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Journal of Dental Health, Oral Disorders & Therapy

Review article
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Advances in professionally applied topical fluoride in prevention of dental caries: a narrative review

Abstract

Fluoride is a double-edged sword. The early optimum exposure during formative years yields preventive effect, however exposure beyond permissible level may exhibit discrete pitting to corroded appearance of enamel. The above review highlighted the advancements in fluoride administered topically. A critical appraisal was done of the latest findings related to the use of topical fluorides by probing through databases such as PUBMED, EBSCO and SCOPUS. Thus fluoride delivered topically should be advocated for prevention of dental caries.

Keywords: topical fluoride, dental caries and remineralisation

Volume 14 Issue 1 - 2023

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Received: January 28, 2023 | **Published:** February 28, 2023

Introduction

Dental caries being a chronic contagious disease arises from cariogenic bacteria consuming sugar producing acid which over a period of time causes chemical change in tooth structure. Dental disease being multifactorial depends on cariogenic biofilm and everyday exposure to fermentable carbohydrates acquired from diet.[1] Dental caries is a major public health concern and the unabated problem can be controlled or at least prevented by considering the application of fluoride.

Presently fluoride can be found in almost every dental product and because of its cariostatic ability dental caries is preventable. It is assumed to enhance the enamel resistance by constraining demineralization, strengthening remineralisation of developing lesions and modifying tooth morphology.[2]

Caries resistance can be attained from both topical and systemic use of fluoride; applying silver diamine fluoride and dental sealants.[3] Topical fluorides provide direct contact of fluoride with teeth as they are applied directly over teeth while systemic fluorides are incorporated into developing teeth. Post-eruptive exposure via topical fluoride has caries preventive effect.[3,4]

In 2006, the Centre for Disease Control and Prevention (CDC) and American Dental Association (ADA) recommended low-fluoride water to be used to mix infant formula to prevent the infant from excess fluoride exposure as they may develop mild fluorosis.[3]

In the year 2011 in USA, the CDC and the ADA recommended that the amount of fluoride in drinking water should be 0.7 ppm in summer and 1.2 ppm in winter.[3] However recently WHO proposed the safe permissible level of fluoride in drinking water to be 1.5 mg F(-) L(-1). Nonetheless excessive exposure to fluoride exceeding 4mgF exacerbates dental fluorosis[5]

Topical fluorides

In 2006 American Dental Association (ADA) Council presented proof -based clinical use of topical fluorides for prevention of caries. The efficacy of various topical fluorides as caries-preventive agents was evaluated.[3]

On evaluating sodium, stannous and 1.23% acidulated phosphate fluoride (APF), 2.26% fluoride varnish, 0.5% fluoride gels, 0.09% fluoride mouth rinses and 0.5% prophylactic pastes in subjects 6 years or older only 2.26% fluoride varnish was advised for children younger than 6 years.[3]

Slow fluoride releasing materials like -sodium mono fluorophosphates, silver diamine fluoride and titanium tetra fluoride were excluded from the study.[3]

Types of topical fluorides[6]

Professionally applied - these products have high fluoride concentration 5000 and 19500 ppm (5-19mg fluoride/ml) so usually dispensed by dental professionals.

Self-applied- these products have low fluoride concentration 200 to 1000 ppm (0.2-1.0mg fluoride/ml) so can be dispensed by patient himself but under advice of the dental specialists. Nevertheless fluoride paint-on-solutions have greater concentrations of fluoride ranging from 5000 ppm to 12,300 ppm[7] (Table 1).

Table 1 Types of topical fluorides

Professionally applied topical fluorides	2 % Sodium Fluoride
	8 % Stannous Fluoride
	1.23 % Acidulated Phosphate Fluoride
	Amine fluoride
	Fluoride containing aqueous solutions and gels
	Fluoride Prophylactic pastes
	Fluoride Foam
	Fluoride Varnishes
	a. Duraphat
	b. Fluorprotector
	c. Carex
Self-applied topical fluorides	Fluoride Dentifrices
	Fluoride Mouth rinses
	Fluoride Gels
	Fluoride Paint-On-Solutions

Professionally applied topical fluorides

Neutral sodium fluoride (Knutson technique)

Sodium fluoride is one of the topical fluoride which is used it reacts with hydroxyapatite crystal to form a product i.e., Calcium Fluoride which further reacts with hydroxyapatite to form stable fluoridated hydroxyapatite. Inhibiting caries progression it offers acceptable taste and is non-irritating to oral tissue. 2% NaF can prevent streptococcal adhesion to titanium (CpTi) and zirconia (TZP) implant abutment

surfaces. Streptococci are the primary -colonizing bacteria that are related with dental plaque formation and source of peri-implantitis by adhering to CpTi andTZP implant abutment surfaces.[8]

Sodium fluoride is prepared by adding 0.2gm of powder in 10ml of distilled water in a plastic bottle as fluoride ions in solution can react with silica of glass forming silicon fluoride reducing free active fluorides for anticariogenic activity. Usually 2% sodium fluoride with 0.9% equivalent to 9050ppm fluoride ion is used.[2] It is proposed to carry out 4 weekly applications of 2% NaF at 3,7,11 and 13 ages which brings down dental decay by 30%.

A study including school children aged 8 to 15 years visiting health and dental services in Mostar was conducted to observe the effects of topical use of 0.5% NaF on teeth. After six-month treatment it was observed that the oral health of the experimental group was improved compared to the non-interventional group.[4]

Stannous fluoride (Muhler's method)

It is considered more effective at reversing dental lesions than sodium fluoride. It is efficacious in treating white-spot lesions and counters deep fissures.[9]

Method of application: Teeth are cleaned and isolated with dry cotton rolls, and then SNF_2 is applied on all teeth surfaces with a cotton applicator. Repeated loading and swabbing done for 4 minutes, and patient is allowed to expectorate. A six-month interval is advised for next appointment, reduces dental caries incidence by 32%.

Mechanism of action: Stannous fluoride reacts with Hydroxyapatite forming Calcium tri-fluoro stannate and Tin tri-fluorophosphates, which is very useful for caries reduction. Tin hydroxy phosphate is also formed which gives metallic taste to the solution. SnF_2 is time saving due to small number of appointments. Stannous fluoride has certain limitations posing a challenge owing to metallic taste, gingival irritation and requiring preparation of fresh solution since aged solution is less effective.[6] A study evaluated the effectiveness of 8% stannous fluoride by applying topically to 226 school children. Those who received topical application had drop in DMF count by 26% than the control group.[10]

Acidulated phosphate fluoride (APF)

Method of preparation: Available as a solution or gel

For solution 20 grams of NaF is added in 1L of 0.1M Phosphoric acid and this added to 50% Hydrofluoric acid to adjust pH at 3.0 and fluoride concentration at 1.23% (known as Brudevold's Solution). The dosage of APF gel could be enhanced upto 1.5mg/g for individuals who have attained age upto 10years and for those who are highly susceptible to caries.[2] The clinical efficacy of APF has been compared with other professionally applied topical fluoride agents and it was more effective than sodium or stannous fluoride. According to Brudevold the low pH of stannous fluoride was very effective in preventing enamel dissolution by permitting faster exchange of hydroxyls with fluoride.[11] On clinical evaluation the usage of APF results in reduction in caries from by 28% to 60%.

Technique of application and mechanism of action of APF (Acidulated Phosphate Fluoride)

When APF gel is applied it results in dehydration and shrinkage of hydroxyapatite crystals followed by hydrolysis. Due to which Dicalcium Phosphate dehydrates (DCPD) an intermediate product is formed. From DCPD fluoride ions penetrate crystals forming fluorapatite.[6]

During application of APF gel the patient should be placed in an upright position and the tooth surfaces are cleaned and dry. Usually foam lined mouth fitting trays are used to load enough gelling agent. Post- applications the patients are instructed not to swallow the gel or apply pressure on trays. To evacuate excess saliva proper suction devices should be used.[6]

Advantages of APF gel

a) 2-4 applications can be applied in a year

b) No staining

c) Stable

d) Self-applicable

Disadvantages

a) Acidic and bitter taste

b) Glass can't be used as a container

c) Expensive as require more chair side time

d) According to a clinical trial, twice annual application of APF though effective in preventing caries but can lead to potential acute toxicity of fluoride in plasma in children.[12] Generally it is suggested by European Academy of Pediatric Dentistry to discourage use of fluoride gel before 6 years of age because of swallowing.

Fluoride varnish

Fluoride varnishes prolong the contact between fluoride and tooth surfaces. In 1994, the Food and Drug Administration (FDA) approved fluoride varnishes to be used as a root desensitizer and cavity liner, but did not approve it as an anti-caries agent.

Despite this, about 200 trials with more than 80,000 participants were conducted to confirm its effectiveness, in preventing dental caries in both primary and permanent teeth.[10]

Commonly used fluoride varnishes are

Duraphat (NaF): The first fluoride varnish, developed in Germany consists of 22,600ppm fluoride. The effectiveness of Duraphat in primary dentition is between 7% to 44% and 30% to 40% in permanent dentition. On the contrary it can cause transient discoloration of tooth which gets eliminated by tooth brushing.[2,13]

Floor protector (silane fluoride): Consists of 7000ppm fluoride. Contains polyurethane lacquer dissolved in chloroform and difluoro silane at concentration of 2% by weight.

Carex: Consists of 1.8% fluoride. Its efficacy is like Duraphat.

Bifluoride: This constitutes 5.6% sodium fluoride. 0.2 to 0.5 mL fluoride varnish can be applied for single use.[2]

Advantages of fluoride varnishes

They set rapidly and establish prolong contact with tooth surface. Do not require prior prophylaxis and are moisture sensitive. Nonetheless can cause stomatitis or dermatitis if the mucosa or skin of a hypersensitive individual gets exposed to varnish and are contraindicated in those distressed with ulcerative gingivitis, stomatitis and in asthamatics.[14,15]

Fluoride foam: Fluoride foam can also inhibit caries formation. It Contains fluoride concentration similar to APF gel that is 1.23% ~12,300ppm of fluoride and at same PH of APF gel.

Hardly 20% is applied for an adequate coverage of the teeth. It can also be effortlessly used in children and disabled persons as even suctioning is not required.[2]

Fluoride containing prophylactic pastes

Their contents are like dentifrices. These pastes help to replenish lost fluorides in inner layers of teeth. They also contain abrasive materials which benefit in plaque removal but may cause surface roughness.[15] An ideal prophylactic paste should cause minimal abrasion and surface roughness of dental hard tissues. We need to exercise caution while using prophylactic pastes bearing high F concentration because they may result in tooth staining, tissue damage and fluorosis.[15]

Recent advances in topical fluoride

The incidence of dental lesions has dropped over the last 25 years due to improved dental hygiene practices and more frequent use of fluoride containing products. Since water fluoridation, newer and improved fluoride products are introduced every day in the markets i.e., amine fluoride dentifrices, 0.2% sodium and 0.63% stannous fluoride mouth rinses, fluoride containing restorative products like silver diamine fluoride which is used for arresting caries according to many clinical studies. Even fluoride containing whitening products are also available. Nowadays intraoral fluoride releasing devices are used for continuous release of fluoride.[16]

Today 5% sodium fluoride varnishes are commonly used. Many clinical studies show that varnishes supply fluoride more efficiently than other topical agents due to their prolonged contact with tooth surface.[17]

In context to usage of fluoridated dentifrices, a recent comprehensive systematic review by Walsh T et al.(2019)[18] on "fluoride toothpaste" says that daily and supervised use of fluoride toothpaste prevents caries and the results were better whenever fluoridated toothpaste with 1450-1500ppm of F were used in comparison with non-fluoridated toothpaste. A 24week randomized controlled trial was conducted to evaluate gingivitis and plaque reduction, after use of an experimental non-aqueous 0.454% w/w stannous fluoride (SnF_2) dentifrice, twice daily. It was found that it prevents dental caries by enamel mineralization and gingivitis by its broad-spectrum antibiotic effect and modulation of the microbial composition of the dental biofilm[19] (Table 2).

Table 2 Effectiveness of topical fluorides in prevention of dental caries

Study	Study Design	Fluoride Vehicle	Results
Arruda AO, Kannan RS, Inglehart MR, Rezende CT, Sohn W (2012) 17	Randomized Controlled Trial	5% NaF Varnish vs Placebo	Varnish group prevented dental caries by 40% in comparison to placebo Randomized Controlled Trial
Jiang H, Bian Z, Du TMQ, Peng B (2005) 20	Cluster Randomized Controlled Trial	APF foam vs Placebo	Bi-annually applied APF decreased mean increment of DMFS by 24.2%
Flamee S, Gizani S, Caroni C, Papagiannoulis, Twetman S (2015) 21	Randomized Controlled Trial	Chlorhexidine/ thymol vs Fluoride Varnish	Incidence of dental caries was low less than <10% in both the groups however occlusal caries development was insignificant

Conclusion

Current research is recommended to evaluate the potential benefits of topical fluoride in caries prevention in future.

Acknowledgments

None

Conflicts of interest

The authors have no conflict of interest.

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Citation: Gupta S, Avasthi A. Advances in professionally applied topical fluoride in prevention of dental caries: a narrative review. *J Dent Health Oral Disord Ther.* 2023;14(1):10–13. DOI: 10.15406/jdhodt.2023.14.00587