chewing gum, i.e. two to three times per day, was associated with a significant reduction in caries increment. Since only a few children had used xylitol regularly on this scale after the experimental period, voluntary use seems to have no or only very limited effect on the long-term results in the main part of the material. However, in high-risk subjects the post-experimental use of xylitol may have confounded the analyses. This is due to the small number of high-risk children in the re-examination, especially with teeth erupting during the use of xylitol.

Earlier long-term studies on caries prevention have not separately analyzed those teeth that erupted during the treatment period. It is possible that the equivocal results obtained in those studies are partly associated with that fact. Our find-

ings indicate that the additional degree of prevention, which was found in all teeth during the post-use years, was even better in teeth erupting during the active period of treatment with xylitol. This observation suggests that the timing of preventive measures (as well as the timing of studies on caries prevention) in relation to the development of the dentition may materially affect the results.

Several possible explanations can be suggested for the fact that an additional degree of prevention was found without any prolonged treatment. In the first place, even discounting biological explanations for the observation, the xylitol group may have showed less caries for "technical reasons". By this we mean that there may have been fewer active subclinical caries lesions which could have grown rapidly to clinically detectable dentinal caries in the xylitol group than in the control group. Especially in the high-risk groups, where the post-experimental follow-up period was only 2 yr, this possible technical effect should be taken into account.

In our view, the more probable explanation for the increased difference between the xylitol and control groups during the post-use years is the occurrence of microbiological changes in the mouth and/or the maturation of the erupting teeth under favorable physico-chemical conditions. The microbiological follow-up of the Ylivieska subjects demonstrated that the reduction in caries incidence during the use of xylitol chewing gum was related to a selective inhibition of *Streptococcus mutans* (17). It is, therefore, possible that those teeth that erupted during xylitol treatment were permanently colonized by bacteria other than *S. mutans*, thus showing high resistance against caries even without prolonged use of xylitol. On the other hand, it has been suggested that a tooth is most sus-

ceptible to caries attack immediately after eruption (19). Because of this, and as a result of successful maturation, the teeth that erupted during the active use of xylitol may be better protected against caries than the teeth in control group children. A study by ALANEN *et al.* (5) demonstrated that teeth that erupted during the Second World War, when the use of sugar was strongly reduced, had after an elapse of 40 yr experienced less caries than teeth erupting before or after the war. Our present results do not make it possible to evaluate the relative weight of these two explanations.

There was also no significant difference in caries increment between those subjects in the xylitol and the control groups who did not have decayed, missing, or filled teeth at the baseline examination. We believe that this finding is associated with the moderately low caries incidence in these control group subjects. It seems that in these subjects the basic prevention with fluorides, and their health behavior in other respects, too, is already so effective that additional prevention is hard to achieve. Both the usefulness and the cost-effectiveness of xylitol, therefore, are likely to be best among subjects who are more caries-active.

The greater reduction in girls than in boys during the post-use years is similar to the result in the original study (9). The sex difference in that study was almost totally explained by more regular use of xylitol chewing gum by the girls than by the boys. The long-term advantage found for the girls is in accordance both with the hypothesis of favorable bacterial colonization and also with that of proper maturation of the teeth.

The difference in total caries experience between the xylitol and control groups had further increased during the 2- or 3-yr follow-ups after the use of the preventive measure. In most cases the

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post-experimental reduction percentage was actually greater, indicating an increasing difference also in caries incidence. This result was achieved at practically no new costs. For this reason, in the evaluation of cost-effectiveness the long-term effect should also be taken into account.

The present results suggest that caries prevention studies should not be terminated at the end of the active use of the treatment, since the total value of the method used can only be seen in the long run. The optimal timing and duration of caries prevention cannot be planned without knowledge of the long-term effects of the preventive procedure chosen, nor without knowledge of the association between the eruption of teeth and their long-term protection. If the hypotheses of favorable bacterial colonization and/or successful maturation hold true, at least part of the preventive measures should be concentrated around the time of tooth eruption, rather than being applied evenly throughout a person's entire life.

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