Review Article

Efficacy of Silver Diamine Fluoride in Management of Caries: A Narrative Review

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ABSTRACT

Dental caries is a microbial disease of the calcified tissues of the tooth, characterized by demineralization and leading to cavitation and is generally irreversible. Early involvement of pulp is associated with pain and loss of teeth as well as has negative impact on the quality of life. Hence, it is recommended to focus on preventive measures to limit the discomfort caused by caries. Silver diamine fluoride is one such medicament used to prevent and arrest dental caries and also helps in overcoming dentinal hypersensitivity. It is colorless or blue-tinted (which has advantage of arrest), odorless liquid composed of fluoride, ammonium, and silver. It is easy to use, efficient, accessible, cost effective, time saving, and patient centered.

Key words: Preventive, Silver diamine fluoride, Dental caries

INTRODUCTION

The most common dental problem which is seen affecting all the age group is dental caries. In India, the prevalence rate of dental caries ranges from 50.8% to 62.4% in children.[1] American Academy of Pediatric Dentistry (AAPD) encourages health-care providers and caregivers to implement preventive practices that can be helpful in decreasing a child's risk of developing this disease.[2]

A decrease in overall caries indicators has been reported, still prevention and control of dental caries in children is one of the difficult problems encountered by pedodontists. Although many advances in treatment and prevention of caries have come up, the various, biological, and environmental factors causing early childhood caries (ECC) make its prevention and control a very challenging task.[1]

Nowadays, silver diamine fluoride (SDF) is getting into limelight for caries prevention. It is a liquid mainly clear that has a combined effect of silver and fluoride, that is, antibacterial and re-mineralizing effect. It can be used therapeutically for treating caries lesions in young children and also those with special care needs.[3] This review article aims to SDF application is 89% more effective compared to placebo and other treatments. It is simple, quick, painless, inexpensive, and non-invasive that can be readily learned by dental health professionals.[4] This review article aims to summarize the therapeutic effect on SDF in primary and permanent teeth, its adverse effect and technique of application.

HISTORY

The approval of the first SDF product, Saforide (Bee Brand Medico Dental Co, Ltd, Osaka, Japan) in 1970 was done by Drs Nishino and Yamaga in Japan. They combined F— and Ag+ and led to the development of ammoniacal silver fluoride, which could be used to arrest caries. Three hundred and eighty milligrams (38 w/v%) of Ag(NH3)2F are present in 1 ml of SDF. They described SDF as a product that could be used to desensitize open dentinal tubules and relief dentinal hypersensitivity, for prevention and arrest of dental caries in children and those with special health-care needs and also to prevent development of any secondary caries after restorations. It was reported that its penetration in sound enamel was 20 μm. In dentin, fluoride ion penetration was between 50 μm and 100 μm, Ag+ penetration was comparatively deeper than fluoride, which was found to be close to the pulp chamber.[5]

With its use in many clinical trials over the years, SDF is also believed to be effective in prevention of pit and fissure caries in the erupting permanent molar and root caries in elderly people.[1]

In 2014, SDF was approved by the US Food and Drug Administration as a treatment for dentinal sensitivity. SDF had been used off-label for caries arrest; however, it was recently approved (code D1354) as an interim caries arresting medicament.[6]

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MECHANISM OF ACTION

According to Yamaga and his coworkers, mechanism of action is due to presence of fluoride and silver ions.[5] They proposed that out of the 2 components, F ionsacted on the tooth structure, while Ag ions were responsible for the antibacterial effect. Reaction of SDF with hydroxyapatite [Ca10(PO4)6(OH)2] in an alkaline environment forms calcium fluoride (CaF2) and silver phosphate (Ag3PO4). CaF2 leads to formation of fluoroapatite [Ca10(PO4)6F2], whose solubility is less than hydroxyl apatite in an acidic environment.[7]

The Ag3PO4 gets precipitated and forms an insoluble layer over the tooth surface. The transformation of hydroxyapatite to fluoroapatite is facilitated by this phosphate ion reservoir.[8] The overall reaction can be summarized by the following equation:

Ca10(PO4)6(OH)2 + Ag(NH3)2F → CaF2 + Ag3PO4 + NH4OH

Mei and her coworkers found that SDF creates an alkaline environment to render CaF2 less soluble and, therefore, serves as a fluoride reservoir for acid challenges by cariogenic bacteria. *In vitro* studies propose that SDF can prevent degradation of collagen and decrease demineralization of hydroxyl apatite.[9] In addition, SDF is believed to reduce collagen breakdown[10] and increase hardness of dentine.[7]

SDF has antibacterial properties which can be attributed to the fact that the silver ions bind to the negatively charged peptidoglycans in bacterial cell walls and lead to disruption of the membrane transport function, which further causes cellular distortions and loss of viability.[11] Binding to sulfhydryl groups (thiol group of cystine), which is essential for enzyme activities,[12] can inhibit bacterial enzyme activities, disrupt metabolic processes, and eventually cause death of the microbe. This was demonstrated by the inhibition of plaque formation on enamel and dextran-induced agglutination of *Streptococcus mutans*.[7] Ag ions can oxidize thiol groups and, therefore, reduce acidogenicity of dental plaque.[13] Moreover; silver ions inhibit bacterial DNA replications by attaching to guanine. In vitro studies show that silver ions can limit and reduce adherence of carcinogenic bacteria to enamel surfaces,[14] formation of *Streptococcus mutans* biofilm, and growth of *Streptococcus mutans*[15] and Lactobacilli acidophilus.

INDICATIONS FOR USE

1. High caries risk (xerostomia or severe ECC)
2. Pre-cooperative and uncooperative children
3. Difficult to treat dental carious lesions
4. Patients with multiple carious lesions that may not all be treated in one visit
5. Patients with special needs
6. Patients with dentinal hypersensitivity and active root caries.

CONTRA-INDICATIONS

1. Teeth with signs pulpal pathology
2. Silver toxicity.

TECHNIQUE OF APPLICATION

SDF can be used as a part of restorative treatment or caries control therapy. According to AAPD, steps for clinical application include:

- Removal of the debris from the caries affected area to facilitate better contact of SDF with the tooth
- Caries dentin excavation maybe done, but is not mandatory. The proportion of area which will become black after application of SDF will reduce if caries is excavated
- Application of protective coating (cocoa butter, Vaseline, etc.) on the soft tissue, lips and skin followed by isolation of the caries tooth with cotton rolls or other methods. (caution must be taken while applying protective coating on the adjoining gingiva. If it coats the caries lesion, contact of SDF with the tooth structure will be limited).
- Drying of lesion with compressed air
- Application of SDF using bent micro sponge brush. (one drop is enough for one sitting. Furthermore, after dipping the brush into SDF, access should be removed by dabbing the brush on a dappen dish)
- Excess SDF from the lesion should be removed using sponge or cotton pellet to minimize systemic absorption
- Application time should be at least 1 min followed by gentle flow of compressed air to dry the medicament
- After SDF treatment, the entire dentition should be treated with 5% sodium fluoride varnish to help prevent caries on sites not treated with SDF.

SAFETY

There are no studies that have reported about acute toxicity of SDF or its adverse effects. Some concerns have been raised over dental fluorosis, and accidental toxic overdose from the use of 40% SDF for arresting dental caries, although these concerns have been refuted.[4] Mild gingival and mucous irritation after SDF application might occur, but, generally, it heals spontaneously within 2 days.[16] Blackish discoloration of the carious lesions is the other side effect of SDF. Application of potassium iodide maybe helpful in decreasing the staining when applied immediately following SDF treatment; however, application of SDF is contraindicated in pregnant women and during the first 6 months of breastfeeding due to concern of overloading the developing thyroid with iodide.[16]

Even a small amount of SDF can cause a "temporary tattoo" to skin (on the patient or provider), similar to a silver nitrate stain or henna tattoo, but does not cause any harm. The natural exfoliation of skin leads to stain resolution, in 2–14 days. SDF stains clinic surfaces and clothes. The stain is permanent once it sets, so it is advised to immediately clean the surface if it spills accidentally.[16]

THE EVIDENCE BASE FOR SDF

The literature available indicates that SDF arrests caries in primary teeth as well as permanent teeth and may prevent formation of new caries. It has also shown to provide relief to dentinal sensitivity by blocking the open dentinal tubules.

Based on the Gao 2016 meta-analysis, the proportion of caries arrest on primary teeth treated with different application protocols (1 application, annual, and biannual), and followed from 6 to 30 months, was 81% (95% confidence interval, 68%–89% $P < 0.001$).[17] Fung *et al.*, in 2016, concluded that arresting rate of caries in primary dentition using SDF was greater at a 18-month follow-up when compared to 5% sodium fluoride varnish.[18]

A meta-analysis conducted on 8 studies, which used 38% SDF to arrest dentine caries in primary teeth in children (Chu e*t al.*, 2002; Fukumoto *et al.*, 1997; Llodra *et al.*, 2005; Wang., 1984; Yang *et al.*, 2002; Ye., 1995; Yee *et al.*, 2009; and Zhi *et al.*, 2012). The results showed that the caries-arresting rate of SDF treatment was 86% at 6 months, 81% at 12 months, 78% at 18 months, 65% at 24 months, and 71% at or beyond 30 months. The overall proportion of arrested dental caries after SDF treatment was found to be 81%.[17]

Braga *et al.* reported that a 38% SDF solution was significantly more effective for caries prevention in primary teeth (80% fewer new caries lesions; $P < 0.05$) and first molars (65% fewer new caries lesions; $P < 0.001$) compared to a control group.[19]

Zhi *et al.* found that the caries arrest rate was significantly higher (53%) when 38% SDF was applied semiannually than when 38% SDF (37%) or GIC (28.6) was applied annually ($P < 0.001$).[20] Chu *et al.* (2002) found that annual application of 38% SDF was more effective than quarterly application of 5% sodium fluoride varnish in arresting caries. Three monthly application of 12% SDF had been found to be more effective than once yearly application, but the difference between biannual and quarterly application was not significant (Llodra *et al.*, 2005). SDF has been found to be most effective at higher concentration, that is, 38% % (Duangthip *et al.*, 2018).

Trials have demonstrated the ability of SDF to block dentinal tubules and create this barrier (Craig *et al.*, 2012 and Castillo *et al.*, 2011). SDF had greater efficacy than either placebo or an oxalic acid-based preparation in reducing short-term sensitivity.[21]

Noriko *et al.*, in 2010, studied the effect of 3.8% SDF and sodium hypochlorite on *in vitro Enterococcus faecalis* biofilm. They reported 100% efficiency of 3.8% SDF against *E. faecalis*.[22] Mathew *et al.* concluded the use of SDF as an endodontic irrigant to be feasible as it can effectively remove the microbes present in the canal and circumpulpal dentin.[23]

CONCLUSION

There is a strong evidence base for SDF as a safe and effective intervention for arresting caries as well as for reliving dentinal hypersensitivity. It has the potential to be useful in the community as primary and secondary care to arrest and prevent caries, thus reducing the overall burden of the disease.

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