

FLUORIDE LEVELS AND DENTAL FLUOROSIS IN DECIDUOUS TEETH OF STUDENTS RESIDING IN KOOHBANAN, IRAN, A CITY WITH HIGH-FLUORIDE WATER AND FOOD

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SUMMARY: This study, in two parts, assessed the prevalence of fluorosis in the primary dentition of students in Koohbanan, Iran, an area with high levels of fluoride in both the water and food, and determined the fluoride content in their deciduous teeth. Part 1: A total of 272 children, 5–6-year-old children were examined and the changes in color caused by fluorosis and its severity were determined according to the Tooth Surface Index of Fluorosis (TSIF). Part 2: Twenty-three healthy teeth, canines and first and second deciduous molars, which were physiologically loose, were extracted from 11–13-year-old healthy students in Koohbanan who had the signs of grade 3 or 4 fluorosis (TSIF) on at least two permanent incisors. The crowns of the extracted teeth were dissolved in 10% nitric acid and a fluoride-specific electrode was used to measure the fluoride content of the enamel and coronal dentin. The prevalence of dental fluorosis in the deciduous teeth was 76.5% and the average fluoride content of the enamel and coronal dentin was 108.7 µg/mL.

Key words: Deciduous teeth; Dental fluorosis; Fluoride in dentin; Fluoride in drinking water; Fluoride in enamel; Koohbanan, Iran.

INTRODUCTION

Dental fluorosis (DF) is an unfavorable side effect of fluoride (F) that can blemish a beautiful smile. It results from a significant rise in the blood and teeth F concentrations following the consumption of water and food containing a high level of F during the period of tooth formation.^{1,2} The small city of Koohbanan (Kerman province, Iran) is located in a cold high-altitude region with most of the surrounding mountains having coal mines. DF of the permanent teeth among Koohbanan teenage students was first reported in 1997.³ The F levels in samples of grain, protein products, fruit, vegetables, and both drinking and agricultural water in Koohbanan have been measured⁴ together with the F intake and the urinary F excretion of 4–5-year-old children in the city.⁵ Another study was conducted to evaluate the effect of F on the intelligence quotient of 7-9-year-old Koohbanan schoolchildren.⁶ These studies have shown the prevalence and intensity of DF of permanent teeth in Koohbanan is high (93% with a mean intensity of grade III). The F content of food products varied from a very low level of 0.02 mg/kg to a high level of 8.85 mg/kg. The F content of water sources ranged from 2.36 to 3.10 mg/L. The mean F intake (1.71 mg per day) and urinary F excretion (0.41 mg per day) in preschool children were both high. The mean IQ

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scores in Koohbanan children were significantly lower than those of children in similar mountainous regions with lower F levels.³⁻⁶

Because previous studies had not been done, we examined the prevalence of DF among primary school children in Koohbanan and determined the amount of F ion in the enamel and coronal dentin of their deciduous teeth.

MATERIALS AND METHODS

Ethical approval: The research was approved by the Ethics Committee of Kerman University of Medical Sciences (Ethical code: K/89-117).

Study design: The study was in two parts. Firstly, to examine the prevalence of dental fluorosis, a cross-sectional study was done on 272 preschool (5-year-old) and first school grade (6-year-old) children. Since the city is small, all the 5- and 6-year-old children born in the city and attending nursery schools or schools were able to be examined. The examination of the teeth was done by one examiner using disposable dental mirrors and probes and a direct 100 watt light bulb in the health rooms of the nursery schools or schools. The changes in color caused by fluorosis and its severity were determined according to Tooth Surface Index of Fluorosis (TSIF), adapted for children (Table 1).⁷

Table 1. Tooth Surface Index of Fluorosis (TSIF), adapted for children, index grading scores

Grade	Description
Grade 0	Enamel shows no evidence of fluorosis
Grade 1	Enamel shows definite evidence of fluorosis, namely, areas with parchment-white color that total less than one-third of the visible surface. This category includes fluorosis confined only to incisal edges of anterior teeth and cusp tips of posterior teeth.
Grade 2	Parchment-white fluorosis totals at least one-third of the visible surface, but less than two-thirds.
Grade 3	Parchment-white fluorosis totals at least two-thirds of the visible surface.
Grade 4	Enamel shows definite discoloration that may range from light to very dark brown.

The dental surfaces examined were: the labial surfaces of upper left and lower right deciduous incisors, the buccal surfaces of the lower left and upper right first and second molar deciduous teeth. If any of the above mentioned teeth were decayed or restored, they were not considered and instead healthy teeth on the symmetrically opposite side were examined. The allocated scores for each child's teeth were recorded in his/her own check list and the average scores of the child's teeth were taken as his/her final score. After the examination, children were given oral health education and a package including toothbrushes and dental floss as an appreciation.

In the second part of the study, the F content of enamel and coronal dentin of deciduous teeth were determined. Twenty-three healthy teeth (canines, and first and second deciduous molars), which were physiologically loose and without any decay, were extracted. The teeth belonged to 11–13-year-old healthy students in Koohbanan who had the signs of grade 3 or 4 fluorosis (TSIF) on at least two permanent incisors. The teeth were cleaned of plaque and attached soft tissues. Any root left on the teeth was cut out with a disk and the crown was then immediately put into a small plastic dish containing 2 mL of 10% nitric acid to dissolve the dental hard tissue. Twenty-five mL of TISAB II (Total Ionic Strength Adjusting Buffer solution [Jeneway, England]) was then added and the volume increased to 50 mL by adding de-ionized water. A F-specific electrode [Sentek Co., England] was used to measure the F content of the enamel and coronal dentin. To use this electrode, the standard solution and related curves were first prepared. Several volumes including 5, 10, 25, 50, 100, 150, and 200 µL of the 1,000 ppm F solution were removed and poured in the balloons with 5 mL of TISAB solution then being added to each balloon. De-ionized water was added to each balloon to bring the volume up to 10 mL to give concentrations of 0.5, 1, 2.5, 5, 10, 15 and 20 µg/mL and the standard curves were plotted. After plotting the curves, 1 mL of each solution containing the dissolved tooth was removed and the amount of F ion in each solution was determined in µg/mL. This method has been used to determine the amount of F in human fluids or tissues as well as animals and plants tissues.^{4,5}

Data analysis was performed by software SPSS V.16 and the t-test and chi-squared statistical tests. Statistical significance was defined as $p < 0.05$.

RESULTS

The prevalence of DF in the deciduous teeth was 76.5%. There was no statistical significant differences between the children related to gender or age (Table 2).

Table 2. Distribution of the children in relation to suffering from fluorosis, values are N (%)

Dental status	5-year-olds	6-year-olds	Girls	Boys
With fluorosis	56 (70.0)*	152 (79.2)*	86 (72.9) [†]	122 (79.2) [†]
Without fluorosis	24 (30.0)*	40 (20.8)*	32 (27.1) [†]	32 (20.8) [†]
Total	80 (100)	192 (100)	118 (100)	154 (100)

* $p=0.0816$, [†] $p=0.0612$

The distribution of the teeth with fluorosis in relation to their position in mouth was 39% Incisors and 61% molars. 75.9% of the children that suffering from fluorosis had grade 1 of DF (TSIF, Table 3).

Table 3. Distribution of the children with fluorosis in relation to severity of fluorosis, values are N (%)

Severity of fluorosis	5-year-olds	6-year-olds	Girls	Boys
Grade 1	40 (71.4)*	118 (77.6)*	66 (76.7) [†]	92 (75.4) [†]
Grade 2	12 (21.4)*	26 (17.1)*	16 (18.6) [†]	22 (18.0) [†]
Grade 3	4(7.2)	8(5.3)	4(4.7)	8(6.6)
Total	56 (100)	152 (100)	86 (100)	122 (100)

*p=0.451, [†]p=0.151

The average of F content of enamel and coronal dentin was 108.7 µg/mL (Table 4).

Table 4. Fluoride content of enamel and coronal dentin of deciduous teeth (µg/mL [ppm])

Sample number	Fluoride content	Sample number	Fluoride content
1	130.5	13	117
2	236	14	130.5
3	64	15	75.5
4	162.5	16	75.5
5	75.5	17	110.5
6	123.5	18	54
7	95	19	91
8	67.5	20	85.5
9	130	21	154
10	110.5	22	99.5
11	54	23	190
12	67.5		
Total Average		108.7	

DISCUSSION

In this research, prevalence of DF in the deciduous teeth was 76.5% and the average of F content of enamel and coronal dentin was 108.7 µg/mL. Kukleva et al. studied children in Dimitrovgrad (Bulgaria), who drank water containing more than 1.5 ppm F, and found in the mixed dentition, that 41.41% of the children suffered from DF in the permanent teeth and 1.64% had DF in the deciduous teeth.⁸ Both our current study and a study by Masoodi³ found a higher prevalence of DF in the deciduous dentition and permanent dentitions in Koohbanan children than in the Dimitrovgrad children. The differences are likely to be due to (1) the differing amounts of F present in drinking water, (2) differing measuring systems

(TSIF versus the Dean System) and (3) the differing altitudes of the cities with some studies showing greater severity and increased prevalence of DF at high altitude.^{9,10}

A result similar to ours was reported by Ruan et al. who found, in a region of China with 7.6 ppm water F concentration, a 96.6% prevalence of DF in deciduous teeth among 7–8-year-old children.¹¹ A DF prevalence in deciduous teeth of 78%, very close to the 76.5% rate we found in Koohbanan, was reported by Loyola et al. in a study on preschool children residing in a mountainous, high-F water, region in Mexico.¹² The high altitude of the two regions in Mexico and Iran was likely to be an important factor for the high prevalence of DF in both areas. Our study found more DF in the primary molars than in the primary incisors, in agreement with the findings of Loyola et al.,¹² Ruan et al.,¹¹ Warren et al.¹³ and Levy et al.⁷

In the current study, the severity of the DF in two-thirds of the children who suffered from DF, was grade 1 (mild fluorosis) in keeping with the studies by Kukleva⁸, Ruan¹¹ and Warren¹³ who showed DF in deciduous teeth is usually mild.

Although a few studies have evaluated the F content of deciduous teeth we did not find an accessible study on the F content of deciduous teeth in association with DF. Pinkham et al. reported the F content of the permanent tooth enamel and dentin as 0.016 and 0.017 g F/100 g of ash (160 and 170 µg F/g of ash) respectively.¹⁴ Stiefel et al. conducted a study in a low-drinking water F area (0.3 ppm) and found the highest values of F in the outermost surface of the permanent teeth enamel (300 and 600 µg F/g of ash) but in the deep layers the F content was only 20–30 µg/g of ash.¹⁵ They found lower concentrations of F in deciduous teeth. Nakagaki et al. measured the distribution of F across enamel and dentin of premolars among the residents in low-drinking water F (≤ 0.1 ppm) Nagoya (Japan) and found the F content of the enamel samples was approximately 20–500 ppm while in the coronal dentin samples, it was approximately 150–800 ppm.¹⁶ Strubig et al. measured the F content in the enamel of deciduous teeth of children from areas with fluoridated drinking water (up to 1 ppm) and from a low-drinking water F area (approximately 0.14 ppm) and found that the F content in the enamel of deciduous teeth of children in the fluoridated area was twice as high as that in teeth of children from the low-F area.¹⁷ Compared to these other studies, the F content of the deciduous teeth of Koohbanan children is relatively high (54–236 ppm).

We found in the Koohbanan children that both the prevalence of DF and the F content of deciduous teeth were relatively high. Previous studies in Koohbanan have shown that the prevalence of permanent teeth DF and the accumulation of F in human tissues were also both high. Deciduous teeth can be used as a readily available source of bone for biopsy and are a biomarker for the evaluation of the exposure of human tissues to F. Deciduous teeth can be a useful tool for assessing the risk of skeletal and dental fluorosis as well as of chronic F poisoning.

Since the consumption of high-F black tea is very common in this region,¹⁸ it is recommended tea should be prepared with low-F bottled water.¹⁹

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