

## Review Article

### Silver diamine fluoride versus fluoride varnish in preventing and arresting dentin caries in children – A review

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#### ABSTRACT:

Since there has been reduction in the prevalence and the severity of dental caries in children observed over the past few decades but still belonging to the poor socio-economic status suffering from various detrimental effects of the dental caries. There are various preventive modalities are currently being used to prevent caries. And in this review article, two agents with therapeutic caries arresting effect were extensively studied that include Silver diamine fluoride and Fluoride varnish.

**Keywords:** fluoride varnish, SDF, caries prevention, topical fluoride, cariostatic agents

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#### INTRODUCTION

Globally, Dental caries is reported to be one of the most frequent microbial infectious diseases affecting almost everything irrespective of any variables taken into account. The World Health Organization (WHO) surveyed that dental caries affect 60% to 90% of all children bearing school going age.<sup>1</sup>It is a multifactorial disease which affects children and adults leading to the demineralization of tooth structure such as enamel and further penetrating the dentin. The most common cause for dental caries are presence of endogenous cariogenic bacteria, overconsumption of fermentable carbohydrates, and a susceptible tooth like molars and host.<sup>2</sup>Though it's been found that dental caries can penetrate if left untreated, it can be prevented, reversed, or arrested during the initial stage of spread.<sup>3</sup>The new emerging philosophy for the management of dental caries is prevention and minimal intervention treatment with early detection of the lesion.

Chlorhexidine is an antibacterial agent found to prevent against dental caries. In addition to that diet and fluoride found to arrest and prevent dental caries.<sup>4</sup>Dental caries is most likely to occur at occlusal surfaces from the early eruptive stages of the tooth in children and young adults.<sup>5</sup>In children about 80% to 90% of dental caries cases are seen in occlusal

caries.<sup>6</sup>The most susceptible teeth to caries is first molars followed by second molars.<sup>7</sup>

Demineralization–remineralization cycles occur in enamel when exposed to various throughout the day. The balance between remineralization processes and demineralization processes regulates whether dental caries remain slow/static, progress, or are reversed.<sup>8</sup>

The most traditional and conventional treatment of dental caries involves mechanical excavation OR removal of infected, irreversibly demineralized tooth structure and replacing the cavity with a restorative material.<sup>9</sup>The management of dental caries basically requires an advanced skill of the clinician particularly when dental caries are present in very young children due to their restricted co-operating ability, it can pose an enigma for the clinician to excavate all the caries and provide a proper restoration.

Arrested caries treatment has been followed to manage untreated dental caries in children of disadvantaged communities.<sup>10</sup>Its been hypothesized that fluoridated agent silver-diamine fluoride's (SDF) was observed to arrest the caries process and prevent the formation of newer caries lesions simultaneously.<sup>11</sup>

Since the beginning of 21st century, SDF has found its clinical usage which has been started in China as caries arresting agent among school aged

children.<sup>12</sup> Knight et al<sup>13</sup> conducted a study in Australia did a series of in vitro studies and proved its efficacy as a caries arresting and antimicrobial agent. Moreover, numerous studies are being carried on in various parts of the world especially the various clinical implication of SDF. Hence, there is a revival of interest on this potential fluoride agent and this review article vastly explores in depth about this promising agent that include its usage as caries preventing and arresting agent in primary as well as permanent tooth.

#### **ACTION OF SILVER DIAMINE FLUORIDE MECHANISM OF ACTION OF SILVER**

There are various modes of action have been proposed for silver. Studies have shown that silver interacts with sulfhydryl groups of proteins and with deoxyribonucleic acid (DNA) which thereby altering hydrogen bonding and inhibiting respiratory processes, DNA unwinding, cell-wall synthesis, and cell division.<sup>14</sup> These interactions greatly affect bacterial killing and inhibit biofilm formation. The central mechanism for these diverse effects is forwarded to be the interaction of silver with thiol groups by the following mechanism:  $A/N - SH + AgX \rightarrow A/N - S - Ag + HX$  Where A/N represents amino (A) or nucleic (N) acids (respectively), SH represents a thiol group, Ag represents silver, and X represents an anion (in the current example, diamine fluoride). This interaction indicates how silver containing compound, might interact with bacteria and mediate caries arrest through bacterial killing and inhibit caries progress through the inhibition of biofilm formation.<sup>15</sup>

Suzuki et al<sup>16</sup> researched the mechanism of antiplaque action of diamine silver fluoride ( $Ag(NH_3)_2 F$ ). This agent displayed excellent antibacterial action against cariogenic strains of *S. mutans* (minimal inhibitory concentration, 0.12  $\mu\text{mol/ml}$ ) and completely inhibited the dextran-induced agglutination of *S. mutans* at 0.59  $\mu\text{mol/ml}$  and sucrose activities of *S. mutans* at 0.2  $\mu\text{mol/ml}$ . These effects were found to be happening as a result of the action of silver ion. These results indicate that silver ion might inhibit the colonization of *S. mutans* on enamel surface and offer a possible explanation for the antiplaque action of the agent. It was also proven that the binding of glucan to HA was inhibited by the treatment of HA with fluoride solution but was slightly promoted by that with silver solution. The adsorption of salivary proteins by HA was inhibited by the treatment of HA with  $Ag(NH_3)_2 F$ . This was due to both fluoride and silver ions. Hence, the potential to inhibit the *S. mutans* is more for SDF than any other fluoridated solution. Also, Mei et al (2013)<sup>17</sup> mentioned that 38% SDF inhibits multi-species cariogenic biofilm formation on dentin carious lesions and reduces the demineralization process. Suzuki et al<sup>16</sup> showed that after SDF application, fluoride ions penetrated the enamel diffusely to about 25  $\mu$ , whereas silver ions were mainly deposited on the

surface and some penetrated as far as 20  $\mu$  into the enamel.

#### **CLINICAL IMPLICATIONS OF SILVER DIAMINE FLUORIDE CARIES MANAGEMENT OF SCHOOL GOING YOUNG CHILDREN WITH A MINIMAL INVASION APPROACH**

Yamagaet al<sup>18</sup> has first advocated the usage of this technique among school going children in Japan. The most frequent approach to deal with dental caries is to use rotary dental handpiece, often thought of as a "drill" by patients or use sharp spoon excavators to remove the infected dentin. A difficulty for the dental practitioner particularly those who are dealing with young children, is the use of conventional rotary instrument or pressure from spoon excavator are often cited as triggering patient fear and anxiety. Since silver diamine fluoride has an ability to arrest caries, it can be considered as a useful alternative technique to deal with such young patient. Once the carious process is relatively slowed down or arrested, caries removal will be done at a later date when child's ability to rationalize fear is increased with age. Various study mentioned below supports this implication Hihara et al<sup>19</sup> in Japan and others found that SDF is significantly effective in arresting the cavitations as well as incipient carious lesions.

#### **THE ABILITY OF SDF TO ARREST CARIES IN ANTERIOR PRIMARY TEETH OF YOUNG CHILDREN**

In pre-school children, various primary teeth are attacked by caries, and a very large number of the children are reported to be diagnosed with "early childhood caries" which takes an acute course. Therefore, the management of such carious deciduous teeth involves many difficulties, so a majority of the patients are left cavitated or untreated mostly. Primary teeth not only play an important role in the normal eruption and growth of the permanent teeth, but also are essential for the growth of the jaw bone which indirectly supports the growth and development of the face. From one point of view, it might be reasonable to compromise the aesthetic factor to a certain extent, if the progress of dental caries can be arrested by the application of the solution. Previous approach to rampant caries was to remove possible carious dentin and use zinc oxide eugenol as temporary restoration. Unlikely, the pattern of caries is so irregular that zinc oxide eugenol cannot be retained. SDF can provide a better alternative for the same procedure. Moritani et al<sup>20</sup> found less caries increment in children who are receiving SDF compared with those without SDF therapy also very rare cases were observed with pain by cool or warm air or friction and that the cavities were arrested its progress. Chu, Lo and Lin<sup>12</sup> found that SDF was promptly effective in arresting dentin caries in primary anterior teeth in pre-school children in a Community-based Caries Control Program.

### PREVENT PIT AND FISSURE CARIES

Pits and fissures are more vulnerable to dental caries when compared with the smooth surface for morphological reasons. It is also cumbersome to clean pits and fissures with a toothbrush. While it is difficult to identify various incipient lesion pertaining to pits and fissures, the topical fluoride application is revealed far less effective in the prevention of the pit and fissure caries than that of the smooth surface. According to *Sato et al*<sup>21</sup> due to its antibacterial and caries preventive property SDF can be effective for the prevention of pits and fissures caries of the first molar teeth. *Nishino* and *Massler*<sup>22</sup> in their study discussed that caries score of  $\text{Ag}(\text{NH}_3)_2\text{F}$  treated teeth was significantly reduced than the fissures treated with  $\text{SnF}_2$  8% or  $\text{Ag}(\text{NO})_3$ .

### PRECAUTIONS

There has to be certain precautions that needs to be followed since there are chances of getting grayish-black and black stain at the pit and fissure by SDF may be mistaken for incipient caries in the later follow-up.

### DEMERITS OF SDF

The inherent drawback of using SDF to arrest caries is that the lesions will be stained black; therefore, some children and their parents may not be pleased with the aesthetics of this treatment outcome. It has been observed that when carious dentin was treated with SDF, silver phosphate was formed and this was insoluble.<sup>23</sup> Silver phosphate is seemed to be in yellow when it is first formed but readily turns black under sunlight or the influence of reducing agents. In order to overcome these limitations, *Knight et al*<sup>13</sup> proposed the usage of Potassium iodide after application of SDF to the tooth structure remaining free silver ions in solution will react with Potassium Iodide to precipitate creamy white silver iodide crystals. Hence, free silver ions no longer available to react with sulphur and other reagents in the mouth to form black that easily precipitates onto the teeth. Further research in this direction is still required in most instances. Additionally, SDF can stain the skin of the body and clothes. The stain caused by SDF on the skin, though not causing any pain, cannot be washed away and it takes a long time for it to be removed from the surface. If the skin or clothes have been stained the following procedure is suggested for removing the stain: (a) Wash out with running water, soap or ammonia, water if immediately after staining. (b) If the discoloration is not removed and persists that apply the solution of sodium hypochlorite or a bleaching powder (with caution in dyed cloth). SDF solution also reported to have a metallic taste which is unpleasant. Also, gingival and mucosal irritation can occur in many instances. In major cases, the damage is transient and the tissue affected mostly turns white but it will heal within 1–2 days. When the solution is to be applied to the lesions very close to the gingiva,

use a rubber dam or protect the gingiva with vaseline or cocoa butter.

### SAFETY OF SILVER DIAMINE FLUORIDE

A study based on the fluoride content of AgF observed that a sample of 40% AgF in Australia had a significantly higher concentration of fluoride than the expected fluoride level of 60,000 ppm.<sup>24</sup> The study therefore proposed that the commercially available 40% AgF in Australia was reported to be high for treatment and possessed a higher risk of toxicity leading to dental fluorosis when used on young school going children. The Dental Services on the Health Department of Western Australia, in response to the study by *Gotjamanos*, observed that they had carried out an investigation and had found no evidence to support the view that use of AgF would cause fluorosis.<sup>25</sup>

### FLUORIDE VARNISH

Fluoride applications were commonly incorporated into clinical dentistry in the 1940s in order to minimize the dental caries. Many fluoride products (such as sodium fluoride gels and stannous fluoride solutions) are aqueous agents.<sup>26</sup> A non-aqueous form of topical fluoride was further developed to promote a longer retention time of this agent onto the surface; in 1964, the literature observed that a 2% sodium fluoride lacquer in an alcoholic solution of natural resins was being used. The active ingredient of this fluoride varnish usually is 5% sodium fluoride (NaF).<sup>27</sup> There are few inactive ingredients in the varnish for flavouring in order to ensure that the fluoride sticks to the tooth surface. The most common ingredients that are usually include sodium saccharin (which is used as a sweetener), beeswax and ethanol (for the purpose of forming a gel-type structure to stabilize sodium ions) and shellac and mastic (to provide a flexible, permeable hard surface that prevents the varnish from dissolving rapidly in saliva). A flow enhancer such as kolophonium also is included in the ingredient details. Sodium fluoride varnish is advocated for moderate and high-risk children, particularly children younger than 5 years of age as well as for children who are receiving orthodontic treatment. The manufacturer of Duraphat showed that the product for preventing caries, promoting remineralization of caries and managing tooth hypersensitivity. More than 90% of the municipal caries-preventive programs in Denmark provided fluoride varnish for children up to 18 years of age. However, children who are at low risk, are caries-free, and live in a fluoridated community may not require fluoride varnish for caries prevention.<sup>28</sup>

### FLUORIDE VARNISH MODE OF ACTION

The mode of action in dental caries still is being under research, although it has been reported that the concentrated fluoride ions in fluoride varnish reported to cause globules of a calcium fluoride-like material

to form on the tooth surface. These globules are stabilized by protein phosphate in the mouth and act as an insoluble reservoir of fluoride at neutral pH. When there is a cariogenic challenge such as sugar consumption, the pH is lowered and the dissolution rate of these globules increases. This response lowers the solubility constant of calcium and phosphate ions, releasing fluoride and increasing the saturation of calcium and phosphate ions in plaque fluid as a result. This reaction helps to prevent the dissolution of calcium and phosphate from the tooth mineral and/or increasing the rate of remineralization or re-precipitation of the lost minerals. This mechanism can further explain topical application of a fluoride varnish in two or three times a year can produce an amazing result in long-term caries reduction.<sup>29</sup>

#### **ADVANTAGES AND DISADVANTAGES OF FLUORIDE VARNISH**

Fluoride varnish offers the theoretical advantage of prolonged contact time, acting as a slow-releasing reservoir to prevent the immediate loss of fluoride after application. The varnish can be applied quickly and easily and sets rapidly on teeth; gagging and swallowing are unusual. The simplicity of its application makes it suitable for special-needs populations—including very young children, patients with autism, and patients with management problems (such as mental or physical disabilities)—as well as for outreach dental services. A professional prophylaxis before varnish application has no additional effect on its caries prevention property and thus is not necessary; as a result, the chairside application time of fluoride varnish is short. Application of fluoride varnish to four first molars may take less than half a minute. Warren et al reported that both patients and operators prefer fluoride varnish to fluoride gel.<sup>29</sup> Moreover, Bowden's 1998 study reported that fluoride varnishes are safe for young children. Compared with other types of topical fluoride treatments (such as gels or rinses) or other caries management methods, fluoride varnishes offer effective caries prevention, ease of application, and safety.<sup>4</sup> A systematic review of caries management methods by Bader et al reported that fluoride varnish was "fair" at preventing dental caries, while the evidence for other methods, including sucrose-free gum and combined chlorhexidine-fluoride methods, was incomplete. In addition, a recent review by Petersson found an average preventive fraction of 30% (0–69%) of fluoride varnish in children.<sup>30</sup> Fluoride varnishes have gained attention in terms of public health dentistry and it is likely that they will become the most common form of topical fluorides applied by dentists. One disadvantage of Duraphat is its poor aesthetic effect. A yellow film of varnish remains on the teeth for several hours after application unless it is removed by brushing; in addition, there is a temporary discoloration of teeth after varnish application. While the majority of

patients find the presence of varnish on their teeth acceptable, it is the authors' experience that some patients dislike its presence as a thin film on their teeth or they find the taste of the varnish objectionable.<sup>6</sup>

#### **SAFETY OF FLUORIDE VARNISH**

Duraphat varnish contains either a 5% NaF ion or 2.26% fluoride ion. It is considered to be a concentrated fluoride therapeutic agent delivered by dental professionals. Ingestion of excessive fluoride can be a hazard to patients (especially preschool children) who are receiving topical fluoride treatment. Roberts and Longhurst conducted a clinical evaluation on the amount of fluoride applied to children with Duraphat in the United Kingdom and found that the amount of fluoride applied on average was 5.2 mg per child; this amount varied little regardless of the children's ages and no child received the level of fluoride ion quoted for toxicity.<sup>31</sup> Fluoride varnish sets rapidly when applied to teeth and most of the sodium fluoride applied will stay on the tooth surfaces in the natural resins. A study of Swedish children by Ekstrand et al showed a plasma fluoride peak level of 3.2–6.3  $\mu\text{mol/L}$  after fluoride varnish was applied.<sup>32</sup> By contrast, a later study noted that a four-minute acidulated phosphate fluoride (APF) gel application produced a plasma fluoride peak of 16–76  $\mu\text{mol/L}$ .<sup>36</sup> By comparison, a 1983 study on preschool children reported that the mean plasma fluoride peak level after brushing with fluoride toothpaste was 3.6  $\mu\text{mol/L}$ , while ingesting a 1.0 mg fluoride tablet produced a peak level of 4.5  $\mu\text{mol/L}$ .<sup>37</sup> Two cases of contact allergy to Duraphat varnish have been reported in the literature; the first caused dermatitis in a dental assistant's hand, while the second caused stomatitis in a patient. It has been suggested that these allergic responses were related to the varnish's colophony component. According to the manufacturer, oedematous swelling and vomiting by patients with sensitive stomachs have been reported as rare side effects. Recent reviews indicate that fluoride varnish is safe for dental care and that risk of acute toxic reactions from fluoride varnish is minimal.<sup>4,30</sup> In addition, the risk of dental fluorosis is minimal because children are not exposed to fluoride varnishes as frequently as they are to fluoride supplements.<sup>33</sup>

#### **CLINICAL STUDIES OF FLUORIDE VARNISH ON CARIES**

In most clinical trials, Duraphat was reported to be effective for preventing caries, with an average reduction of approximately 30%.<sup>32</sup> Meta-analysis has been conducted using a fitted fixed and a random effects model.<sup>14</sup> The overall effect size of caries reduction was approximately 0.38 in both models. Fluor Protector deposited more fluoride in and on the enamel and protected the enamel more effectively in situ than Duraphat; however, it was not proven clinically to be more effective. Some studies found

NaF more effective than difluorosaline, while others reported that both were equally effective at reducing caries. Topical application of a sodium fluoride varnish is carried out using a small brush and a very small amount of varnish (especially for young children). One study found that an average of 0.17 mL of Duraphat was used in each topical application.<sup>34</sup>The teeth do not have to be very dry and the patient should not eat for approximately two hours after application. Since tooth-brushing can remove fluoride varnish, the varnish should be left on the teeth and brushing on the day of application should be avoided whenever possible.<sup>4</sup> In a two-year randomized study in Finland, *Seppa* and *Tolonen* studied 300 children at risk of caries and did not find any significant difference in the increment of caries experience between those who received two applications of sodium fluoride varnish per year and those who received four applications.<sup>12</sup>

## CONCLUSION

Fluoride varnish can be considered as an effective agent in caries management and it is observed to be further superior topical fluoride agent among school going children. SDF is observed to be simple and easy to use therapeutic agent available in affordable prices in various developing countries. However, further researches needed to be carried out in an attempt to prove that the SDF as a material of choice in this 21<sup>st</sup> century also.

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