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Prevalence of dental fluorosis in children taking part in an oral health programme including fluoride tablet supplements from the age of 2 years

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Aim. To investigate the prevalence of dental fluorosis in children who had participated in an oral health programme between the ages 2–5 years, including fluoride tablets from the age of 2 years.
Design. The study group consisted of 135 10- to 11-year-old children who had participated in the programme, including parent education, tooth-brushing instruction and prescribed fluoride tablets (0.25 mg NaF) (2–3 years: 1 tablet/day; 3–5 years: 2 tablets/day). The prevalence of dental fluorosis in the study group was compared with that in a nonintervention reference group consisting of 129 children of the same ages. The analysis was based on photos of the permanent maxillary front teeth using the Thylstrup & Fejerskov (TF) Index.
Results. No statistically significant difference in prevalence of dental fluorosis was seen between the two groups. Forty-three percent of the children in the study group and 38% in the reference group had fluorosis, the majority of a mild nature (TF-score 1). None had a TF score above 2. The pattern was the same after correction for parent reported intake of tablets at 3 and 5 years of age.
Conclusion. Introduction of fluoride tablets at the age of 2 years did not result in increased prevalence of dental fluorosis.

Introduction

It is generally recognized that the use of fluorides has contributed substantially to the decline in dental caries in industrialized countries. In addition to fluorides in the drinking water (natural or fluoridated), fluorides can be administered by the patient in the form of toothpaste, mouth rinse or tablets for example, and by professionals in the form of varnishes or gels. However, for the individual as well as in population based preventive programmes, the caries controlling qualities of fluorides have to be balanced against the risk of inducing dental fluorosis.

Dental fluorosis is hypomineralization of the enamel resulting from exposure to fluorides during tooth formation. For the aesthetically important maxillary permanent front teeth the first years of life are critical for development of fluorosis and susceptibility in these teeth is reported to be highest during the first 24–30 months of life[1,2].

McDonagh *et al.*[3], in a systematic review of studies on water fluoridation reported a dose-dependent increase in dental fluorosis and the pooled estimate of prevalence of fluorosis at 1 ppm water fluoride concentration was 48% and for fluorosis of aesthetic concern 12.5%. The corresponding figures for 0.2 ppm water fluoride concentration were 23% and 6.9%. A recent Swedish study[4] reported fluorosis in 55% and fluorosis of aesthetic concern in 13.4% of children living in a naturally water fluoridated community (1.3 ppm F) and in 29% and 2.3%, respectively, in children living in a low-fluoride area (0.1 ppm). The authors suggested that the relatively high prevalence of fluorosis of low aesthetic concern may be attributable to

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the frequent use of fluoridated toothpaste from young age in the study areas. Recent findings, however, indicate that the risk of inducing fluorosis by early introduction of fluoridated toothpaste is lower in high caries risk-deprived communities than in less deprived communities[5].

Rosengård is a multicultural, low socio-economic urban area in Malmö, Sweden, with a high prevalence of early childhood caries and low fluoride content in the piped water supply (≈0.2 ppm)[6]. With the object of combatting the high caries situation a 3-year comprehensive oral health programme was launched, initiated at the age of 2 years and centered on diet, tooth-brushing and fluoride tablets. The parents were recommended to brush the teeth of the child twice daily with fluoridated toothpaste and to give the child one fluoride tablet (0.25 mg NaF) per day from the age of 2 years and 2 tablets/day from the age of 3 years. The programme significantly reduced caries prevalence, with a 47% reduction of children with dentinal caries after 1 year and a 33% reduction after 3 years when the children were 5-years-old[7,8].

The aim of this study was to investigate the prevalence of dental fluorosis in the aesthetically important permanent maxillary incisors of 10- to 11-year-old children who had participated in an oral health programme including extra fluorides in the form of fluoride tables from the age of 2 years. The null hypothesis was that no difference would be demonstrated between the intervention group and a reference group subjected to the conventional preventive care of the Public Dental Service.

Material and methods

Participants

The groups of participants consisted of 10- to 11-year-old children who had taken part in an oral health project in the suburban, low socio-economic multicultural area of Rosengård in Malmö, Sweden. Out of the 804 children in the intervention group who entered the oral health programme at the age of 2 years (born between July 1998–June 2000), 651 (81%) were still in the programme at the age of 5 years when the project was finished. Of these, a subgroup made up of all children born between July–December 1998 (n = 195) was identified for photographic assessment of dental fluorosis at the age of 10–11 years. Thirty-three of these children had moved from the area during the intermediate period and 162 children were invited to take part in this study. Twenty-seven declined participation and the study group thus consisted of 135 children.

The original reference group consisted of 238 children (born between July 1997–December 1997) and 201 of them (90%) were still in the study at 5 years of age. Fifty-seven children had moved from the area and 144 were invited for photographic assessment of dental fluorosis; 15 declined, leaving a reference group of 129 children.

The design of the intervention study, including follow-up evaluations, was approved by the ethics committee at Lund University, Sweden. For the present photographic recording of the teeth, informed consent was obtained from the child and parent.

Oral health programme

The children in both groups had been offered dental health information at their local Child Health Centers at around 1.5 years of age. In addition, all children had received preventive care and restorative treatment based on their individual needs in connection with annual appointments at their local Public Dental Clinic from the age of 3 years. In Sweden, children between the ages 3–19 years have free dental care from the Public Dental Service.

The children in the study group had taken part in the intervention programme starting at the age of 2 years with tooth-brushing training and diet counseling once every 3 months. Between the ages 3–5 years, the children were recalled semi-annually. Fluoride tablets and toothbrushes were provided free of charge. The programme was carried out by the same two specially trained dental assistants throughout the study period. Of the

participants who were still in the programme after 3 years, 96% had attended four or more and 60% all of the scheduled sessions. The study groups and the prevention programme have been described in detail elsewhere[7].

Fluoride exposure

The mean level of fluoride in the piped water supply in the area was ≈ 0.2 ppm. The standard information at the Child Health Centers includes the use of fluoridated toothpaste twice a day from the start of eruption of the first primary molar. It is recommended that the amount of toothpaste should not exceed the size of the child's little finger nail. The toothpaste available over the counter contains 1000 to 1450 ppm F. After the age of 3 years, fluoride varnish application by professionals is recommended for children with high caries risk, for a limited period. This standard routine applied to the children in both the study and reference groups. In addition to this, the children in the study group were prescribed fluoride tablets from the age of 2 years as one tablet daily (0.25 mg NaF) to be taken in the evening after tooth-brushing and between 3–5 years as two tablets, one in the morning and one in the evening.

When the children were 3 and 5 years information about use of fluoridated toothpaste and fluoride tablets was collected from all parents in both groups using a structured interview. All parents in both groups, except two in the reference group, reported that they used fluoride toothpaste when brushing their child's teeth. The parents of 120 of the 135 children in the study group reported that their children were taking fluoride tablets at both 3 and 5 years and 134 at the age of 3 years, but not all of them at the age of 5 years. In the reference group seven of the 129 children had taken fluoride tablets at both 3 and 5 years of age and 14 at the age of 3 years. Seventy-two parents of children in the reference group reported no intake of fluoride tablets at any age and 115 no intake at the age of 3 years but in some cases an intake at the age of 5 years. The various subgroups are presented in Table 1.

Assessment of dental fluorosis

Photographic documentation was carried out in a dental chair under standardized conditions using a Canon EOS 400D camera with a 60 mm f/2.8 macro lens and ringflash. The shutter time setting was 1/125, the aperture setting f/32 and the ISO equivalent was 100. Only ordinary room lighting was used as background lighting. Before photographing, the upper front teeth were polished with tooth polishing paste (RDA 250), rinsed with water and dried with compressed air. One photo was taken of the labial surfaces of the upper incisors by the same photographer (L.P.) with the aid of a pair of sterilized lip retractors.

Dental fluorosis was assessed on a PC with Windows XP and a 19 inch liquid crystal display (1280 × 1024) under standardized background lighting conditions. The labial surfaces

Table 1. Number and % of 10- to 11-year-old children with dental fluorosis on permanent maxillary incisors. Corrected data based on reported intake of fluoride tablets (F-tablets) at the age of 3 and 5 years.

	TF score 0		TF score 1		TF score 2	
	n	%	*n*	%	*n*	%
Study group						
F-tablets at 3 and 5 years (*n* = 120)	67	55.8	45	37.5	8	6.7
F-tablets at 3 years (*n* = 134)	77	57.5	49	36.5	8	6.0
No F-tablets at 3 and/or 5 years (*n* = 15)	10	66.7	5	33.3	–	
Reference group						
F-tablets at 3 and 5 years (*n* = 7)	5	71.4	2	28.6	–	
F-tablets at 3 years (*n* = 14)	12	85.7	2	14.3	–	
No F-tablets at 3 and 5 years (*n* = 72)	39	54.2	26	36.1	7	9.7
No F-tablets at 3 years (*n* = 115)	68	59.1	39	33.9	8	7.0

of the maxillary lateral and central incisors were examined for mineralization defects in order to distinguish between dental fluorosis and generalized or localized opacities of non-fluorosis origin. Fluorosis was diagnosed and classified according to the Thylstrup & Fejerskov Index (TF Index), as modified by Fejerskov *et al.*[9]. Only individuals with at least two fully erupted incisors were included. To be classified as fluorosis the lesions were to appear symmetrically across the midline. The highest score of a tooth was used to classify each individual.

Evaluation of the photos was carried out by two examiners (C.E. and U.S.) after an initial training and calibration session when 50 cases were evaluated simultaneously. All photos were then evaluated separately by each examiner, after which all diverging diagnoses were discussed to reach a consensus. The examiners were blinded for group affiliation. For standardization, the diagnostic plate system of Fejerskov *et al.*[9] was used at all examinations.

For statistical comparisons of differences in dental fluorosis between the groups the Chi-square test was used. Differences at the 5% level of probability were considered statistically significant. Cohen's kappa was used to study the inter-examiner variability and the intra-examiner variability (based on the consensus diagnoses) of the prevalence fluorosis per individual.

Results

At the main evaluation, 92% of all 264 individuals were uniformly classified (TF score 0 or ≥ 1) by the two examiners separately before the consensus session, giving an inter-examiner weighted kappa value of $k = 0.83$. One month after the main evaluation, 50 randomly selected individuals were re-examined using a consensus procedure identical with the main evaluation. In this group, 87% turned out to have been uniformly classified on two occasions, giving a kappa value of $k = 0.74$.

Fifty-eight (43%) of the 135 children in the study group showed dental fluorosis, as compared with 49 (38%) of the 129 children in the reference group. Fifty (37%) children in the study group had fluorosis at TF score 1 and 8 (6%) at score 2. The corresponding figures for the reference group were 41 (32%) and eight (6%). The differences between the groups were not statistically significant ($X^2 = 0.81$; $P = 0.67$). None of the children in the two groups had a TF score above 2.

Table 1 shows the number of children with dental fluorosis according to TF scores after correction for intake/no intake of fluoride tablets at the ages 3 and 5 years, based on parental interviews at these ages. A comparison of the children in the study group who were taking fluoride tablets at both 3 and 5 years of age with the children in the reference group who were not taking any tablets at all did not reveal any statistically significant differences ($\chi^2 = 0.58$; $P = 0.75$). Neither was there any significant difference between the children in the study group who were taking fluoride tablets at 3 years (but not necessarily at 5 years) and the children in the reference group who were not taking tablets at the age of 3 years ($\chi^2 = 0.25$; $P = 0.88$).

Discussion

This study reports the prevalence of dental fluorosis in 10- to 11-year-old children who had taken part in a community based oral health programme, launched in a suburban area with a low water fluoride content (0.2 ppm F) and a high prevalence of early childhood caries[6]. A major component of the intervention programme was daily intake of fluoride tablets (0.25 mg NaF) from the age of 2 years. Use of fluoridated toothpaste was reported by virtually all children in both groups of study. No significant difference in the prevalence of dental fluorosis was noted between the study group and the reference group and thus, the null hypothesis could not be rejected. This was confirmed in a supplementary analysis, correcting for a possible spillover effect of the reported intake/no intake of fluoride tablets in both groups. Thus, with the present background fluoride exposure, i.e., fluoride in drinking water and in toothpaste, the introduction of fluoride tablets at the age of 2 years did not add to the risk of developing dental fluorosis.

Early studies reported an increased risk of developing dental fluorosis after administration of fluoride tablets from early infancy[10,11]. In contrast, however, later studies found no differences in prevalence of fluorosis between children who started using fluoride supplements (drops or tablets) from birth or in the first year of life as compared with nonusers[12,13]. In this study fluoride tablets were introduced at the age of 2 years. The rationale for this was to benefit from the child's ability to chew and keep the tablet in the mouth for as long as possible to achieve maximum local caries preventive effect and at the same time, by waiting till the age of 2 years, to minimize the risk of aesthetic side effects. Since the use of fluoride toothpaste was similar in both groups, the caries reducing effect found in our previous study[7,8] may be ascribed to a great extent to the use of fluoride tablets. Apparently this was achieved without any negative effects on dental development.

In this study 43% and 38% of the children in the study and reference groups, respectively, were classified as having dental fluorosis. Conway *et al.*[14], studying children of similar ages from a nonwater fluoridated (0.1 ppm F) area in Sweden, found a prevalence of 49%. In a later study from the same area, but using a different method of analysis, the reported prevalence was 29%[4]. Although the frequency of cases of aesthetic concern was low in these studies, the overall prevalence seems to exceed previously reported prevalence figures from low fluoridated areas[3]. Macpherson *et al.*[4] point out the almost universal use of fluoridated toothpaste as the most important factor behind the comparably high prevalence of mild fluorosis in their study. This is supported by several studies indicating that the use of fluoride toothpaste constitutes a risk factor for dental fluorosis in young children, influenced by fluoride concentration and pattern of use[15–18].

In previous studies different diagnostic methods have been used, which makes comparisons with our results difficult. Still it can be noted that our prevalence figures for dental fluorosis are in the upper part of the previously reported levels. Our comparably high prevalence of mild fluorosis in both groups of study may be partly ascribed to the photographic method and the thorough polishing and drying of the target teeth before taking the photo, a procedure that discloses even very mild signs of hypomineralization. Tavener *et al.*[19] reported higher prevalence figures for dental fluorosis when using a dry photographic method as compared with a wet one and a dry method might thus lead to overestimation of clinical dental fluorosis. Still, it is not likely that the present diagnostic procedure masked a clinically significant difference in fluorosis between the study group and the reference group, as no difference in the frequency of TF score 2 was noted. In addition, the present photographic method has the advantage of allowing for blind evaluation of the material.

Macpherson *et al.*[4] described a TF score of ≥ 3 as an enamel disturbance of 'aesthetic concern'. The same cutoff point for dental fluorosis of aesthetic concern was chosen by McDonagh *et al.*[3] in their NHS initiated systematic review of dental fluorosis. In this study, all children with fluorosis scored below this level, the vast majority having a TF score of 1 and only a few a score of 2. In addition, none of the children or their parents expressed any concerns about the aesthetic appearance of the upper anterior teeth during the photo session. Thus, in spite of an overall high prevalence of dental fluorosis in this study, there was little or no aesthetic impact of the sum of the fluoride exposure. It can be added that a gradual regression of the degree of severity of these mild forms of fluorosis due to attrition and abrasion of the enamel surface can be expected[9].

In summary, this study showed that the introduction of fluoride tablets (0.25 mg NaF) at the age of 2 years did not result in a higher prevalence of dental fluorosis in the permanent maxillary front teeth of children participating in an oral health programme. Although the prevalence of fluorosis was high in both groups, possibly owing to the established practice of early introduction of fluoride toothpaste, the enamel defects were generally of no aesthetic concern.

What this paper adds

- The paper adds new information on how early introduction of fluoride supplements influence the occurrence of dental fluorosis in the permanent dentition.
- The results indicate that in areas with a low water fluoride concentration the intake of fluoride tablets from the age of 2 years has no negative aesthetic effects on the permanent front teeth.

Why this paper is important to paediatric dentists

- Introduction of fluorides for dental caries prevention in young children always involves risks of inducing negative side effects in terms of dental fluorosis. Knowledge about such risks is important and early introduction of fluoride supplements needs to be balanced against the positive caries preventive effects.

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