

Original Research

Silver Diamine Fluoride: A Magical Tool in Caries Management

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ABSTRACT:

In the past few years, silver diamine fluoride (SDF), a medicament for topical use, has increasingly gained recognition amongst clinicians and patients as an effective tool for arresting caries, treating dentinal hypersensitivity, and enhancing tooth bond strength. Actually makes the SDF a magic in pediatric dentistry is that its minimal invasive practice and non-restorative procedure to halt caries. Pediatric patient with uncooperative behavior are often difficult to manage and the practitioner has to use different modes of behavior management techniques and this may take at least two or more appointments to desensitize the patient to the environment. What if such a patient comes to the clinic already with progression of caries and in such cases waiting for next appointments only worsen the situation, and clinician can't jump to a restorative procedure using arotor and do a restoration, which will only make the child more uncooperative. In such cases SDF do wonders by just brushing on to the tooth surface and with no invasive technique we can halt the caries and can delay the restorative procedure once the child is ready to accept the treatment. So the aim of present review is to discuss role of silver diamine fluoride in the management of caries in children.

Keywords: Silver Diamine Fluoride, Dental Caries, ECC

Received: 20 August, 2021

Accepted: 24 September, 2021

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This article may be cited as: Rajan M, Sharma N, Najeeb A, George AY, Seal B, Dasgupta B. Silver Diamine Fluoride: A Magical Tool in Caries Management. J Adv Med Dent Scie Res 2021;9(10):58-61.

INTRODUCTION

Dental caries is a chronic disease that frequently affects children all over the world. Even though there has been a reduction in caries indicators in recent years, dental caries, similar to diseases associated with community disparity, is heavily shifted toward lower socioeconomic groups.¹ "Early childhood caries (ECC), the presence of 1 or more decayed, missing, or filled tooth surfaces (dmfs) in any primary tooth in a preschool-aged child", has been on the rise in many countries and is recognized as an important public health concern by the American Dental Association.² If ECC remains untreated, it has effects on the growth of the child, their body weight, oral health-related

quality of life and both attendance and performance at school.^{3,4}

Conventionally, the management of the carious lesions follows surgical eradication of the carious tissue and the replacement with a suitable restorative material.⁵ Subsequently, minimal invasive dentistry (MID), which aims at maintenance of the sound tooth structure using non-invasive techniques, has replaced the conventional procedures. Treatments such as arresting the carious lesions can be delivered at the community level regularly to halt the progression of the carious lesion.^{6,7} Though not new, silver diamine fluoride (SDF) most recently had demonstrated amplified attention by clinicians globally due to its

effectiveness in arresting the progression of carious lesions. More than four decades witnessed the successful usage of silver fluoride (AgF) as a preventive material in both clinical and *in vitro* studies.⁸ The U.S. Food and Drug Administration (FDA) gave clearance in August 2014 to the first SDF preparation for dental use in the United States and is available for use since April 2015. Horst et al. opined that SDF makes its use in community dental health programs due to its low cost, and it was recommended for once or twice a year application of this as a preventive agent.⁹ So the aim of present review is to discuss role of silver diamine fluoride (SDF) in the management of caries in children.

SILVER DIAMINE FLUORIDE

Silver diamine fluoride, a transparent colourless liquid, is a combination of the remineralizing effects of fluoride and the antibacterial effects of silver. The ammonia ions combine with the silver to produce a complex ion called the diamine-silver ion, $[\text{Ag}(\text{NH}_3)_2]^+$. This formation of diamine-silver ions is reversible and very stable with an alkaline pH of 8-9. Although available in various concentrations, SDF is commonly used in 38% solution as a commercial preparation and traded by the brand name Saforide (J. Morita Corporation, Osaka, Japan), which contains 380 mg water-soluble silver diamine fluoride in 1 ml colourless solution, or about 44,800 ppm of fluoride ions.^{5,10}

COMMERCIALY AVAILABLE SDF

Product name	Concentration of SDF	Package
FAgamin Tedequim SRL, Argentina	38	5-mL dropper bottle
Riva Star SDI dental Ltd, Australia	30-35	Unit 1: 0.05 mL
e-SDF Kids-e-dental, Mumbai, India	38	5-mL dropper bottle
Cariostatic Inodon Laboratorio, Brazil	10	5-mL dropper bottle
Cariestop Biodinamica, Brazil	12/30	5-mL or 10-mL dropper bottle

MECHANISM OF ACTION

There could be following possible mechanisms of action of SDF against caries:

1. The first mechanism may be the occlusion of dentinal tubules with silver. According to Shimizu et al. (1974), when SDF is applied on dentine, its dye permeability reduced and electric resistance enhanced.¹¹ He also reported that silver and its compounds from SDF application blocked the diffusion of acid and invasion of microorganisms into the dentinal tubules. It also inhibited the further growth of microorganisms by oligodynamic action of silver. Additionally, obturation of the dentinal tubules decreased the surface area of dentin, which may be attacked by caries. It has also been seen that the use of 38% SDF repressed demineralization and preserved collagen from degradation in demineralised dentin.¹²
2. The other mechanisms could be the cariostatic action of products produced by reaction between SDF and minerals of the tooth. The fluoride present in amplified the resistance of the dentin to action of acid resulting in reduced penetration of acid into inner dentin. When SDF is applied to dentin under *in vivo* conditions, its fluoride ions penetrated to a depth of 50–100 μ . It has been proved that SDF ($\text{Ag}(\text{NH}_3)_2\text{F}$) reacts with

hydroxyapatite (HA) of tooth to release calcium fluoride (CaF_2) and silver phosphate (Ag_3PO_4), resulting in hardening of affected dentine. The Ag_3PO_4 that is formed on the tooth is insoluble to acid attacks. The CaF_2 formed as a reaction product becomes a pool of fluoride ions for the formation of fluorapatite ($\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2$).³² It is also proved that fluoride ions enhances calcification of tooth, and restores lattice imperfection,³³ and improves the crystallinity of HA.¹³⁻¹⁶

3. The anti-enzymatic actions of the reaction products between $\text{Ag}(\text{NH}_3)_2\text{F}$ and organic component of the tooth can be the next mechanism of action for caries arrest. Its antibacterial properties arise from inhibition of the enzyme activities and dextran-induced agglutination of cariogenic strains of *Streptococcus mutans*. Resistance of dentin to trypsin increased when SDF is applied on tooth surface. Also, a study reported that resistance to collagenase and trypsin for dentin protein increased after treating the tooth with SDF.¹⁷⁻¹⁹

CLINICAL APPLICATION OF SDF^{8,20}

1. Individuals with high caries risk with active cavitated lesions on any surface of the anterior or

posterior primary teeth and permanent first molars.

2. Individuals with behavioural or medical management problems having cavitated dental caries lesions, when local or general anesthesia is not preferred or to be delayed to a later date as a holding measure until definitive treatment is possible, as in cases of pre-cooperative children.
3. For management of patients with high caries prevalence like with xerostomia.
4. SDF is effective in arresting dentin caries in a Community-based Caries Control Program- SDF can be used to tackle the caries problem in community dental health programs especially in developing and low income countries.
5. Active cavitated dental caries lesions without any clinical signs of pulp involvement
6. As part of the silver modified atraumatic restorative technique (SMART)
7. Treatment of dentinal hypersensitivity
8. Treatment of molar incisor hypomineralization (MIH)
9. Treatment of recurrent caries (secondary caries) at the restoration margins
10. Treatment of incipient interproximal lesions
11. To disinfect root canals- SDF can be effectively used as an endodontic irrigant
12. Indirect pulp treatment
13. Arresting caries to maintain the teeth nearing exfoliation
14. As a substitute to sealants in children who cannot endure a scrupulous sealant procedure.
15. Annual application of SDF is effective in arresting the root caries.

With above mentioned clinical condition SDF application should be avoided in patient with silver allergy, soft tissue ulceration, tooth with pulpal involvement.

CLINICAL STEPS FOR APPLICATION OF SDF²¹

1. Remove gross debris from cavitation
2. To minimize contact with gingiva and mucosa apply petroleum jelly or use cotton rolls to protect surrounding gingival tissues
3. Dry with a gentle flow of compressed air
4. Dispense 1 drop into a disposable dish. Use a micro-brush to apply on the lesion. Interproximal decay can be treated using a Super floss (1 drop treats up to 5 tooth surfaces).
5. Allow it to soak in for 1-3 minutes.
6. Remove excess with a cotton pellet or roll.
7. To reduce blackening of the filling:
 - Polish away discoloration along the margins.
 - Restore using glass ionomer cement, composite resin or crowns
8. To optimize caries arrest, reapply once at intervals of every 6 months

DISCUSSION

Dental caries is still one of the most common chronic dental diseases affecting various age bars in all countries and all populations with varying degree of severity. Treatment of the dental caries may require advanced skills of clinicians and high cost of general anesthesia for patient management.²² In 1942, Bibby began era of topical fluorides with the use of a solution of 0.1% sodium fluoride (NaF). Subsequently over the years, various other topical fluoride agents have been evolved which in sequential order are stannous fluoride (SnF₂) (1947), acidulated phosphate fluoride (APF) (1963), varnish containing fluoride (1964), and amine fluoride (1967). Fluorides have been proved to be the single most effective weapon in still limited arsenal of anticaries agents in last 60 years. Caries preventive programs can be effectively carried out using topical fluoride agents like fluoride mouth rinse and fluoride varnish. Studies also conclude that caries preventive effects of fluoride are almost exclusively topical.^{23,24,25} Among them fluoride varnish and 1.23% APF gel were the most commonly used professionally applied topical fluoride agents till date, still none of them have proved completely satisfactory.

Silver diamine fluoride was introduced in Japan in 1970s. Since then it was used in Japan as an effective caries arresting agent. SDF is a caries-controlling reagent and is widely adopted in the USA off label, like fluoride varnish for caries prevention. However, it is being used for arresting caries in primary teeth. SDF is available in various concentrations, namely 12%, 30%, and 38%. However, 38% of SDF is found to be highly effective in arresting carious lesions and promoting remineralization.²⁶

Interest in the use of silver diamine fluoride (SDF) has been rapidly increasing. Even though SDF had been used off-label for caries arrest; was recently approved (code D1354) as an interim caries arresting medicament. Silver diamine fluoride is indicated for interim treatment (nonsurgical caries management) for patients who cannot receive traditional restorative due to pre-cooperative behavior because of age, cognitive, or physical disabilities; patients at high caries risk having many carious lesions that cannot be addressed in a single visit, un-affordability, and inaccessibility resulting from low socioeconomic status and poor awareness. Silver diamine fluoride is indicated for cavitated caries on crown or root surfaces which are cleansable, asymptomatic, and do not have pulpal involvement.²⁷

Fung et al. (2018) conducted a study including children between 3 and 4 years where SDF 12 and 38% were applied annually and semi-annually. It was found that the caries arrest was improved with the higher concentration of SDF and that the caries arrest improved by 15% on the increasing frequency of application from annual to semi-annual.²⁷ Chibinski et al. (2017) reported that at 12 months, the caries arrest as a result of SDF application was 66% higher than

any other product with active ingredients and it was 76% higher than caries remaining untreated.²⁸

The main disadvantage following SDF application is the darkening of the carious tooth, which becomes difficult for parental acceptance. Potassium iodide application to control or reverse the staining after SDF is painted on the tooth has been studied by many investigators.²⁹

Since the management of dental caries with SDF is non-invasive and much comfortably performed, it can be a favourable means to treat dental caries in children.

CONCLUSION

SDF is a magical tool for caries management in pediatric patient. Minimal invasive technique used for SDF application helps children increase their positive attitude toward dentistry. Silver diamine fluoride can be an effective, inexpensive, and sustainable option for high-risk children and adolescents across all the age groups in arresting dentin caries.

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