# Paradigm Shift In Professionally Applied Fluoride Therapies For Arresting Caries: A Scoping Review

**Abstract:**
Fluoride has become an important tool in preventive dentistry. There is a scientific consensus regarding the benefit of an early optimum exposure to fluoride during the formative years of teeth, by maintaining a constant supply of low levels of fluoride, especially at the biofilm/saliva/ tooth interface in preventing dental caries. There has been an ongoing research to discover methods for enhancing fluoride effectiveness. For several years, toothpaste, mouth rinses, gels, varnishes, and other forms of fluoride treatment have been widely utilised as caries-preventive measures. The limited availability of fluoride from these agents has led to the advent of newer fluoride therapies in Pediatric Dentistry that aim to deliver fluoride over a longer period of time. The purpose of this scoping review is to highlight these advancements in professionally applied topical fluorides and to provide an insight into the paradigm shift in topical fluoride therapies that has occurred over the past decade.

**Key-words:** Topical fluorides, silver diamine fluoride, dental caries, varnishes

## Introduction:

Dental caries, a persistent dental illness, caused by cariogenic bacteria , over time causes a chemical change in the tooth structure. It is a multifactorial illness, the occurrence of which depends upon regular consumption of fermentable carbohydrates.[1] Fluoride serves as a headway in controlling this major public health concern as it can be found in almost every dental product and holds the ability to enhance enamel resistance by restricting demineralization, boosting remineralization of emerging lesions, and reshaping tooth anatomy.[2],

Fluoride can be delivered topically and systemically. Topically applied modalities can be divided into self-applied and professionally applied topical fluorides. Self-applied fluorides are typically for home use: toothpastes, mouth rinses, and gels. The amount of fluoride released during tooth brushing (for 2 minutes) has recently been assessed in a few studies.[4] There is strong evidence that daily use of fluoride toothpaste has a significant caries-preventive effect in children, compared with placebo (prevented fraction 24%), according to a recent systematic review by Twetman et al. on "fluoride toothpaste" (2002-2008). The efficacy was enhanced by dental brushing under supervision, increasing brushing frequency to twice daily, and using toothpaste with a fluoride content of 1500 ppm.[5]

Fluoride gels, foams, and varnishes with greater concentrations of fluoride and metal ion-fluoride adducts are a recent addition to the arsenal of efficient fluoride therapies.[6] A transient coating of calcium fluoride-like

| Access this article online | |
|---|---|
| Website: www.ujds.in | Quick Response Code |
| DOI: https://doi.org/10.21276/ujds.2024.10.4.13 | |

[1]MALLIKA ARORA, [2]RIYA GUPTA, [3]AAYUSHI SANGAL, [4]MOUSUMI GOSWAMI
[1-4]Department of Pediatric and Preventive Dentistry
I.T.S Dental College, Hospital and Research Centre, Greater Noida

**Address for Correspondence:** Dr. Mallika Arora
Intern
Department of Pediatric and Preventive Dentistry
I.T.S Dental College, Hospital & Research Centre, Greater Noida, U.P, India
Postal Address: A/303 Pawittra Apartment Vasundhara Enclave , East Delhi, Delhi Postal code:110096
Email: dr.mallikaaroraa@gmail.com

**Received :** 7 Nov., 2024, **Published :** 31 Dec., 2024

**How to cite this article:** Arora, M., Gupta, R., Sangal, A., & Goswami, M. (2024). Paradigm Shift In Professionally Applied Fluoride Therapies For Arresting Caries : A Scoping Review. UNIVERSITY JOURNAL OF DENTAL SCIENCES, 10(4).

substance forms on the enamel surface as a result of high fluoride levels from topical fluoride applications, serving as a fluoride reservoir. Fluoride is released gradually and can be used to remineralize enamel or impede bacterial metabolism, especially during acidic episodes caused by cariogenic bacteria.[7]

This narrative review evaluates the effectiveness of various professional topical fluorides on the prevention of dental caries in primary and permanent dentition and also discusses recent advancements and innovations on this topic.

## Search strategy:

A literature search was carried out for articles on various professionally applied topical fluoride agents using different search engines including Pubmed, Cochrane Library, Google Scholar and Research gate. Articles fulfilling the following inclusion criteria were selected for the review:

1. Articles Published between 2013 – 2023
2. Articles published in English language
3. Reviews, systematic reviews, Original researches, clinical trials and case reports

## Results and discussions:

Gels Marinho et al (2002) gave a clear evidence of caries-inhibiting effect of fluoride gels in permanent dentition with 28% reduction in decayed, missing, and filled tooth surfaces (DMFS).[8] This can be attributed to their high fluoride concentration and their stable, easy applicability and non-staining properties. Brudevold et al. has also reported that gels have an acidic pH which increases fluoride uptake by enamel and in turn increased efficacy.[9]

Various formulation of gels are available for professional use, most popular being 1.23 % acidulated phosphate fluoride (12,300 ppm) and 2% sodium fluoride (9050ppm). When APF's clinical effectiveness was compared to that of other topical fluoride therapies, it outperformed sodium and stannous fluoride. According to a clinical i[nvestigation, APF reduces dental cavities by 28% to 60%.[10] Urquhart et al. (2019) conducted a meta-analysis and stated that , 1.23% APF gel has a twofold greater probability than no fluoride therapy of ceasing or reversing non-cavitated carious lesions.[11]

Because fluoride gel is administered by a dental expert only occasionally, studies have shown that there is no possibility of dental fluorosis, even in children under the age of six.[12] However, the chances of swallowing of the gel by the child always remain, hence they should be applied in an upright position and along with suction devices. Also the child should be restrained from eating/drinking for 30 minutes post application.

## Varnishes:

The commonly used dental varnishes[3,12] in the clinical practice are:-

1. Duraphat (sodium fluoride with 2.26% F) "First Developed Dental Varnish in Germany"
2. Fluor Protector (0.9% difluorsilane with 0.1% F)
3. Bifluoride (sodium fluoride with 5.6% F)
4. Carex (sodium fluoride with 1.8%F)

Fluoride varnishes offer several advantages over gels. They set fast by coming in contact with saliva.[3,12] Additionally they have reduced chair time, less intake of fluoride by the child and prolonged contact with the tooth surface. 2.26% fluoride varnish has been advised for children below 6 years.[4] The US Preventive Task Force suggested that fluoride varnish should be applied after the eruption of the first deciduous tooth in the child's oral cavity. European Academy of Paediatric Dentistry(EAPD) also recommends fluoride varnish application 2-4 times a year in children with caries index, undergoing orthodontic treatment as well as those with special health care needs.

In 2021, Manchanda et al. in their meta-analysis concluded that the application of 0.9% difluorsilane and 5% sodium fluoride varnish application after 3 months and 6 months respectively was effective in preventing caries in deciduous teeth in the children below 6 years.[13] Urquhart et al. (2019) in their meta-analysis concluded that the combination of sealants and 5% NaF dental varnish was efficacious in reversing or arresting the lesion present on the occlusal surface of the tooth as well as 5 times more effective in arresting non cavitated carious lesions when combined with resin infiltration.[11]

## Restorative materials:

Fluoride ions have been in cooperated into a multiplicity of dental materials including glass ionomer cements (GICs), composites, compomers, giomers and pit and fissure sealants. Pit fissure, GIC, composites with fluoride. Fluoride ions are released from dental materials depending on parameters specific to each material namely composition, filler content, powder/liquid ratio, mixing method, and surface exposed to the aqueous medium well as those specific to the oral environment like application of a dental adhesive system or coat.[14-19] Kelić K et al (2020) studied the effect of adhesive systems on the fluoride releasing efficacy of different restorative materials (a giomer Beautiful II, an "alkasite" material Cention, a conventional composite Filtek Z250, and a glass ionomer cement Fuji IX Extra ) over 168 days and proved that uncoated specimens showed significantly greater fluoride release than those coated with adhesive agents. Also, fluoride release by Fuji IX Extra was significantly higher than other materials. Hence, it was concluded that the amount of fluoride released differed amongst the tested restorative materials and was influenced by the application of dental adhesives and coatings.[20]

## Recent advancements:

### A) Compounds with superior fluoride release

In a recent study by Keng-Yuan Li et al. a new light cured composite (LCC) restorative material was developed which combined the mixture of fluoridated montmorillonite (MMT) and hydrophobic 3YSZ in a Bis-GMA matrix. The material aimed to have adequate fluoride release and recharge abilities, strong mechanical properties and biocompatibility. He concluded that the resin material has a higher fluoride releasing concentration than the conventional GIC and can be used in the treatment of secondary caries in clinical practice.[21]

The recent study conducted by ZRaszewski et al. showed the use of a Bioactive Glass-Modified Methacrylate Resin used in 3-d printing technology. The material was developed by the addition of sodium fluoride or other fluoride salts, full prereacted glass-ionomer fillers (F-PRG), and surface PRG cements (S-PRG). It aimed to create a novel dental material which could yield better response in the remineralisation of the lesions developed during the orthodontic splinting. The study concluded, the material used showed a higher fluoride releasing concentration in the oral cavity which aids in the remineralisation of the enamel but a decrease in the flexural strength and higher solubility and sorption levels than the non modified material was observed.[22]

### B) Fluoride impregnated crowns[23]

Clark DR et (2013) synthesised fluoridated hydroxyapatite (FA) crystals directly on etched preformed metal crowns (PFM) in an in-vitro study and evaluated the anti-cariogenic effect of this model. Four sets of FA coated discs were subjected to solutions with a pH range of 4 to 7. After each exposure, the amount of fluoride in the solution was measured. Additionally, twenty-four caries-free extracted human molars were divide into the following four groups depending upon the material used for cementation and the crown: FA-coated PMCs + GI, FA-coated PMCs+ resin; non-coated PMCs+ GI and non-coated PMCs+ resin. For 9 weeks, teeth were exposed to gelatin that had been acidified (pH = 4.3). Scanning Electron Microscopy (SEM) was used to assess the morphological features of the crystals, including alignment, size, and form, as well as surface coverage of the crowns. On the interior and exterior of the crowns, SEM revealed considerable FA crystal growth. At pH < 5.0, the average fluoride release from FA-coated discs was 0.16 mg/L/cm2. Compared to non-coated crowns, lesions in FA-coated crowns were much smaller, as determined by polarised microscopic examination.

### C) Silver Diamine fluoride (SDF)

Silver Diamine fluoride is known to arrest caries owing to the antibacterial effects of silver and re-mineralising effects of fluoride. Bactericidal effect of silver is due its ability to interact with sulfhydryl group of bacterial proteins and interfere with bacterial metabolism by inhibiting cell wall synthesis and cell division. 38% SDF is one of the most common techniques of minimal intervention dentistry used to arrest and prevent caries in children. Remineralizing effect of SDF on dental caries can be attributed to its ability to inhibit the proteolytic activities of matrix metalloproteins, such as MMP-2, MMP-8 and MMP-9 which have a degrading effect on the dentin surfaces. Elemental analysis performed in a study reported that the concentrations of calcium and phosphorus in demineralized dentine treated with SDF were significantly higher than those of calcium and phosphorus in demineralized dentine without SDF treatment.[24,25] Besides, it also prevents loss of minerals from the demineralized tooth surfaces. Another study reported the formation of a highly mineralized zone abundant in calcium and phosphate in arrested carious lesions treated with SDF.[26]

### SDF and SMART :

SDF can be used to compliment atraumatic restorative procedures (also known as **Silver Aided ART or SMART**) thereby combining the antimicrobial effects of silver, remineralizing effects of fluoride and having the added advantage of being minimally invasive, cost effective, ease of use and good patient compliance. The silver ions present in SDF also have the potential to occlude dentinal tubules by producing calcium fluoride and silver iodide.[27] This property of SDF can be used for treating dentinal hypersensitivity and symptomatic molar incisor hypomineralization (MIH).

### SDF and Hall's Technique [28]

GA Salem et al (2022) aimed to increase the success rate of Hall's technique in carious primary molars by using it in conjunction with SDF or Laser. Study participants were divided into three groups: Application of Hall's technique (group 1), SDF with Hall's technique (group 2) and laser with Hall's technique (group 3). In group 38 % SDF was applied on the carious area prior to crown cementation. In group 3, diode laser (wavelength 970 nm) was used in continuous wave and contact mode to irradiate the tooth before crown cementation. Group 2 was found to have the highest clinical success rates (96.2%) after one year of follow-up followed by group 2 (94.3%). These results could be accredited to the antibacterial effect of SDF and its ability to inhibit glucan formation as well enzymes essential for bacterial metabolism including enolase and ATPase. Additionally, SDF promotes the occlusion of dentinal tubules by precipitating calcium fluoride, silver protein, and silver phosphate etc on the tubular orifices. These substances facilitate the development of an invisible layer, which serves as a protective barrier to stop further demineralisation.

### D)Sustained releasing fluoride devices:

The ability for controlled release systems to elevate salivary fluoride levels without substantially increasing serum and urine fluoride concentrations during the treatment period merits their preference above conventional fluoride therapies. Focusing on high-risk groups, these devices demonstrate favourable results both in vitro and in vivo with no related side effects.[29]

### Three distinct techniques:

➔Asustained F-release from tablets/capsules,

➔An aerosol system for delivering microcapsulated F,

➔F-releasing intra-oral devices.

The documented F discharge from tablets/capsules and aerosols is extremely short lived , however the F devices have been proven to substantially and consistently raise salivary F levels.

### Numerous Fluoride-Releasing Device Methods:

● **Copolymer membrane device:**

Cowsar et al. [1976] designed the shape of a membrane-controlled reservoir. It is composed of an acrylic polymer matrix coated with granulated sodium fluoride surrounding an acrylic polymer membrane. A handful of granulated NaF are diluted until the matri itself is saturated.

The device can operate precisely and reliably as a release controlling mechanism owing to the optimal water absorption. Once inside the oral cavity, the device becomes saturated via saliva and, depending on its size, begins to produce sodium fluoride at as eady rate of 0.02-1.0 mg/day for up to 4-6 months. The device's dimensions are close to 8 mm in length,3 mm wide, and 2 mm thick. It is generally spot-welded to simple, typical orthodontic bands or adhered to the tooth surface via adhesive resin to secureit to the buccal region of the first permanent molar.[0]

● **Glass device:**

Curzon designed the glass device in 1984. When the fluoride glass device gets moist, it gradually dissolves, releasing F without significantly compromising the device's integrity. The first permanent molar's buccal surface was bonded to a dome-shaped (4 mmin diameter) device with adhesive resins. Due to the lack of retention rates, it was further substantially changed to a kidney-shaped device which measured 6mm long, 2.5mm broad, and 2.3mm deep. This device demonstrated effective fluoride release as wellas retention rates.[1]n order to make handling, attachment, and replacement of the device easier, the device has more recently taken on the shape of a disc that is set inside a plastic bracket. Installation f he evice s imple, without the need to debond, remove any remaining composite resin, and do a fresh acid etch to bond the device.[9]

● **Hydroxyapatite - Eudragit RS100 diffusion controlled F-system:**

This is the recent slow-releasing F device, which incorporates hydroxyapatite, NaF, and Eudragit RS100. It is composed of 18 mg of NaF and is designed to deliver 0.15 mg of F per day. The efficacy of this device to drastically elevate salivary and urineF concentrations for a minimum of thirty days has already been proven.[2]

● **Slow fluoride release tablets for intrabuccal use:**

Formulated tablets containing 160–00 mg F were developed to be cemented to a tooth. These tablets are composed of a pure hydroxyapatite, eudragit, and/or ethyl cellulose granular matrix. Mechanical mixing or an impregnation process is employed to add NaF.[3]

### E) Intraoral fluoride releasing patches:

YarmunjaMahabala Karuna et al (2020) conducted research to develop and evaluate an intra oral fluoride releasing patch containing chlorhexidine. The efficient usage of fluoride and antimicrobial compounds like chlorhexidine,can help in strengthening the enmel and lowering the bacterial count leading to reduction in the dental caries. The study showed that a slow-releasing polymeric patch with gelatin content of 1,000 mg and concentrations of fluoride (288 mg) and chlorhexidine (80 mg) was used to demonstrae the sustained release of the medications over a 20-day period. In contrast to the glass beads and copolymer types of slow-releasing fluoride devices (Cowsar et al,1976) and slow-dissolving fluoride glass beads (Toumba and Curzon, 1993), the polymeric paches utilized were flexible and thin, better patient compliance and increased retention due to better attachment to the tooth surface. The clinical efficacy of the patch is yet to be tested in vivo.[4]

## Conclusion:

Fluoride will forever stand out as an effective treatment modality for arresting and treating dental caries particularly in the pediatric age group. Besides being minimally invasive and atraumatic, it s a quick, inexpensive ethod that oesn't require the assistance of additional complex equipment. Patient acceptability with professionally applied fluorides s quite high because there are no arduous or drawn-out procedures for the patient to undertake. This is why fluoride therapies continue o develop with new discoveries even fter more than a century of research and the use of fluoride products in linical practice. This is especially true with the development of novel fluoride-containing compounds like cariostatic SDF, restorative materials and devices. However further research and studies are still needed on this caries preventive tool in order tooptimise its use and effectiveness in pediatric dentistry.

## Limitations:

Some novel topical fluoride application techniques are yet to be used on mass populations and therefore there is no concrete evidence regarding their effectiveness.

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