Chapter

# The Use of Fluoride for Enamel Caries Management in Infants

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## Abstract

The presence of one or more decayed surfaces (cavitated or non-cavitated), lost or restored (due to caries) in any primary tooth in a child under 6 years old is considered Early Childhood Caries (ECC). Therefore, as soon as an initial enamel caries lesion is detected in a primary tooth, adequate measures must be adopted to halt the progression of this lesion into a cavity. To achieve this objective, fluoridated products are the most common resource, being available worldwide. Considering the age group, the use of fluoridated toothpaste and fluoride varnishes are indicated as simple and effective preventive and therapeutic methods. This chapter will discuss the advantages of these methods based on contemporary scientific evidence, as well as their expected clinical results when properly indicated and used.

**Keywords:** fluorides, toothpastes, fluoride varnishes, infants, dental caries

## 1. Introduction

It is expected that more than 530 million children around the world have untreated caries lesions, with the largest number of these lesions concentrated at the age of 5 years old [1]. These lesions are the clinical sign of Early Childhood Caries (ECC), defined as "the presence of one or more decayed surfaces (cavitated or non-cavitated), lost or restored (due to caries) in any primary tooth in a child under 6 years old" [2]. Specifically, in America, data from a systematic review showed a 48% prevalence (CI 95% 42–54) of ECC [3].

Therefore, any clinical evidence of disease activity in babies may be classified as ECC, since a white spot can evolve to cavitation. So, different strategies must be adopted, which include effective procedures for controlling lesions in their different stages of development. Ideally, this disease management should occur before cavitation, preventing the need for restorative treatment and maintaining the integrity of the dental structure.

Considering current knowledge about cariology, the treatment can be done through non-invasive procedures and carious lesions can be controlled before cavitation (primary prevention) [2]. These procedures offer the patient a "friendly"

treatment for the child and tooth that prevents further loss of tooth structure, associating home care performed by parents/caregivers with in-office professional care. The aim is to adapt hygiene and diet to control the dysbiosis responsible for dental demineralization, associated with non-invasive methods to remineralize active lesions.

The prevention and treatment of caries disease involve the use of fluoride, which is a substance that interferes in demineralization-remineralization dynamics (DES-RE process). Therefore, fluoride is considered "a therapeutic agent that acts by controlling the beginning and development of caries lesions from the pre-cavitated stage of lesions formation" [4]. After topic application, the fluoride may be present in 5 different sites in the mouth: (1) biofilm and saliva; (2) incorporated into hydroxyapatite crystals into fluorapatite-like crystals; (3) enamel fluid; (4) adsorbed into hydroxyapatite surface, and (5) in the form of calcium fluoride (CaF2) [5]. Furthermore, its action is based on the constant presence of fluoride in the mouth, acting to reduce the demineralization and favoring the remineralization of the tooth. Therefore, the benefit is achieved by local and not systemic action [5], which is why oral fluoride supplementation is not recommended.

The fluor may be administered collectively to the population (fluoridation of public water supply, fluoridated salt, fluoridated milk), individually for self-application (fluoridated toothpaste, fluoridated solutions for mouthwashes), and exclusively for professional use (gels, foams, varnishes, slow-release devices, and fluoride-releasing restorative materials).

The use of fluoride agents in children and adolescents was analyzed by different systematic reviews, and it was concluded that toothpastes [6], fluoride mouthwashes [7], fluoride gel applications [8] and fluoride varnishes [9] are effective in reducing the incidence of caries.

Notwithstanding, not all forms of fluoride administration may be used in babies, safely, for prevention and caries treatment. Despite the patient's risk, fluoridated water and fluoridated toothpaste should be a constant in the baby's daily life. However, additional methods should only be indicated by a professional if an imbalanced condition is present in the baby's oral cavity. Fluoride gels, foams, and mouthwashes are not indicated for use in babies due to the possibility of inadvertent ingestion of the product.

Therefore, in this chapter, the discussion is focused on fluoride toothpaste, the main individual method, and fluoride varnishes, the main professional method, for the use of fluoride in infants.

## 2. Fluoride toothpaste

The understanding that caries is a biofilm-dependent disease can justify that toothbrushing is an essential process to control dental caries, using the association of systematic disorganization of the biofilm (toothbrushing) with daily topical application of the fluoride present in the toothpaste.

Strong evidence supports the use of fluoride toothpaste for caries prevention [10] with a minimum concentration of 1.000 ppm of Fluor [6]. This protocol was recommended in the Bangkok Declaration to reduce the prevalence of ECC [2].

In addition to the fluoride concentration in the toothpaste, other factors can also influence the use of toothbrushing in the prevention of caries. The best results are obtained with at least two brushings a day [2], and the toothbrushing before bedtime is the most important one because there is a reduction in salivary flow during sleep. It

is also advisable not to rinse with water after brushing, as it may reduce the amount of fluoride in the oral cavity.

### 2.1 Fluoride toothpastes and acute toxicity

The probably toxic fluoride dose is 5.0 mg F/kg of body weight. Therefore, a 2-year-old child weighing approximately 12 kg would only be at risk of acute toxicity if he/she ingests 60 g of fluoride toothpaste with a concentration of 1.000 ppm F, which is more than the whole amount in a tube of toothpaste commonly sold (50 mg) [11]. So, although it is a possibility, it is a quite remote one. Conversely, chronic toxicity (fluorosis) occurs more frequently and it is what will be discussed below.

### 2.2 Fluoride toothpastes and fluorosis

Children under 5 years old have not yet developed the expectoration reflex and they swallow most of the fluoride in the toothpaste used during toothbrushing. For this reason, for a long time, fluoridated toothpaste and fluoridated water were considered responsible for the prevalence of fluorosis, and the recommendation was to use fluoride-free toothpaste for babies [12].

Currently, the importance of fluoride toothpaste in daily oral hygiene procedures is known, but the dose used in each brushing must be controlled (**Table 1**), since the amount of toothpaste swallowed is inversely proportional to the child's age and directly proportional to the distribution of toothpaste in the toothbrush [14].

The use of fluoridated dentifrices in babies is based on the concept that the benefit in controlling dental caries is obtained with a minimum risk for the development of fluorosis. There is a "window of susceptibility" for the occurrence of dental fluorosis, which is the period that coincides with enamel formation. For most permanent teeth,

| Age | Weight | Erupted Teeth | Amount of toothpaste per brushing | Amount of soluble fluoride per brushing | Daily dose to 2 brushes | % limited dose* |
|---|---|---|---|---|---|---|
| 1 year | 10 kg | 4–8 incisive | 0,05 g like a half-rice grain  | 0,055 g | 0,011 mg F/kg/day | 16% |
| 2 years | 12,5 kg | All the incisives | 0,1 g like a rice grain  | 0,11 g | 0,0176 mg F/kg/day | 25% |
| 5–6 years | 20 kg | All primaries teeth | 0,3 g like a pea grain  | 0,33 g | 0,033 mg F/kg/day | 47% |

** Adapted from [13].*

**Table 1.**
*Use of fluoride dentifrices with 1.100 ppm in the first years of life and the risk of dental fluorosis.*

this occurs in the first 6 to 8 years of a child's life, with the exception of permanent incisors, when it corresponds to the first 3 years of a baby's life [15]. Therefore, since the birth of the first deciduous tooth, when brushing with fluoridated dentifrices is implemented, until approximately 8 years old, constant supervision is important to minimize swallowing while maintaining effective exposure to fluoride. Using the correct amount of toothpaste on the toothbrush, even if it is ingested (which is common in babies), the daily limit of systemic fluoride needed to develop fluorosis is not reached (**Table 1**).

Association with additional sources of fluoride like fluoridated water, may result in levels capable of causing fluorosis. However, it has been observed in most of the studied populations that if fluorosis develops, it is very mild, with little importance for the esthetics and quality of life of patients [16].

An important advice during this step is to guide parents/caregivers about the correct amount of toothpaste in each brushing according to the baby's age group. Often, the description used by the dentist may not be correctly interpreted by parents/caregivers, as demonstrated in a recent study [17]. These parents/caregivers tend to use larger amounts of toothpaste as the baby grows. Also, they tend to use significant variations from the ideal portion, which may interfere with the preventive effect of the dentifrice or have a greater influence on the development of fluorosis. Such observations show the importance of adequate guidance for parents/caregivers, preferably demonstrating the ideal amount with a toothbrush and toothpaste.

## 3. Fluoride varnishes

In this topic, the use of fluoride varnishes for the prevention of carious lesions and the treatment of initial lesions in enamel is discussed. This is not the first choice of dental material for the treatment of dentin lesions, but it may be considered a good treatment option for enamel lesions, mostly white spot lesions.

According to the American Dental Association (ADA), in addition to silver diamine fluoride (SDF) [18], fluoride varnishes are the only products for professional topical application recommended for use in patients younger than 6 years old [19].

The main advantages of fluoride varnishes are the prolonged contact time with the dental tissue, which favors the absorption of the ion and the formation of calcium fluoride (CaF2) reservoirs, and the possibility of using reduced amounts of the product, minimizing the possibility of ingestion and making it safer for use in babies.

The traditional formulation consists of a natural resin matrix (colophony) with a high concentration of sodium fluoride (22.600 ppm, 2.26% F- ions, or 5% NaF).

The natural resin base forms a film on the tooth surface and, once NaF is exposed to the oral cavity, it dissolves and solubilizes, forming CaF2 reservoirs. The reaction continues for periods up to 24 hours, which is favored by the contact of the varnish with the tooth, because it is time/contact-dependent. Therefore, it is recommended that patients treated with fluoride varnishes remain without brushing their teeth for different periods [20], which can vary from 45 minutes after application to 24 hours. This procedure not only increases the amount of CaF2 formed, but also favors remineralization over time [20].

### 3.1 Effectiveness of fluoride varnish for prevention and treatment of caries disease in babies

Varnishes can be applied to a specific carious lesion, where they will have a therapeutic/remineralizing effect, or to the entire dentition for a preventive effect.

Analyzing randomized clinical trials that studied the preventive effect of fluoride varnishes applied twice a year, it was observed that, in babies aged 18 to 47 months old, the preventable fraction was 31%, namely, there is 31% more chance that babies who received varnish treatment will not develop caries lesions when compared to those who did not receive the treatment [21]. On the other hand, with the same frequency of application, treatment with varnish in patients aged 2 to 5 years old had a preventive effect similar to supervised toothbrushing [22]. Systematic reviews on this topic are also available. The first one shows that the estimated preventable fraction in patients who received the application of fluoride varnish is 37% (95% CI 25–51%) when compared to placebo or no treatment and, therefore, there is a protective effect in deciduous teeth [9]. The second, considering the same comparison, found a protective effect of varnish on the tooth surface, but with questionable clinical relevance, concluding that the preventive effect of fluoride varnish is uncertain [23]. What is common in both reviews is that primary studies (those studies from which data are extracted) are at high-risk of bias or uncertain bias. Still, the preventive use of fluoride varnishes in babies is recommended by the American Dental Association (ADA) [19, 24] and by the International Association of Pediatric Dentistry [25].

There is consensus in the literature regarding the ability of varnish to remineralize enamel lesions. Among non-restorative treatments, varnish is effective [24, 26], with better results than fluoride gel [27]. In the remineralization of initial carious lesions of deciduous teeth, fluoride varnish with 5% NaF reached the level of 65.9% (95% CI 41.2–90.7%) of inactivated lesions [28]. The remineralizing capacity of varnish was also confirmed when only studies with patients with ECC (early childhood caries) were considered [29].

The vast majority of studies are performed with Duraphat (Colgate-Palmolive), which was the first fluoride varnish manufactured in the 1960s and is considered the gold standard when it comes to research. However, variations have been observed in the formulas of fluoride varnishes, with the addition of active ingredients such as tricalcium phosphate (TCP), calcium and phosphate, calcium sodium phosphosilicate (CSPS), amorphous calcium phosphate (ACP), casein phosphopeptide and amorphous calcium phosphate (CPP-ACP), xylitol, among others [30], aiming to increase the formation of CaF2 on the tooth surface and potentialize remineralization in the body of the lesion [31], in a synergistic effect with fluorine. Varnishes with 5% NaF and CPP-ACP [32] and with TCP have already demonstrated, in randomized clinical trials, greater remineralizing potential than varnish exclusively based on 5% NaF in children with ECC.

### 3.2 Application protocol and periodicity

The application of fluoride varnish is indicated for babies with high-risk or caries activity; for low-risk patients who live in regions with fluoridated water, there is no need for professional fluoride application, for these patients, only brushing with fluoridated dentifrice is recommended.

The fluoride varnish application protocol has variations according to the manufacturer's instructions. Some products require humidity for application on tooth surface

| **Sodium Fluoride-Based Varnishes** | | |
|---|---|---|
| **Product** | **% of Fluor. Other active components** | **Protocols** |
| Duraphat (Colgate-Palmolive GmbH, Waltrop, Germany)<br>  | 5%<br>Sodium Fluoride | 1. Exclusive dentist use.<br>2. Clean and dry the surface.<br>3. Apply with a brush in a thin layer on the areas to be treated. |
| Biophat (Biodinamica, Ibiporá, PR, Brazil)<br>  | 6%<br>Sodium Fluoride | 1. Prophylaxis and removal of excess moisture from the teeth.<br>2. Application with a brush in the desired areas.<br>3. Patient: do not eat solid food during the first 4 hours; do not brush your teeth 24 hours after application to avoid removing the varnish film prematurely.<br>4. It is recommended to make 2 to 3 applications with an interval of 3 to 4 days. |

| **Varnishes based on Sodium Fluoride and Calcium Fluoride** | | |
|---|---|---|
| **Product** | **% of Fluor. Other active components** | **Protocols (by fabricants)** |
| Duafluond XII (FGM, Joinvile, SC, Brazil)<br>  | 6% Sodium Fluoride<br>6% Calcium Fluoride | 1. Cleaning and drying the surface to be treated;<br>2. Product homogenization;<br>3. Application on the surface to be treated;<br>4. After 10 to 20 seconds, dry with compressed air;<br>5. Careful brushing for the first 24 h to avoid premature removal of the varnish |
| Bifluorid 12 (VOCO GmbH, Cuxhaven, Germany)<br>  | 6% Sodium Fluoride<br>6% Calcium Fluoride | 1. Clean and dry the surfaces;<br>2. Varnish homogenization;<br>3. Application on surfaces in a thin layer with a brush;<br>4. Absorption for 10 to 20 seconds and air drying;<br>5. No toothbrushing for 12 to 24 h after application |

| **Varnishes with other associated active components** | | |
|---|---|---|
| **Product** | **% of Fluor. Other active components** | **Protocols (by fabricants)** |
| Mi Varnish (GC. Tokyo, Japan<br>  | 5% Sodium Fluoride<br>CPP-ACP (1–5%) | 1. Clean and dry tooth surfaces;<br>2. Applying a thin, ever layer of varnish to the teeth using a microbrush. If there is separation between the components, homogenize with microbrush;<br>3. MI Varnish takes prey on contact with water/saliva;<br>4. Patients: avoid hard, hot or sticky foods, toothbrushing, flossing for 4 h after application. |

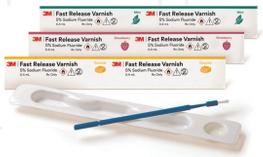
| **Varnishes with other associated active components** | | |
|---|---|---|
| **Product** | **% of Fluor. Other active components** | **Protocols (by fabricants)** |
| 3 M Fast Release Varnish (3 M ESPE Saint Paul, USA)  | 5% Sodium Fluoride Xylitol | 1. Dental brushing or prophylaxis and drying of the surfaces to be treated;<br>2. Opening the single-dose package and mixing the varnish with the applicator provided;<br>3. Application of the varnish with the applicator, forming a thin layer on the treated area;<br>4. Patient: do not brush teeth, floss, or consume hot drinks for at least 4 h after treatment. |
| Clinpro White Varnish (3 M ESPE, Saint Paul, USA)  | 5% Sodium Fluoride 5% Modified Tricalcium Phosphate (TCP) | 1. Determining the appropriate dose for the patient (application guide - 0.25 ml - primary dentition);<br>2. Cleaning the tooth surface (brushing);<br>3. Mixing the varnish;<br>4. Application of the product (in the presence of saliva without excess), in a thin layer;<br>5. Patient: close the mouth to facilitate the setting of the material;<br>6. Do not rinse or suck immediately after application;<br>7. Patient: avoid hard and sticky foods, hot drinks, toothbrushing, and flossing for at least 4 h after application. |
| Fluor Protector (Ivoclar-Vivadent)  | 1% Difluorosilane (1.000 ppm F) | 1. Dental prophylaxis and relative isolation;<br>2. Apply a thin layer with a single-use applicator and dental floss (interproximal areas);<br>3. Disperse and dry the varnish, optionally using an air syringe;<br>4. Remove insulation after 1 minute;<br>5. Patient: do not rinse mouth, eat, or brush teeth for 45 minutes. |

**Table 2.**
*Commercially available fluoride varnishes, percentage of fluoride, other active components, and protocol of use according to manufacturers.*

and others recommend drying the teeth; there are different guidelines regarding the time to restrict toothbrushing and ingestion of hard food after application. Therefore, it is essential to read the instructions before using a specific product. The application characteristics of each varnish, according to the manufacturer's recommendations, is described in **Table 2**.

As for periodicity, it is believed that the preventive effect of fluoride varnish is achieved with 2 to 4 annual applications [9]. The American Dental Association (ADA) recommends the application of varnish every 3–6 months [19, 24], and the International Association of Pediatric Dentistry (IAPD) every 3 months, in patients with high-risk of caries [25].

When fluoride varnish is used for remineralization of initial enamel lesions, there is no standard protocol in the literature. There are reports of two applications (initial consultation and after 4 months), four consecutive weekly applications, applications every 3 months, and even daily applications [27]. More frequent applications can be advantageous, accelerating the inactivation of the carious lesions. Recently, an in vitro

study confirmed this hypothesis: the use of fluoride varnish with CPP-ACP applied at 4-week intervals was more effective in remineralizing white spots than applications every 12 or 6 weeks [33]. This effect was observed in permanent teeth, but it can be extrapolated to primary teeth. Therefore, the protocol depends on the individual analysis of the patient, the clinical characteristics of the lesion, and the response obtained during the treatment.

### 3.3 Toxicity of fluoride varnishes

Even considering the high concentration of fluoride present in varnishes, the possibility of acute toxicity after ingestion of small amounts of the product is practically non-existent. The bioavailability of fluorides was studied after the application of fluoride varnishes in 5-year-old patients, concluding that, despite a transient increase in the amount of fluoride in the urine, the levels returned to normal after 48 hours and the product is safe for use in children [34]. Plasma levels are also far below from the toxic dosage [35].

The probably toxic level of fluoride corresponds to 5 mg of fluoride per kg of body weight. The approximate amount of fluoride in 1 g of fluoride varnish is 22 mg. Approximately 0.5 g of fluoride varnish is used in one application. In order to be toxic, it would be necessary that the baby ingests 4.5 g of varnish at once. Knowing that in a tube of Duraphat (Colgate-Palmolive), the varnish most used in the world, there is 10 mg of the product, the child would have to ingest half of its content at once, which will hardly happen.

The possible adverse effects of using fluoride varnish were evaluated based on 3 different clinical trials carried out with patients with ECC and whose treatment protocol included periodic applications of fluoride varnish. A total of 2.424 children aged between 0 and 5 years old were included. On average, each child received 4 treatments with fluoride varnish. No systemic alterations (nausea, vomiting, etc.) or the need for medical consultation, which could be considered as an adverse effect to the application of fluoride varnish, were reported by parents/guardians within 10 days after treatment. At the end of 3 years of follow-up, no adverse effects were related to the application of fluoride varnish [36].

## 4. Conclusion

Toothbrushing with fluoridated dentifrice is the main resource to prevent and treat white spot lesions in babies. In patients who are at high-risk of caries and during the active phase of the disease, the association with fluoride varnishes is indicated to accelerate the inactivation process of the lesions. Irrespective of the fluoride treatment selected, when correctly indicated and performed, home-based or professionally applied fluoride treatments are safe for babies and effective in controlling enamel carious lesions.

## Conflict of interest

“The authors declare no conflict of interest”.

*DOI: http://dx.doi.org/10.5772/intechopen.113204*





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