Effect of professional flossing with NaF or SnF_2 gel on approximal caries in 13–16-year-old schoolchildren

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The aim of this study was to evaluate the effect of professional flossing with NaF and SnF_2 gels on caries development on approximal tooth surfaces. Two-hundred-and-eighty 13-year-old schoolchildren were divided into 3 groups: (1) NaF ($n = 97$), (2) SnF_2 ($n = 85$), and (3) placebo gel group ($n = 98$). The investigation was carried out double-blind. The children were treated 4 times a year for 3 years with 1% NaF gel, 1% SnF_2 gel, or placebo gel. The treatment was carried out by dental nurses and the time required per visit was approximately 10 min. After 3 years, the mean approximal caries increment, including initial caries lesions, was 2.8 in the NaF, 2.4 in the SnF_2, and 4.0 in the placebo gel group ($P < 0.05$ for SnF_2 vs placebo); a reduction compared to the placebo of 30% and 39% in the NaF and SnF_2 groups, respectively. Thus, professional flossing with NaF or SnF_2 gel carried out 4 times a year may be considered as an interesting caries-preventing method for large-scale application in schoolchildren.
☐ *Dental caries; dental prophylaxis; dental floss; fluoride gel*

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In 2 earlier 3-year clinical studies, we have evaluated a new technique for applying chlorhexidine gel between the teeth by professional flossing 4 times a year (1, 2). The treatment was originally designed for schoolchildren, using a mobile dental unit at the school (1). Later, the method was evaluated in pre-school children who came to the Public Dental Clinic for gel treatment (2). The caries reduction in both these studies was around 40%.

Chlorhexidine, which is known to suppress mutans streptococci in dental plaque, has shown impressive results in the prevention of dental caries when used in high-risk subjects (3). Because the use of fluoride is more widely used than chlorhexidine in caries prevention, we thought it was of interest to incorporate and evaluate fluoride instead of chlorhexidine in the flossing gel in order to find a simple and inexpensive preventive method for large-scale application in schoolchildren. The purpose of the present investigation was thus to evaluate the caries-reducing effect of professional flossing 4 times a year with gels containing either NaF or SnF_2. A placebo gel was used as a control.

Materials and methods

Population

A total of 317 children, 12 years old, in the community of Eslöv, Sweden, were selected for the study in the autumn of 1992 ($n = 141$; born in 1980) and in the autumn of 1993 ($n = 176$; born in 1981). They were randomly allocated to 3 gel groups. At the start of the study, 8 individuals did not want to participate. During the following 3 years, 29 children moved from the area or preferred to visit a private dentist. Thus, the results are based on 280 children in the 3 groups. They belonged to 26 separate school classes, and the 3 groups were evenly distributed in every class. The children were only exposed to fluoride in connection with daily brushing of teeth. The drinking water contained approximately 0.2 ppm F.

Gel treatment

All children visited the Public Dental Clinic in Eslöv every 3rd month and were treated with the gel from October 1992/1993 to the last time in October 1995/1996, i.e. altogether 13 times (Fig. 1). The gel (~1 ml for the whole dention) was applied with a syringe in the interproximal spaces, using both the buccal and the lingual approach. Approximal surfaces of all teeth were then exposed to the gel by means of flat dental floss (Dentotape ribbon floss, waxed, Johnson & Johnson, New Brunswick, USA). Each tooth surface was flossed about 10 times. Cotton rolls were placed in the vestibulum and the 4 quadrants were treated one by one after being dried in compressed air. The time required per visit was approxi-

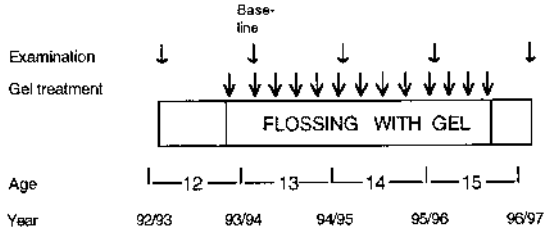

Fig. 1. Design of the study.

Table 1. Ingredients of the 3 gels used in the study.

1% NaF gel	Sodium fluoride	1 g
	Methyl cellulose	3 g
	Peppermint oil	20 mg
	Polysorbate 20	10 mg
	Sodium saccharine	20 mg
	Methyl parahydroxy benzoate	0.1 g
	Purified water to 100 g	
1% SnF_2 gel	Stannous fluoride	1 g
	Hydroxyethyl cellulose	0.4 g
	Glycerol, max. 0.5% water to 100 g	
Placebo gel	Methyl cellulose	2 g
	Peppermint oil	20 mg
	Polysorbate 20	10 mg
	Sodium saccharine	20 mg
	Methyl parahydroxy benzoate	0.15 g
	Purified water to 100 g	

mately 10 min. The gel treatment of the 280 children was carried out by 3 dental nurses, and every nurse treated children from all the groups.

The ingredients of the gels are given in Table 1. The different gels were marked 1, 2, and 3, and the study was carried out double-blind. All gels were manufactured and packed in identical bottles by Apoteksbolaget AB (Stockholm, Sweden). New gel was made throughout the study, and it was never more than 6 months old. The code was not broken until all caries data had been analyzed.

Diagnosis of approximal caries and fillings

A first registration of approximal caries was carried out in January/February 1992/1993, when the children were 12 years of age (Fig. 1). Bitewing radiographs were then taken in all children except 10 (thus, $n = 270$) in whom approximal caries lesions were judged not to be present. The baseline examination, when the children were 13 years old, was carried out in January 1993/1994. At this time, i.e. in January 1993/1994, the children had thus been treated 1–2 times with the gel, since the treatment started in October the year before (Fig. 1). All children were examined with bitewing radiographs at 15 and 16 years of age, and most of them at 14.

Approximal caries (DS = decayed surfaces) and fillings (FS = filled surfaces) from the distal surface of the canines to the distal surface of the second molars, i.e. altogether 36 surfaces per child, were diagnosed on the bitewing radiographs by one of the authors (H.G.).

Caries lesions in enamel, including those just passing the enamel-dentin junction, were defined as "initial caries lesions" (DS_i). Lesions which clearly reached into the dentin were defined as "manifest caries lesions" (DS_m). This distinction corresponds to lesions in enamel ($D_1 + D_2$) or dentin (D_3) according to recommendations issued by the Swedish National Board of Health and Welfare (4). The few approximal caries lesions and fillings in the front regions were obtained from the annual records of the Public Dental Clinic in Eslöv and were based on clinical examinations by the 11 different dentists who treated the children.

Statistical methods

Differences between means in the 3 gel groups were tested by analysis of variance (ANOVA) followed by Scheffe's test. The Kruskal-Wallis test was used to compare the distribution of caries lesions and fillings in the different groups. The chi-squared test was applied for assessing the differences in distribution of individuals. $P < 0.05$ was considered statistically significant.

Ethical considerations

The study was approved by the Ethics Committee at Lund University and the Swedish National Board of Health and Welfare, Drug Division, Uppsala, Sweden.

Results

Baseline data

Table 2 gives the prevalence data of caries on approximal tooth surfaces at 12 ($n = 270$) and at 13 years of age ($n = 280$). The mean number of DFS_{i+m} in the SnF_2 gel group was slightly less (0.89 ± 1.24) than in the placebo gel group (0.95 ± 1.67) and the NaF gel group (1.24 ± 2.52) at 12 years of age; the differences between the 3 groups were not statistically significant. One year later, i.e. at the baseline registration, the mean values of

Table 2. Prevalence of caries, expressed as DFS_{i+m} including both initial and manifest lesions, and of fillings (FS) on approximal tooth surfaces (mean ± SD) at the first registration at 12 years and the baseline examination at 13 years of age. The proportions (%) of children with $DFS_{i+m} = 0$ and FS = 0 are also given

	NaF		SnF_2		Placebo	
	12 ($n = 92$)	13 (n = 97)	12 ($n = 81$)	13 ($n = 85$)	12 ($n = 97$)	13 ($n = 98$)
DFS_{i+m}	1.24 ± 2.52	2.54 ± 3.78	0.89 ± 1.24	2.01 ± 2.89	0.95 ± 1.67	2.67 ± 3.40
$DFS_{i+m} = 0$	57%	35%	58%	44%	64%	38%
FS	0.04 ± 0.41	0.13 ± 0.53	0.06 ± 0.45	0.08 ± 0.47	0.07 ± 0.39	0.11 ± 0.45
FS = 0	99%	92%	98%	95%	96%	93%

Table 3. Caries incidence on approximal tooth surfaces (expressed as new DFS_{i+m}) during 3 years (from 13 to 16 years of age). The number of individuals with 0, 1–5, 6–10 and >10 new DFS_{i+m} and the mean ± SD are given. Besides, DFS_{i+m} is separated in its components (DS_i, DS_m, and FS)

New DFS_{i+m}	NaF ($n = 97$)	SnF_2 ($n = 85$)	Placebo ($n = 98$)
0	39	41	31
1–5	35	30	41
6–10	17	10	14
>10	6	4	12
Mean	2.78	2.42 — * —	3.98
SD	± 3.73	± 3.42	± 4.63
DS_i	2.26 ± 3.24	2.07 ± 3.18— * —3.48 ± 4.31	
DS_m	0.12 ± 0.79	0.06 ± 0.42	0.12 ± 0.85
FS	0.40 ± 1.18	0.29 ± 0.75	0.38 ± 1.19

* $P < 0.05$.

DFS_{i+m}were more than doubled in all 3 groups ($P < 0.001$), but no statistically significant differences were revealed between the various groups. At the age of 12, 97% of the children had no approximal fillings and 60% had neither initial nor manifest caries lesions. The corresponding figures for the 13-year-olds were 93% and 39%, respectively.

Caries incidence

The distribution of children developing 0, 1–5, 6–10 and >10 new approximal DFS_{i+m}in the 3 groups is given in Table 3. The greatest proportion of children who did not develop any new caries lesions during the 3-year period was found in the SnF_2 group (48%), followed by the NaF group (40%), and the placebo group (32%); the difference between the SnF_2 group and the placebo group was statistically significant ($P < 0.05$). There were also more children developing >10 new caries lesions in the placebo group than in the other two groups. The mean caries incidence was significantly lower in the SnF_2 group than in the placebo group (2.42 vs 3.98; $P < 0.05$). The percentage reductions of approximal caries compared to the placebo were 30% and 39% in the NaF and SnF_2 groups, respectively.

When increment of DFS_{i+m} is separated into its components DS_i, DS_m, and FS, the DS_i accounted for the greatest part of the index in all 3 groups (Table 3). The incidence of fillings (FS) was higher than the incidence of manifest caries (DS_m). The only significant difference between the 3 groups was for DS_i in the SnF_2 group compared to that in the placebo group (2.07 vs 3.48; $P < 0.05$).

In Fig. 2, the yearly caries increments in the 3 groups are illustrated by the slope of the lines. Between 13 and 16 years, almost parallel lines are noted between the NaF and SnF_2 groups. The rate of caries increment in these two groups was slower than that in the placebo group. At 14, 15, and 16 years of age, the caries prevalence was lowest in the SnF_2 group and highest in the placebo group with statistically significant difference only at 16 ($P < 0.05$).

Regarding children without new approximal caries lesions during the 3-year period, 65% of the initially caries-free children in the NaF (22/34) and SnF_2 (24/37) groups did not develop any new caries lesions, compared to 51% (19/37) in the placebo group. The corresponding proportion of children with caries initially, but caries-free during the following 3 years, was 27% (17/63) in the NaF, 35% (17/48) in the SnF_2, and 20% (12/61) in the placebo gel group. None of these differences was statistically significant.

Discussion

The flossing technique used in this study has earlier been evaluated in teenagers and pre-school children (1, 2). The method is simple to perform and can easily be carried out by a trained dental nurse. It does not require a professional dental chair with compressed air. Instead, the treatment can be carried out with fairly simple mobile equipment; for example, at a school. This will save the time of the children and the dental staff. The method was well accepted by the teenagers. They came regularly every 3rd month and few appointments were canceled; when all 3 groups were combined, 63% of the children were treated 12–13 times and another 32% 10–11 times.

Flossing with fluoride gel 4 times a year resulted after 3 years in a mean caries reduction of 30% in the NaF group and 39% in the SnF_2 group compared to the placebo group. This effect is of the same magnitude as that (42%) obtained after flossing with 1% chlorhexidine gel for 3 years (1). In the NaF and SnF_2 groups, 40% and 48% of the children, respectively, did not develop any new caries. Moreover, 65% of the children caries-free at baseline in the NaF and SnF_2 groups remained caries-free. In the

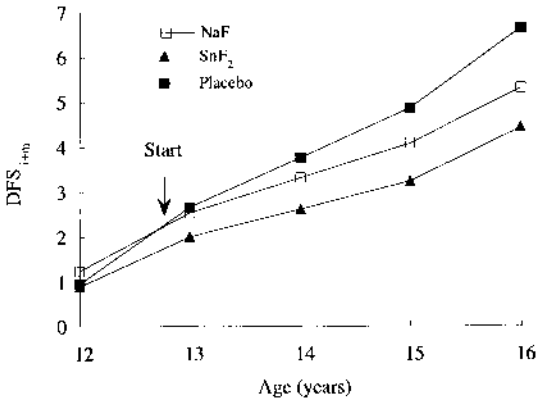

Fig. 2. Approximal caries incidence in the 3 gel groups.

chlorhexidine gel study (1), 44% did not develop any new caries and 64% of the children caries-free at baseline remained caries-free. Thus, the similarities in the caries-reducing effect between gels containing 1% NaF, 1% SnF_2, or 1% chlorhexidine are obvious.

The approximal caries incidence, including initial lesions, in the present study was rather high. In the placebo gel group, for example, the number of new DFS_{i+m} was on average 1.3 per year, and 27% of the children developed ≥ 2 new lesions. When the children were 16 years old, the mean caries prevalence, expressed as DFS_{i+m}, was between 4.4 and 6.7 in the various groups. The incidence of manifest decay (DS_m), however, was fairly low compared to the incidence of fillings (FS), since filling treatment as a rule follows the diagnosis manifest caries. Consequently, the difference between the DFS_m indices of two consecutive examinations reflects the incidence of manifest caries. The mean number of new DFS_m was in the range 0.4–0.5 in the 3 groups during the 3 treatment years, or about 0.15 new manifest caries lesions a year as a mean; 79% of the children did not develop any new manifest lesions, and only 6% showed >2 new lesions. Thus, if the caries incidence is expressed as new DFS_m, the situation is quite different than it is when DS_i is included.

The flossing program with fluoride gels in this study was carried out 4 times a year. It may therefore be of interest to compare the caries-reducing effect with that of other professional preventive programs also including 4 applications a year. Several studies have been carried out with the fluoride varnish Duraphat, with an overall caries reduction of 38% in permanent teeth (5). When Duraphat was applied 4 times a year, a caries reduction of around 36% on approximal tooth surfaces was reported (6), which is in agreement with the fluoride gels in the present study. The treatment time with the flossing technique and varnish application is fairly similar, roughly 10 min per visit. Professional flossing with fluoride gels should therefore be considered as an interesting alternative to fluoride varnish application for preventing approximal caries in teenagers.

On comparing the two fluoride gels, there was a tendency for a better caries-reducing effect of SnF_2 than of NaF. This may depend on the fact that SnF_2 is more bactericidal than NaF at the same fluoride concentration. Thus, considerably lower concentrations of SnF_2 are required to suppress mutans streptococci in vitro (7–9). Similar results have been found in vivo (10–15). The improved antibacterial effect of SnF_2 could perhaps be ascribed to the metal component, which appears to play a major role in its bactericidal effect (10). It should be remembered, however, that the difference in caries reduction in the present study between the treatment with 1% NaF gel and 1% SnF_2 gel was rather small (around 9%), and no statistically significant difference was found between the two gels.

A control group without any gel treatment was not included in the present study. Thus, the placebo gel group was influenced by the flossing. This may have caused periods with less plaque as well as positive changes of the microflora with respect to dental caries. This is supported by studies showing that mechanical removal of plaque has resulted in short-term reductions of mutans streptococci (15–17). This could mean an increased remineralization of the tooth surfaces. In the flossing study with chlorhexidine gel (1), a control group without any gel treatment was also included. These children developed on average 17% more caries during 3 years than the children in the placebo gel group. It is therefore probable that the differences in caries reduction in both the NaF and the SnF_2 groups in the present study would have been higher compared to a control group without flossing 4 times a year.

To conclude, this study showed that professional flossing with 1% NaF or 1% SnF_2 gel, carried out 4 times a year, may be considered an interesting caries-preventive method for large-scale application in schoolchildren.

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