

## Fluoride Concentration in Saliva following Professional Topical Application of 2% Sodium Fluoride Solution

### Abstract

**Background:** Topical fluoride application in moderate and high-risk individuals and in those living in low-fluoride communities has been a common practice by dental professionals. **Objectives:** The objective of this study was to assess fluoride concentration available in saliva after a professional 2% sodium fluoride solution application (9000 ppm), and the duration of its availability to have an evidence-based practice for application. **Materials and Methods:** Two percent sodium fluoride application was carried out in 45 participants residing in a boarding school. The participants were non tea drinkers and nonfluoride users. Water fluoride of the area ranged from 0.34 ppm to 0.38 ppm. Whole mixed saliva samples were collected at baseline and various time intervals postapplication of 2% sodium fluoride solution. Fluoride in saliva was estimated using the fluoride combination electrode (Orion model 94–09, 96–09) coupled to an ionanalyzer. **Results:** IBM SPSS statistics version 23.0 was used for the analysis. Normality of the data was assessed using the Kolmogorov–Smirnov test and box plot, and it was found to be nonnormal. Wilcoxon signed-rank test was used to compare all time intervals with baseline, and statistically significant differences were observed ( $P = 0.0001$ ). Salivary fluoride according to this study showed a biphasic clearance pattern with a peak at 15 min and a rapid fall in 60 min followed by a slow, consistent decline over a 20-h period. The fluoride concentration in saliva remained elevated above baseline from 0.03 ppm to 0.076 ppm even 3 months after application. **Conclusion:** Findings of this study show that, in this population, the frequency of application should be between 2 and 3 months (four applications per year).

**Keywords:** Clearance pattern, dental practice, fluoride, saliva, sodium fluoride, topical application

### Introduction

Professional topical application of fluorides for the prevention and progression of dental caries is carried out by dentists in dental clinics at the chairside as well as in community settings with an application frequency of 2–4 times a year. Fluoride availability in the oral environment is important for the prevention and reversal of early dental caries. In communities, where water fluoridation exists the use of professional topical fluorides has been restricted to individuals who are moderate and high risk to dental caries. However, in places, where there is no water fluoridation or there is suboptimal fluoride in drinking water and due to lack of awareness, there is limited use of fluoride dentifrice, in these situations, the regular professional topical application may be considered for schoolchildren at the chairside or in a field

setting. Salivary fluoride is considered an important parameter to predict the effectiveness of topical fluoride agents.<sup>[1,2]</sup> It has been proven that low levels of fluoride 0.03–0.5 mg/L in saliva are sufficient to effectively inhibit demineralization and enhance remineralization of enamel. Cycles of demineralization and remineralization continue throughout the lifetime of the tooth constantly exposing it to at risk of developing dental caries. The preventive effect of 2% sodium fluoride solution against dental caries has been reported.<sup>[3–5]</sup> Two percent sodium fluoride solution remains in contact with teeth for a shorter duration resulting in the formation of bonds in the superficial portion of the enamel.<sup>[6,7]</sup> Maintenance of low levels of fluoride in saliva for long-term periods can control the carious lesion progression. Salivary fluoride levels in the range of 0.1–1 ppm are of clinical importance.<sup>[8]</sup> The present investigation was

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Access this article online

**Website:**  
[www.contempclindent.org](http://www.contempclindent.org)

**DOI:** 10.4103/ccd.ccd\_681\_18

**Quick Response Code:**



**How to cite this article:** Talwar M, Tewari A, Chawla HS, Sachdev V, Sharma S. Fluoride concentration in saliva following professional topical application of 2% sodium fluoride solution. *Contemp Clin Dent* 2019;10:423-7.

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carried out to assess the fluoride concentration available in saliva following a 2% NaF professional topical application and evaluate the duration of availability of fluoride in saliva post 2% NaF professional topical application to establish scientific rationale for the frequency of use.

## Materials and Methods

The study was carried out in a community setting in 45 schoolchildren of Chandigarh, aged 7–15 years. The participants were residing in the hostel accommodation of the school. They were nontea drinkers and were using a nonfluoridated dentifrice with more or less similar dietary intake. Water fluoride of the area ranged from 0.34 ppm to 0.38 ppm of fluoride. Students undergoing orthodontic treatment and those with any medical history were excluded from the study. The written informed consent was taken from the children and their parents along with permission to carry out the study from the school authorities. Two percent sodium fluoride solution was prepared by dissolving 20 g NaF powder in 1000 ml of deionized water. On the day of application, baseline saliva samples were taken early morning upon rising (without the participants eating, drinking, or brushing their teeth) before exposing the participants to the topical fluoride agent. After collection of the baseline saliva sample, the participants brushed their teeth with a nonfluoride dentifrice, had breakfast, following which the 2% NaF solution was applied. The participants were made to sit upright in a chair in daylight, isolation was done with gauze pieces, and standardized small plastic brushes with plastic handles were used for the application of 2.5 ml solution/participant. After application, the solution was left in the mouth for 4 min. After the removal of the gauze (6 per participant, 2 on the lingual, and 2 on the buccal side of the lower jaw and 2 in the buccal vestibule of the upper jaw), spitting was not permitted. The participants were instructed not to eat or drink anything for 1 h. Postapplication unstimulated whole saliva samples were collected at 15, 30, 45, 60 min, before lunch (5 h), before dinner (10 h), and early next morning, i.e., 20 h. As baseline levels of fluoride in saliva after 20 h from the commencement of the experiment had not reached, a time schedule for the saliva sample collection at weekly intervals was chosen. Saliva samples were collected at weekly intervals up to a period of 1 month (four

samples) and then after 3 months. These samples were of unstimulated saliva collected early morning from the participants upon rising. The participants were followed till the salivary fluoride levels approximated those at baseline (up to 3 months postapplication).

## Estimation of fluoride in saliva

The collected saliva samples were transported within 30 min of collection to the Department of Dentistry at PGI, Chandigarh, and stored in a refrigerator at 4°C until the analysis.<sup>[9]</sup> The saliva samples were brought to room temperature and treated with total ionic strength adjustment buffer (TISAB) III (Orion Boston, MA, USA) buffer. To 10 parts of saliva, 1 part TISAB III buffer (5 ml for 50 ml of sample) was added in a plastic vial and shaken before fluoride estimation. The addition of TISAB to saliva samples was done to liberate free fluoride ions (i.e. to break the aluminum and fluoride-ion complexes and adjust the pH between 5 and 5.5). At a pH below 5.0, H<sup>+</sup> form complexes (HF, HF<sup>2-</sup>) that interfere in fluoride estimation. Similarly, if the pH of the solution is above 7.0, there is interference by OH<sup>-</sup> ions during fluoride estimation. The AMS P507 Multichannel ion-analyzer with fluoride combination electrode (Orion model 94–09, 96–09 Boston, MA, USA) was used for the estimation of fluoride in saliva samples. The instrument was calibrated in incremental order, i.e., 0.01, 0.03, 0.1, and 0.3–1 ppm with temperature remaining constant.

## Statistical analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. The normality of the data was tested at all-time intervals using the Kolmogorov–Smirnov test and box plot, and it was found to be nonnormal. All-time intervals were compared with baseline using the Wilcoxon signed-rank test, and a statistically significant difference was observed at all-time intervals compared to baseline ( $P = 0.0001$ ).

## Results

Fluoride concentration in saliva increased above baseline, with peak at 15-min postapplication [Table 1]. Salivary clearance according to this study showed a biphasic pattern with a peak at 15 min followed by a rapid fall in 1 h, i.e., 60 min and a slow consistent decline over a

**Table 1: Mean and standard deviation of fluoride concentration in saliva (ppm)**

	Baseline	Time interval of saliva sample collection post 2% sodium fluoride solution application											
		15-min	30-min	45-min	60-min	5 h (before lunch)	10 h (before dinner)	20 h (early next morning)	Day-7	Day-14	Day-21	Day-30	3-month
Number of participants	45	45	45	44	44	43	45	44	45	45	44	44	45
Mean	0.02911	0.777	0.509	0.365	0.336	0.284	0.244	0.231	0.188	0.205	0.181	0.165	0.076
SD	0.021087	0.431	0.304	0.147	0.132	0.146	0.134	0.181	0.052	0.133	0.057	0.060	0.024
Skewness	1.172	0.449	2.183	0.685	1.317	2.268	4.589	5.253	1.027	4.702	1.315	1.080	1.717
Kurtosis	0.646	-1.014	7.151	-0.641	1.546	6.906	26.247	31.582	1.538	27.857	2.184	1.339	3.086

Skewness and Kurtosis values deviate from zero which means the normality assumption is violated. SD: Standard deviation

20-h period [Figure 1]. The fluoride concentration in saliva remained elevated above the baseline from 0.03 ppm to 0.231 ppm after 20 h. A weekly follow-up was decided upon, and it was observed that fluoride concentration remained elevated to 0.076 ppm up to 3 months postapplication of 2% NaF professional topical application [Tables 2 and 3].

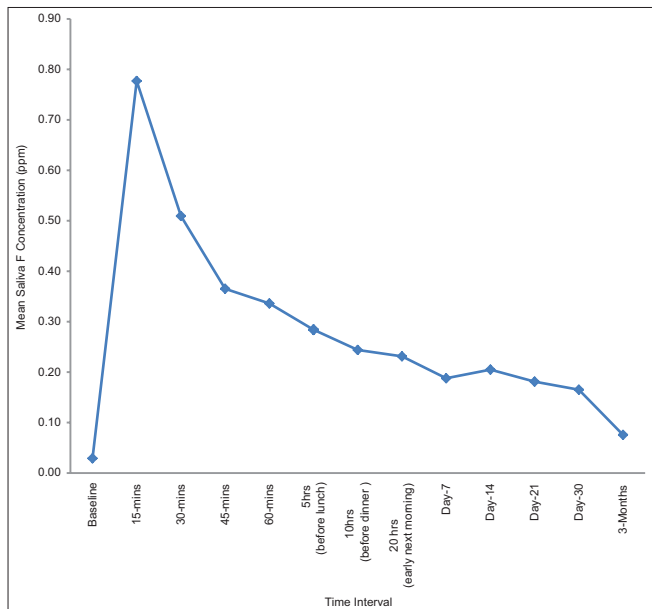
**Discussion**

Salivary fluoride levels are considered important parameters to predict the effectiveness of fluoride agents.<sup>[1,10]</sup> The preventive effect of 2% sodium fluoride solution against initial dental caries has been reported, although it remains in contact with teeth for a short duration resulting in the formation of bonds in the superficial portion of the enamel.<sup>[6,7,10]</sup> Saliva has remineralizing potential<sup>[11]</sup> that is enhanced in the presence of fluoride. Any elevation of salivary fluoride concentration may prevent enamel demineralization by increasing the degree of saturation of saliva, thereby promoting remineralization of early carious lesions. The prevention of demineralization has been observed at 0.1 ppm and at even lower levels of 0.014 ppm present

continuously for 72 h. Salivary fluoride levels in the range of 0.1–1 ppm are of clinical importance (Heintze and Petersson 1979). The increase in fluoride concentration in saliva from 0.01 ppm to 0.1 ppm, i.e., 5–10 fold increase for prolonged periods may be effective for caries control.<sup>[12,13]</sup> Saliva is an important source of fluoride for concentration in plaque.<sup>[2,14]</sup> Salivary fluoride concentration shows a biphasic clearance pattern, an initial rapid phase lasting 60 min followed by a slower decline. Similar findings have been reported by (Duckworth and Morgan 1991) following fluoride dentifrice use.<sup>[15]</sup> Findings of this study show long-term fluoride retention compared to other studies which have been carried out in fluoridated communities. A possible explanation for this is that plaque binding sites are occupied by fluoride ions largely in communities with fluoridated water but not where water contains only traces of this ion.<sup>[16]</sup> The gradual increase in the salivary fluoride concentration may be due to a reservoir effect. Soft tissues such as oral mucosa, tongue, and plaque take up fluoride where it is bound and is released in ionic form during lowering of the pH.<sup>[2]</sup>

Socioeconomic status, patient education, diet, periodic clinical examination, community where the patient resides, water fluoridation and use of fluoride dentifrice all affect the caries preventive plan and prescription.<sup>[17]</sup> Dental caries was recorded for these participants according to Moller’s index 1966<sup>[18]</sup> (PGI modification), no radiographs were taken. The severity was based on  $\geq 4$  open carious lesions (Grade 3, 4, and 6) + 11 decayed, missing and filled surfaces (DMFS) + defts-high caries activity  $n = 8$  participants;  $\geq 2-3$  open carious lesions (Grade 3, 4, and 6) or  $\geq 5$  DMFS + defts moderate caries activity  $n = 23$  participants; and  $\leq 1$  open carious lesion (Grade 3, 4, and 6) or  $\leq 4$  DMFS + defts low caries activity  $n = 13$ ; no caries  $n = 1$ .

Considering that, out of 45 participants, 31 (8 + 23) participants belonged to the high and moderate caries activity for this population, the recommended application of 2% NaF solution is every 2–3 months, approximately 4 times a year. Certain population groups who do not have access to regular dental care may benefit from topical fluoride application even in a field setting in the community.



**Figure 1: Clearance curve of fluoride postapplication of 2% sodium fluoride solution**

**Table 2: Assessment of normality of the data (Kolmogorov–Smirnov test)**

	One-sample Kolmogorov–Smirnov test													
	Baseline	15-min	30-min	45-min	60-min	5 h (before lunch)	10 h (before dinner)	20 h (early next morning)	Day-7	Day-14	Day-21	Day-30	3-month	
Number of participants	45	45	45	44	44	43	45	44	45	45	44	44	45	
Kolmogorov-Smirnov Z	1.792	0.894	1.964	1.074	1.014	1.211	1.424	1.707	0.866	1.670	1.039	0.878	1.079	
P	0.003*	0.401	0.049*	0.199	0.255	0.106	0.035*	0.006*	0.442	0.008*	0.231	0.423	0.195	

\*Statistically significant at  $P < 0.05$  level

**Table 3: Comparison of fluoride concentration in saliva at various time intervals postapplication of 2% sodium fluoride solution with baseline (Wilcoxon signed-rank test)**

	<i>n</i>	Mean rank	Sum of ranks	Wilcoxon signed ranks test	<i>P</i>
15 min versus baseline					
Negative ranks	0	0.00	0.00	5.841	0.0001***
Positive ranks	45	23.00	1035.00		
Ties	0				
30 min versus baseline					
Negative ranks	0	0.00	0.00	5.841	0.0001***
Positive ranks	45	23.00	1035.00		
Ties	0				
45 min versus baseline					
Negative ranks	0	0.00	0.00	5.777	0.0001***
Positive ranks	44	22.50	990.00		
Ties	0				
60 min versus baseline					
Negative ranks	0	0.00	0.00	5.777	0.0001***
Positive ranks	44	22.50	990.00		
Ties	0				
5 h versus baseline					
Negative ranks	0	0.00	0.00	5.712	0.0001***
Positive ranks	43	22.00	946.00		
Ties	0				
10 h versus baseline					
Negative ranks	0	0.00	0.00	5.841	0.0001***
Positive ranks	45	23.00	1035.00		
Ties	0				
20 h versus baseline					
Negative ranks	0	0.00	0.00	5.777	0.0001***
Positive ranks	44	22.50	990.00		
Ties	0				
Day 7 versus baseline					
Negative ranks	0	0.00	0.00	5.841	0.0001***
Positive ranks	45	23.00	1035.00		
Ties	0				
Day 4 versus baseline					
Negative ranks	1	1.00	1.00	5.83	0.0001***
Positive ranks	44	23.50	1034.00		
Ties	0				
Day 21 versus baseline					
Negative ranks	0	0.00	0.00	5.777	0.0001***
Positive ranks	44	22.50	990.00		
Ties	0				
Day 30 versus baseline					
Negative ranks	0	0.00	0.00	5.777	0.0001***
Positive ranks	44	22.50	990.00		
Ties	0				
3 months versus baseline					
Negative ranks	2	1.50	3.00	5.808	0.0001***
Positive ranks	43	24.00	1032.00		
Ties	0				

\*\*\*All values were highly significant at  $P < 0.0001$  level

## Conclusion

Clinical practice in preventive dentistry should be based on evidence. Findings of this investigation in the population

studied suggest that scientific rationale of frequency of application of professional topical 2% sodium fluoride solution is between 2 to 3 months which is 4 applications yearly.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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