Caries incidence in adolescents with low caries prevalence after cessation of weekly fluoride rinsing

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The aim of this study was to determine whether cessation of weekly fluoride rinsing leads to an increase in caries incidence in a group of adolescents with low caries prevalence. Sixty randomly selected 12- to 14-year-olds were asked to stop rinsing at school (test group). After 3 years caries increment and caries progression were compared with an age- and sex-matched control group ($n = 60$), who continued to rinse weekly with a 0.2% sodium fluoride solution. All children in both groups had followed a school-based fluoride rinsing program from the age of 6 years. The mean (standard deviation) caries increment, including only open lesions, during the 3 years was 1.58 (1.73) in the test group and 1.48 (1.80) in the control group. The corresponding figures for incipient lesions were 3.13 (3.63) and 4.03 (4.23), respectively. The mean caries progression was 0.92 (1.34) in the test group and 0.72 (1.03) in the control group. None of these differences were statistically significant. Thus, this study showed that a cessation of weekly fluoride rinsing did not lead to an increase of caries incidence in a group of adolescents with low caries prevalence. □ *Adolescents; caries incidence; caries progression; fluoride rinsing*

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The caries-reducing effect of school-based fluoride rinsing programs is well documented in many studies (1). Torell & Ericsson (2) introduced this preventive method in Göteborg in the 1960s, and later it became a routine for all 6- to 16-year-olds in Swedish schools. Many studies in Sweden and worldwide have subsequently confirmed the results obtained by Torell & Ericsson (3). A remarkable improvement in dental health among children could be seen at the end of the 1970s and during the next decade (4, 5). It was claimed that the main reason for the decline of caries was that fluoride toothpaste was more regularly used in the population. Thereby, dental health promotion was more focused on individual rather than general fluoride prophylactics. However, it should be noted that the caries decrease started before the use of fluoridated toothpaste became a commonly used caries-preventive method (6, 7).

In some studies, no additional effect from fluoride rinsing compared with the daily use of fluoride toothpaste was observed (8–12). Before terminating the rinsing program in the county of Bohuslän, it was decided to evaluate the effect of rinsing in a controlled clinical trial. The aim of this study was to determine whether the cessation of weekly fluoride rinsing led to an increase in caries incidence in adolescents with low caries prevalence but with many newly erupted teeth and with a large number of unfilled surfaces at risk.

Materials and methods

Dental health program in the county of Bohuslän

Since 1965 all 6- to 16-year-olds have participated in a school-based fluoride rinsing program in the county of Bohuslän, located on the Swedish west coast. The rinsing procedures have been carried out by dental nurses once a week, using a 0.2% sodium fluoride solution. The dental nurses also taught the children to brush their teeth twice a day at home with a fluoride-containing toothpaste. Furthermore, all children were treated with fluoride varnish (Duraphat®) once a year at the dental clinic. Children with a high caries risk and/or with many carious lesions were given an individualized preventive program, including more intensive fluoride therapy and dietary restrictions. Efforts were also made to improve their oral hygiene.

Longitudinal study

Test persons. Sixty randomly selected 12- to 14-year-olds at one elementary school constituted the test group (T_1 group). They stopped the rinsing procedure in June 1990. Another 60 randomly selected age- and sex-matched adolescents from a neighboring elementary school in the same city constituted the control group (C_1 group). The

Table 1. Demographic data for participants of the longitudinal and the cross-sectional study

	Test groups	Control groups
Longitudinal study, 1990–93	No. of participants: 60 (females, 31; males, 29) Mean age in years at base line/final caries recording: 13.2/16.2	No. of participants: 58 (females, 30; males, 28) Mean age in years at base line/final caries recording: 13.2/16.2
Cross-sectional study, 1994	No. of participants: 59 (females, 23; males, 36) Mean age in years at caries recording: 15.9	No. of participants: 57 (females, 20; males, 37) Mean age in years at caries recording: 15.9

latter group continued to rinse with a 0.2% sodium fluoride solution once a week during school terms for the next 3 years, a procedure in which both groups had taken part since the age of 6 years. The C_1 group received 34 rinses each school year. All the adolescents but two, who moved out of the region during the 3-year period, took part in the study. The T_1 group therefore included 60 patients and the C_1 group 58 patients (Table 1). The T_1 group was treated at a dental clinic in the city of Uddevalla, and the C_1 group was treated at another dental clinic in the same city. It was taken for granted that all the adolescents used a fluoride-containing toothpaste once or twice a day at home. There was no difference in the fluoride content of the drinking water used by the two groups (0.1–0.2 mg F/l). The socioeconomic factors of the adolescents were similar according to the municipal authorities.

Recording. Both the recording at base line in 1990 and the final one in 1993 were combined clinical and radiologic recordings blindly performed by three of the authors. Initially, four bitewing radiographs (Kodak Ektaspeed Plus, Eastman Kodak Co., Rochester, N.Y., USA) were taken of each patient in a standardized manner by two dental nurses. One of the authors, who is a pedodontist (C.-G. Rasmusson), then performed the caries recording using the criteria set by the WHO (13). Incipient lesions and fissure sealants were recorded as well. The caries recording was immediately repeated by another author (U. Moberg Sköld), and the two examiners came to an agreement. The examiners were carefully calibrated before the caries recording and had participated in similar investigations in the past (14–16). The bitewing radiographs were analyzed by two of the authors (U. Moberg Sköld and A.-M. Lindvall), one of whom is an oral radiologist, using a light desk and a Mattsson viewer (17), after which an agreement was reached. The final score was a combination of the clinical and the radiologic recordings for both incipient and open lesions. All approximal surfaces from the distal surface of the canine to the mesial surface of the second molar were analyzed. A distinction was made between incipient lesions (lesions in the enamel) and open lesions (lesions extending beyond the enamel–dentin border). For intra- and inter-examiner reliability, 10% of the radiographs were read twice by two authors (U. Moberg Sköld and A.-M. Lindvall). The intra-examiner kappa values for the two examiners were 0.81 and 0.90. The inter-examiner kappa value was 0.82.

Cross-sectional study

Test persons. As the size of the groups in the longitudinal study was somewhat limited, a supplementary cross-sectional study was performed in 1994. In that study the caries prevalence was compared between a test group of another 60 randomly selected 16-year-olds, called the T_c group, and a sex- and age-matched control group ($n = 60$), called the C_c group. The T_c group had not taken part in the school-based fluoride rinsing program for the past 3 years, whereas the C_c group had rinsed weekly with a 0.2% sodium fluoride solution at school. Supplementary fluoride treatment depending on the level of the oral health was performed on visits to the clinics. The T_c group belonged to the same school as the T_1 group, and the C_c group to the same school as the C_1 group in the longitudinal study. Both groups had previously rinsed weekly with a 0.2% sodium fluoride solution between the ages of 6 and 12 years. Four patients did not show up for the caries recording. The results are therefore based on 59 patients in the T_c group and 57 patients in the C_c group (Table 1).

Recording. The caries recording was performed in the same manner as in the longitudinal study.

Statistical analysis

In the longitudinal study differences in initial values were eliminated by comparing changes intraindividually from initial to final values between groups. Student *t* tests were used to establish differences as significant at the 5% level. Since counts have usually skewed distributions, we also confirmed the results with the Wilcoxon two-sample test. In the cross-sectional study, counts were compared by means of Student *t* tests and confirmed with the Wilcoxon two-sample test.

Results

Longitudinal study

The mean caries prevalence at base line and after 3 years is presented in Table 2. Open lesions expressed as decayed surfaces (DS) were already significantly different in the two groups at the start, as the T_1 group had more open lesions than the C_1 group, whereas the numbers of filled surfaces (FS) were similar in the two groups. The

Table 2. Mean (standard deviation) caries prevalence (clinical and radiologic) at base line and after 3 years in the longitudinal study

	T_1 group	C_1 group	*P* value
1990			
DS	0.90 (1.26)	0.33 (0.69)	$P < 0.01$
FS	2.30 (2.99)	2.02 (2.25)	NS
DMFS	3.20 (3.64)	2.34 (2.41)	NS
Incipient lesions	3.82 (4.20)	2.40 (4.12)	NS
Total caries value (DMFS + incipient lesions)	7.02 (6.86)	4.74 (5.24)	$P < 0.05$
1993			
DS	2.18 (2.15)	1.26 (1.83)	$P < 0.05$
FS	3.28 (3.50)	3.43 (2.90)	NS
DMFS	5.47 (4.85)	4.69 (3.79)	NS
Incipient lesions	6.02 (4.92)	5.67 (6.39)	NS
Total caries value (DMFS + incipient lesions)	11.48 (8.29)	10.36 (8.76)	NS

DMFS values did not differ significantly at base line, but the T_1 group had a higher value than the C_1 group. When the incipient lesions were included, however, there was a statistically significant difference between the groups; that is, the T_1 group had a higher total caries value. After 3 years, there was still a statistically significant difference between the groups in terms of open lesions. The number of patients and molar teeth with fissure sealants was much higher in the C_1 group than in the T_1 group (Table 3).

The mean (standard deviation) caries increment (including both open and incipient lesions) on different tooth surfaces after 3 years was slightly higher in the C_1 group than in the T_1 group: 5.52 (5.32) versus 4.72 (4.69). The caries increment when including only open lesions was almost the same in the two groups, T_1 = 1.58 (1.73) and C_1 = 1.48 (1.80). The caries increment when including only incipient lesions was slightly higher in the C_1 group, 4.03 (4.23), than in the T_1 group, 3.13 (3.63). The differences were not statistically significant. Seventy per cent of the open lesions were found on occlusal surfaces in the T_1 group, whereas the corresponding figure for the C_1 group was 80%. Eighty-four per cent of the incipient lesions developed on approximal surfaces in the T_1 group, whereas the corresponding figure for the C_1 group was 92%.

There were no statistically significant differences in the progression figures—that is, incipient lesions that proceeded to open lesions or fillings—between the two groups: 0.92 (1.34) in the T_1 group, compared with 0.72 (1.03) the C_1 group. Of the lesions that progressed, 82% were found on approximal surfaces in the T_1 group, and 90% in the C_1 group.

The caries increment and caries progression, expressed as a percentage of the total number of approximal surfaces at risk (from the distal surface of the canine to the mesial surface of the second molar), are presented in Table 4. Of the 1,783 caries-free surfaces at base line in the T_1 group, 91% were caries-free after 3 years. In the C_1 group 89% of 1,918 surfaces remained caries-free. On surfaces with existing incipient lesions at base line 76% did not progress in the T_1 group compared with 65% in the C_1 group. In the T_1 group 19% of the incipient lesions had progressed to open lesions, and 5% were filled. The corresponding figures for the C_1 group were 24% and 11%, respectively. In the T_1 group 50% of the open lesions were restored, whereas the corresponding figure for the C_1 group was 80%.

Table 3. Total number of patients/molar teeth with fissure sealants in the longitudinal and the cross-sectional study

Total no. of patients/teeth with fissure sealants	Test groups	Control groups
Longitudinal study	6/16	33/104
Cross-sectional study	5/12	39/125

Cross-sectional study

The differences in mean caries prevalence between the two groups are presented in Table 5. After 3 years without rinsing, the adolescents in the T_c group had significantly more open lesions (DS) than the adolescents in the C_c group, mainly on the occlusal surfaces; this was three times higher in the T_c group than in the C_c group. The difference in the total caries value—that is, DMFS + incipient lesions—however, was not statistically significant. The number of patients and molar teeth with fissure sealants was much higher in the C_c group than in the T_c group (Table 3).

Discussion

There were no statistically significant differences in caries increment and caries progression between the T_1 group and the C_1 group in the longitudinal study. At base line, however, there was a significant difference in the mean (standard deviation) caries prevalence between the two groups; that is, the DMFS + incipient lesions figure was 7.02 (6.86) in the T_1 group versus 4.74 (5.24) in the C_1 group. In the statistical analysis the differences at base line were compensated for in the manner in which the comparisons were made intraindividually and the initial differences were accounted for. It can be argued that the

Table 4. Caries increment and caries progression on approximal surfaces (distal surface of the canine to mesial surface of the second molar) expressed as a percentage of the number of surfaces at risk in the longitudinal study

		1993			
		Caries free	Incipient lesions	Open lesions	Fillings
1990	Caries free				
	T_1 group	91	8	1	0
	C_1 group	89	10	1	0
	Incipient lesions				
	T_1 group		76	19	5
	C_1 group		65	24	11
	Open lesions				
	T_1 group			50	50
	C_1 group			20	80
	Fillings				
	T_1 group				100
	C_1 group				100

T_1 group $n = 1{,}783$ surfaces.
C_1 group $n = 1{,}918$ surfaces.

risk of recurrent decay will increase with more filled surfaces and that the statistical method used did not compensate for the risk. However, in this study recurrent decay was not registered in any patient. An analysis designed to identify possible reasons for the discrepancy showed differences neither in the fluoride content of the drinking water nor in the socioeconomic background factors, and, furthermore, we were unable to find any differences in the approach to preventive efforts at the dental clinics except for the frequency of fissure sealants. The clinicians at the dental clinic who treated the C_1 and C_c groups seemed to be more positive towards fissure sealant treatment, which was reflected in a great difference in the fissure sealant frequency between the groups in both the studies. This is probably the major reason for the difference in the amount of open lesions on occlusal surfaces. Thus, the results indicate that cessation of fluoride rinsing with a 0.2% sodium fluoride solution did not lead to increased caries activity in adolescents who used fluoridated toothpaste daily, who saw a dentist yearly, and who rinsed with a 0.2% NaF solution during a period of 7 years before the study started. The results from the cross-sectional study support this statement. Similar results have been reported in other Nordic studies (9–12).

Many clinical studies have, however, shown an additional effect of fluoride mouth rinsing on caries incidence compared with unsupervised tooth brushing with fluoridated toothpaste and a continuing positive effect many years after the rinsing period (18–24). In some of these studies a lasting positive effect has been seen for up to 7 years after discontinuation (20–22). During this time, however, there has been a general downward trend in caries prevalence in most industrialized countries with or without fluoride rinsing programs. Still, a possible explanation for the lack of effects of ceased rinsing in the present study is that earlier rinsing still affects the teeth's caries susceptibility; that is, if the study had been done over a 6-year period, the results might have been different. It can also be argued that the sample size in the present study is too small with a low prevalence of disease, and that statistical significances will therefore not be detected. However, it is often impractical to secure all differences of clinical importance since the prevalence of caries today is so low.

It is obvious that all reasons for the decline in caries incidence are not known (25). A questionnaire study by Bratthall et al. in 1996 (26) showed that an overwhelming majority of caries researchers thought that the use of fluoridated toothpaste had caused the decrease in caries incidence, even though the downward trend in some

Table 5. Mean (standard deviation) caries prevalence in the cross-sectional study (1994)

	T_c group	C_c group	*P* value
DS	2.34 (2.62)	1.21 (2.24)	$P < 0.05$
Occlusal	1.51 (1.73)	0.54 (0.94)	$P < 0.01$
Approximal	0.80 (1.61)	0.68 (1.73)	NS
FS	2.36 (3.00)	3.44 (5.24)	NS
DMFS	4.69 (7.43)	4.73 (5.23)	NS
Incipient lesions	5.46 (5.11)	4.39 (5.35)	NS
Occlusal	0.73 (1.32)	0.67 (1.07)	NS
Approximal	4.70 (4.81)	3.77 (5.30)	NS
Total caries value (DMFS + incipient lesions)	10.15 (9.00)	9.12 (11.34)	NS

countries started before fluoridated toothpaste was introduced (6, 7). Since all the children in the present study used fluoridated toothpaste at least once a day and, moreover, were treated with fluoride varnish at least once a year, the most probable explanation of our results is that children in the test groups had an appropriate fluoride exposure in spite of ceased rinsing.

Large differences in dental health can be seen between different dental clinics within a county (14) and between counties in Sweden (27), where the use of fluoridated toothpaste is approximately equal. In regions with a low caries incidence, as in the present study, school-based fluoride rinsing programs do not appear to be cost-effective. According to Burt (28), however, there is reason to believe that school-based fluoride rinsing is more appropriate for children in targeted geographic areas where the caries incidence is high, especially if fluoridated toothpaste is not used on a regular basis.

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