

# Silver Diamine Fluoride, the Magic Bullet; Is it Really a Magic Alternative in the Caries Management?

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**Abstract:- Dental caries, childhood's most common chronic disease, associated with pain and inability to maintain normal nutrition intake. It do interfere with speech, self-esteem and quality of living, thus results in children with low body mass index and abnormal cognitive development. There are proven approaches for caries maintenance, but that requires financial burden and patient cooperation. Silver diamine fluoride (SDF) has proved to offer an interchange care way for patients for whom conventional restorative treatment isn't promptly beneficial.**

**Keywords:- Silver diamine fluoride, silver bullet, magic bullet, decayed teeth, pre cooperative child treatment.**

## I. INTRODUCTION

Silver diamine fluoride (SDF) provides an alternative treatment for patients in which other restorative options are not immediately accessible. It is an affordable treatment for arresting carious lesions in a minimally invasive way. Due to which it is gaining popularity. SDF kills the bacteria and hardens the teeth surface, thus both arresting and halting the caries progression. It is double fold proven to be effective as fluoride varnish in arresting caries<sup>[1]</sup>.

This literature review attempts to discuss SDF in depth, as caries prevention and arresting agent in primary as well as permanent dentition.

## II. HISTORY & EVOLUTION

About 1000 years ago, ladies after being married used to dye their teeth black. This being a custom as well as tooth cosmetic, it too had anti caries activity. This practice came

to an end during early 20th century<sup>[2]</sup>. Many Silver formulations, especially silver nitrate, were used for hundred years in medical sciences to control infections<sup>[3]</sup>. In dentistry too its use is well marked for caries prevention<sup>[4]</sup>. Prior to twentieth century, silver nitrate was immovably used in a cure for dentin hypersensitivity, erosion, pyorrhoea and in caries prevention in both primary as well as permanent teeth<sup>[5]</sup>. Fluoride combinations and prevention of caries has been well documented by numeral researches and clinical trials since twentieth century. Ammoniacal silver fluoride in combination with the actions of F and Ag in arresting dental caries was significantly summarised by Dr Nishino and Yamaga in japan<sup>[6]</sup>; thereafter the first SDF product, Saforide (Bee Brand Medico Dental CO, Ltd, Osaka, japan) got approved in 1970<sup>[7]</sup>. Within the howe's arrangement, ammoniacal silver nitrate has been utilized since 1917 caries disinfection later as a sterilizing and disclosing agent for about one-half of a century<sup>[8]</sup>, to detect incipient lesions and to disclose leftover carious dentin. In 2015, the first 38% SDF solution, commercial product became available in the United States of America. Advantage Arrest (Elevate Oral care, LLC, West Palm Beach)

Horst et al<sup>[9]</sup> in the year 2016 stated that SDF in one application shows the efficacy to arrest 80% of decayed lesions. With the addition of living bacteria with those killed by silver ions, silver re-activation takes place that leads to "zombie effect."

## III. PHYSICAL AND CHEMICAL PROPERTIES

Silver diamine fluoride is colorless, odorless and stable chemical that can be kept in a constant concentration. It is an ammonia complex of silver fluoride. The effects of SDF are summarised in table 1.

Table 1: Effect of SDF

Effect on Enamel <sup>[2]</sup>	Effect on Dentin <sup>[2]</sup>	Antimicrobial action <sup>[2]</sup>
<ul style="list-style-type: none"> <li>• Increase micro-hardness</li> <li>• Increase calcium</li> <li>• Decrease mineral loss</li> </ul>	<ul style="list-style-type: none"> <li>• Decrease lesion depth</li> <li>• Forms precipitate</li> <li>• increase micro-hardness</li> <li>• less mineral loss</li> <li>• forms highly re-mineralized surfaces</li> <li>• Less degradation of collagen (MMP-2, MMP-8, MMP-9, and Cysteine cathepsin)</li> </ul>	<ul style="list-style-type: none"> <li>• Less growth of <i>S. mutant</i> and lactobacillus in biofilms</li> <li>• Minimum bactericidal concentration for <i>S. mutan</i></li> <li>• 33.3ug/mL-50.0ug/mL (more effective than silver ammonium nitrate and sodium fluoride)</li> </ul>

A. Concentration of SDF

Various concentration of SDF available are –

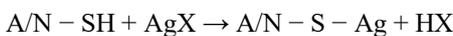
10% - Howe’s solution

12% - Cariostop (Biod- inamica, Brazil)

38% - Kids- e crown, Mumbai (India),Tedequim SRL,FAgamin,Cordoba (Argentina)

B. Mechanism of action of SDF

On applying SDF to the teeth surface, silver interacts with clusters of sulfhydryl proteins and deoxyribonucleic acid (DNA) which alters hydrogen binding and inhibits respiratory processes, cell wall integration, DNA disassembly and cell division<sup>[10]</sup>; inhibiting biofilm and initiating bacterial killing<sup>[11]</sup>(figure 1) . The central mechanism for these diverse effects is proposed as:

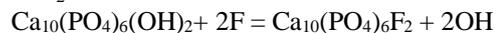
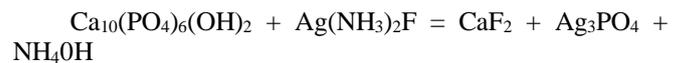


Where A/N represents amino (A) or nucleic (N) acids respectively, SH represents a thiol group, ag represents silver, and X represents an anion (ie diamine fluoride)<sup>[12]</sup>.

Shimizu and Kawagoe<sup>[13]</sup> in the year 1976 proposed three possible actions of SDF on caries.

When dentin is treated with SDF it obturates dentinal tubules which causes decrease in dye permeability and increase in electric resistance.

SDF expands the resistance of the peri- and inter-tubular dentin to acid decalcification, leading to blockage of acid into deeper layers of the dentin.



The third mechanism may be by the anti-enzymatic actions between  $Ag(NH_3)_2F$  and organic component of the tooth; arising antibacterial properties from inhibition of the enzyme activities of cariogenic strains of streptococcus mutans<sup>[14]</sup>.

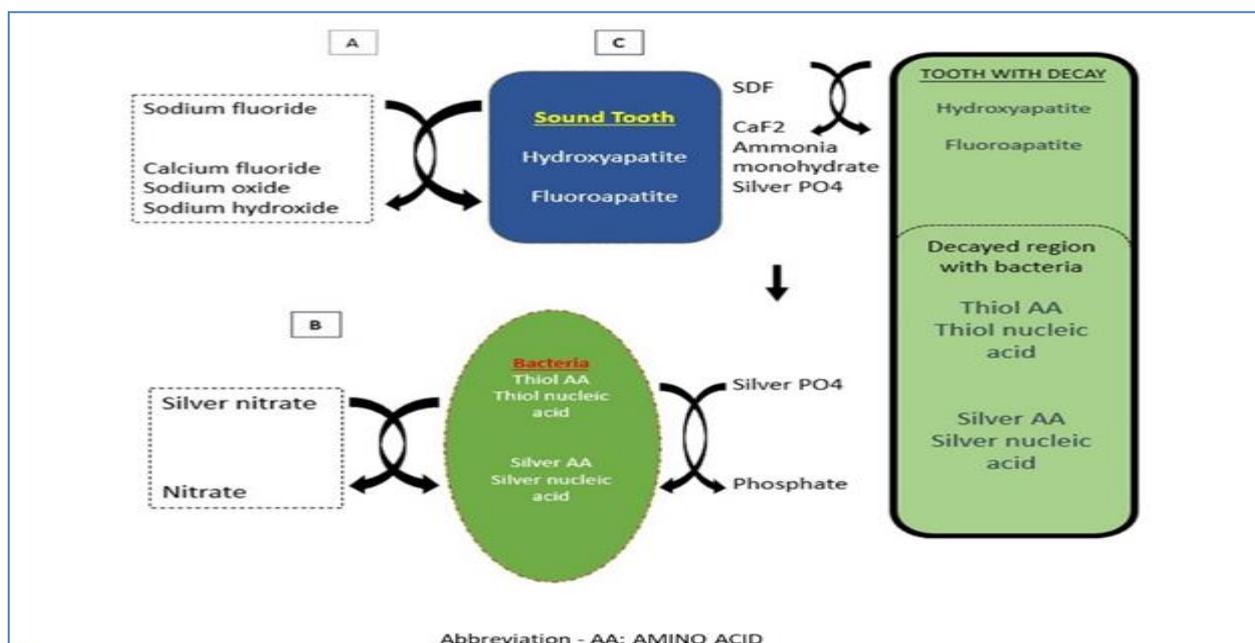


Fig. 1: Effects of fluoride, silver nitrate, and silver diamine fluoride on teeth and bacteria.

### C. Penetration depth of SDF

SDF has an ability to penetrate in enamel and dentin

In enamel – 20 µm

In dentin – 50-100 µm

### D. Indications of SDF

- Patients who cannot tolerate conventional dental care. SDF provides preventive care in single appointment.
- Very young “pre-cooperative” children who are difficult to manage.
- Person with intellectual/developmental disabilities who cannot withstand long appointment duration.
- Old patients for hypersensitivity.

### E. Contraindications of SDF

SDF is contraindicated in patients with<sup>[15]</sup>

- Silver allergy.
- Pulpitis or pulpal necrosis as it causes pulpal irritation.
- Deep carious lesions where dentin has been excavated.
- Ulcerative gingivitis/ stomatitis as it may cause irritation and worsen the situation.

### F. Advantages of SDF

SDF has many advantages in dentistry such as –

- It showed an antimicrobial activity against cariogenic biofilm thus, inhibiting biofilm formation<sup>[16]</sup>.
- Fluoride in SDF promotes caries lesion remineralization by reacting with hydroxyapatite and generating calcium fluoride.
- Simple procedure which requires no injection or drilling.
- No need of expensive infrastructure equipment.
- Beneficial in treating caries in apprehensive patients with dental fear, patients with special health care needs.

### G. Disadvantages of SDF

- SDF application causes blackish discoloration.
- SDF can also stain clothes and the skin, although there is no associated pain with it. Stain on the skin resolves within 2-14 days where as the stain on clothes is permanent.
- It has metallic taste.

- Gingival and mucosal irritation if comes in contact; which gets resolve in 4-7 days.

### H. Method of application

American Academy of Pediatric Dentistry guidelines<sup>[18]</sup>

- Removal of gross debris
- A layer of petroleum jelly may be applied to the lips and skin to prevent soft tissues contact with SDF.
- Careful application of SDF with a micro brush directly to the affected tooth surface is done. No more than one drop of SDF should be used for the entire appointment.
- Gentle flow of compressed air is used to dry lesion.
- Application time should be at least one minute if possible.

## IV. CLINICAL APPLICATION OF SDF

SDF due to its beneficial effects has been widely used in dentistry in multiple different cases.

### A. In caries control

The US Food and Drug Administration accepted SDF for treatment of tooth hypersensitivity and in the management of caries<sup>[19]</sup> as shown in Figure 2 (a) & (b). Based on the Gao 2016 meta-analysis,<sup>[20]</sup> caries arrest on primary teeth with different application protocols for the duration from 6 to 30 months, was 81%. Chibinski and colleagues (2017)<sup>[51]</sup> reported that the caries arrest at 12 months promoted by SDF was 66% higher than other method of management. It can also be used in cases of secondary caries and root caries. SDF has also been used as non-restorative cavity control (NRCC) in uncooperative or pre-cooperative patients where conventional restorative treatment cannot be achieved.<sup>[21]</sup>

When this technique is accompanied by a GIC restoration it is termed as silver modified atraumatic restorative treatment (SMART). This technique is easy to use, economical, biocompatible and requires less chairside time.

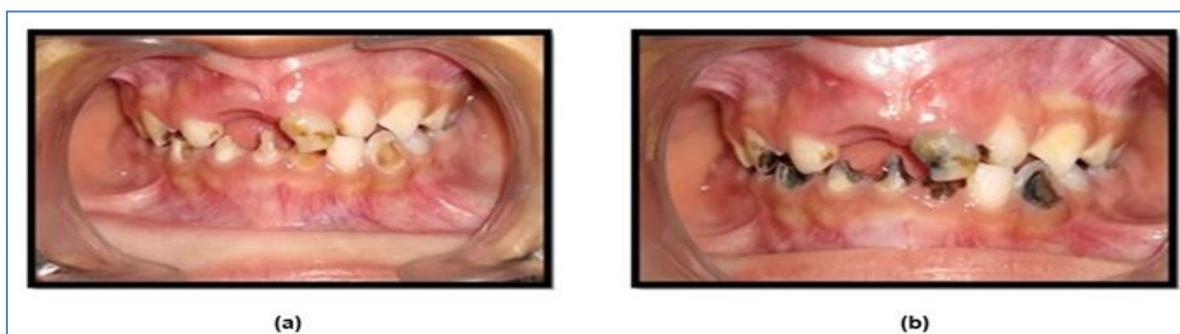


Fig. 2 (a) Cavitated lesions before SDF treatment; (b) Arrested lesions after SDF treatment

### B. Management of hypersensitivity

Dentin hypersensitivity usually occurs on exposed dentin surface<sup>[22]</sup> and is associated with variable pain. The application procedure is same as treating caries. Isolation by

cotton rolls is done, followed by gently drying the area and the SDF is applied with a small disposable brush which results in a hard, blackened and impermeable layer. (Figure 3 (a) & (b)\* - \*Picture Courtesy – Chu et al 2014<sup>[23]</sup>)



Fig. 3(a) SDF application in hypersensitivity; 3(b) SDF 1 week follow up in hypersensitivity

C. Disinfection of root canal in endodontic treatment

SDF at 3.8% (sافرید 3.8%) is used for root canal disinfection ie 1:10 dilution of the 38% SDF solution<sup>[24]</sup>.

V. OTHER USES OF SDF FOR DENTAL TREATMENT

Numerous studies have concluded that Er:YAG (2,980 nm) and CO<sub>2</sub> (10,600 nm) laser irradiation possibly increases the fluoride uptake of SDF on tooth surface<sup>[25]</sup>.

Management of children with special health care needs SDF is an economical treatment of dental caries among high-risk patients with behaviour management issues. Dental caries management in children with special health care needs is challenging and it usually requires pharmacological assistance as sedation and general anaesthesia, which can be expensive.

A manuscript was presented by Crystal et al (2017) on the management of dental caries with silver diamine fluoride in children and adolescents, including those with special health care needs. The guide summarised that the use of 38%

SDF improves outcome for management in children and adolescents, including those with special health care needs.<sup>[19]</sup>

Parental perceptions and acceptance for silver diamine fluoride treatment Parental acceptance varies depending on age, gender and whether the tooth to be treated is anterior or posterior. SDF treatment is more widely accepted for posterior teeth as compared to the anterior teeth and more in boys as compared to girls.

In the year 2016, Fung et al in his study stated that more than 60% parents accepted SDF discoloration in posterior teeth where as only 29% in anterior teeth<sup>[26]</sup>.

Crystal et al<sup>[27]</sup> in the year 2016 developed a cross-sectional design survey for analysing SDF staining perception among parents. The author stated that the perception varies based upon location, treatment difficulty, age, family income, education and ethnicity of the parent. The authors concluded that in lower income and of Hispanic ethnicity, there is increased parental acceptance of anterior staining. Also, with lower level of parent's education, parental acceptance increased.

Table 2: Comparative Evaluation of SDF with other Topical Fluoride Agents<sup>28</sup>

Characteristics	Sodium Fluoride	Stannous Fluoride	APF	SDF
Percentage	2%	8%	1.23%	38%
Fluoride concentration (ppm)	9200	19500	12300	44,800
pH	Neutral	2.4-2.8	3.0	8-9
Frequency of application	4 at weekly intervals 3,7,11 & 13 years	Biannual	Biannual	Biannual
Adverse effects	no	Tooth pigmentation, gingival irritation	no	Black staining
Caries reduction	30%	32%	28%	47-90%
Cost	60/1.5ml	7160/kg	1180/475 ml	2000/5ml

## VI. CONCLUSION

SDF was first developed in Japan and the US Food and Drug Administration approved it in August 2014. SDF has proved to be a superior edge as compared to other fluoride components. Table 2 summarises the evaluation of SDF with other topical fluoride agents.

38% SDF contains 44,800 ppm fluoride, and this high fluoride concentration is favourable in halting dentine demineralisation. SDF is a cost-effective procedure and is indicated in patients who cannot withstand conventional dental care, young uncooperative children, patients with special health care needs and in geriatric patients for hypersensitivity. Despite its overruling benefits in caries management, dark black staining after the use of 38% SDF raises esthetic concerns particularly in the anterior teeth and permanent dentition. Most parents accept SDF application due to its non-invasive protocols and reduction in chair side time. Although there has been varying perception among parents due to unpleasing discoloration caused by it, SDF has proved to be a superior edge for use in community dental health because of its low cost and easy procedure. Thus, it can be appreciated as a safe, effective, efficient, and equitable caries preventive agent and can be justifiably said as a magic alternative in the caries management.

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