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Original Research

Silver Diamine Fluoride: A Magic Bullet

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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. Present review of literature aims to discuss silver diamine fluoride in detail.
Keywords: SDF, Dentinal Hypersensitivity, Dental Caries

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INTRODUCTION

Dental caries remains a severe oral health problem in young population and its impact in terms of pain, impairment of function, and oral health-related quality of life of the population is high, especially the disadvantaged individuals and communities. Despite the widespread use of fluoride dentifrice, preschool children, compared to the other age groups, still show a high number of untreated caries lesions.[1]

Conventionally, the management of the carious lesions follows surgical eradication of the carious tissue and the replacement with a suitable restorative material.[2] Subsequently, minimal invasive dentistry (MID), which aims at maintenance of the sound tooth structure using non-invasive techniques, has replaced the conventional procedures.[3] Treatments such as arresting the carious lesions can be delivered at the community level regularly to halt the progression of the carious lesion.[4] Though not new, silver diamine fluoride most recently had demonstrated amplified attention by clinicians globally due to its effectiveness in arresting the progression of carious lesions.[5,6]

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.[1]

In recent times, silver diamine fluoride has been popularized for its capability to stop the caries progression and concurrently arrest the formation of new carious lesions. (Fung et al. 2018; Zhao et al.) Also, SDF can be used in children who are too young to have their carious teeth restored by traditional methods.[8] Present review of literature aims to discuss silver diamine fluoride in detail.

HISTORY OF SDF

Japanese have used silver as tooth cosmetics to prevent dental caries for 1000 years. (de Olivera Carrilho 2017) In 1891, silver amalgam and nitric acid was used on carious teeth and had caries arresting properties. Silver nitrate was directly applied to carious cavities with analogous outcomes, and it was termed as Howe's solution, which was used for caries inhibition. In Western Australia, 40% silver fluoride (AgF) was applied as the treatment for deep dental caries in primary teeth at school dental care services. Until the late 1960s and 1970s, SDF was not much exposed to other parts of the world other than Japan. (Koch et al. 2017; Clemens, Gold, and Chaffin 2018)[8]

Craig et al. (1981)[9] reported that AgF solution was used in dentistry as early as the 1970s. A similar compound, SDF, has been accepted as a therapeutic agent by the Central Pharmaceutical Council of the Ministry of Health and Welfare in Japan for dental treatment since the 1960s.[10] A solution of 38% SDF was also used in China to arrest caries. Also, a few dentists in Southern California who used SDF to arrest caries of young children with early childhood caries.[11] Community projects using SDF to arrest caries were planned for Cuba, sub-Saharan Africa and in several African countries. The use of SDF is quite scarce during this period and not much literature is available in English during this period.[12]

COMPOSITION AND PHYSICAL PROPERTIES OF SDF

Silver fluoride is a colourless aqueous solution containing silver ions and fluoride ions; solution consisting of silver (254,709 ppm) and fluoride (44,860 ppm) ions.[12] SDF can be stored conveniently at a steady pH of 10.4 for a considerable amount of time and is also more stable than silver fluoride.[13] Ammonia helps in reducing the oxidative potential of SDF, thus, increasing its stability and deionized water acts as a liquid base The liquid has a specific gravity of 1.25 and presents with pungent ammonia odor.[14]

Few of the commercially available SDF include advantage arrest (38% SDF), Bioride (30% SDF), Cariestop (12% and 38% SDF), Cariostatic (10% SDF), Dengen Caries arrest (38%), FAgamin 38%, FluoroplatV (38%), Riva Star (38% SDF), and Saforide (38% SDF).[15]

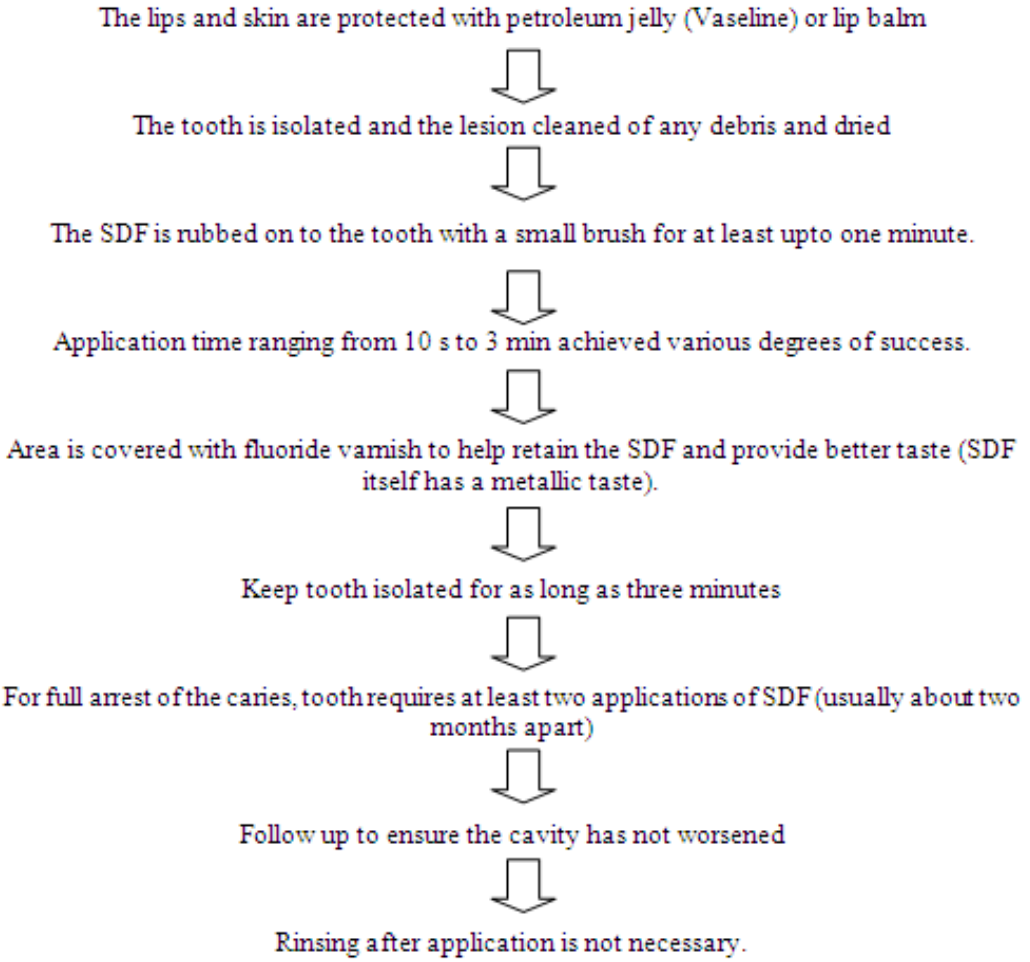
MECHANISM OF ACTION

The phenomenal mechanics behind the success rate of SDF pertains to the dual activity portrayed by silver and fluoride. The anti-microbial effect of silver is due to the fact that, there is an interaction between the sulfhydryl groups of proteins and DNA of the bacteria with silver ions that leads to the inhibition of respiratory process, DNA-unwinding, cell-wall synthesis, and cell division.[16] Different theories proposing the mode by which SDF acts are as follows:

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.[17] 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.[13]
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 (Ag(NH3)2F) reacts with hydroxyapatite (HA) of tooth to release calcium fluoride (CaF2) and silver phosphate (Ag3PO4), resulting in hardening of affected dentine. The Ag3PO4 that is formed on the tooth is insoluble to acid attacks. The CaF2 formed as a reaction product becomes a pool of fluoride ions for the formation of fluorapatite (Ca10(PO4)6F2).32 It is also proved that fluoride ions enhances calcification of tooth, and restores lattice imperfection,33 and improves the crystallinity of HA.[18,19]
3. The anti-enzymatic actions of the reaction products between Ag(NH3)2F 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.[20,21]

Zombies effect is another proposed theory that signifies the action of silver component present in SDF, which is responsible for the solution's antibacterial property. It states that the bacteria killed by silver show biocidal activity and effectively kill the remaining living bacteria. The metal-induced biocidal action occurs wherein metallic species remain activated, and the dead bacteria act as a reservoir that releases metallic cations which are lethargic in nature and act against the viable bacteria.[16]

APPLICATION OF SDF[22]



APPLICATION OF SDF IN DENTISTRY

MANAGEMENT OF DENTAL HYPERSENSITIVITY

Dental hypersensitivity is characterized by varying severity of pain, initiated by the thermal, chemical, tactile, evaporative, or osmotic stimulus. The most widely accepted theory of its pain mechanism is that the mentioned stimuli can cause inward or outward fluid displacement in dentinal tubules, which activates intrapulpal nerve endings.[23] SDF has been shown to reduce the dentinal hypersensitivity in various studies. It prevents or treats dentinal hypersensitivity by occluding the dentinal tubules. The occlusion is achieved due to precipitation of proteins in dentinal tubules by silver ions. Moreover, fluoride ions in SDF can form calcium fluoride when these ions react with free calcium. The calcium fluoride can block the dentinal tubules.[24]

The clinical procedure is similar to treating caries. The hypersensitive teeth can be isolated with cotton rolls. The area to be treated is gently dried, and SDF is applied with a disposable microbrush. Knight and co-workers suggest applying potassium iodide immediately after SDF application. In their study, they found that potassium iodide could further reduce dentin permeability when it was applied after topical fluoride treatment.[25] Studies found that both SDF and SDF plus potassium iodide are effective and safe in desensitizing teeth 1 week after treatment.[26]

ROOT CANAL IRRIGATION

The elimination of microorganisms of root canal in endodontic treatment is fundamental for a successful treatment. Several antibacterial agents were used for root canal disinfection but resistance of the Enterococcus faecalis was reported. A laboratory study showed that 3.8% SDF exhibited 100% reduction of E. faecalis after 60-minute exposure. The SDF stained the root canal, and the application time of SDF was associated with the percentage of precipitates on pulpal dentin. SDF is also suggested to be used as an antimicrobial root canal irrigant or inter-appointment dressing. Clinical data is needed to support the laboratory findings.[27]

CARIES PREVENTIONS

When silver diamine fluoride was applied only to carious lesions, impressive prevention is seen for other tooth surfaces. Fluoride releasing glass ionomer cement (GIC) can have this effect; however, it is limited to surfaces adjacent to the treated surface and of short duration. Direct application to healthy

surfaces in children also helps prevent caries. Annual application of silver diamine fluoride prevents many more carious lesions than four times per year fluoride varnish in both children and elders.[28]

OTHER CLINICAL APPLICATION[1]

1. Treatment of molar incisor hypomineralization (MIH)
2. Treatment of recurrent caries (secondary caries) at the restoration margins
3. Treatment of incipient interproximal lesions
4. Indirect pulp treatment
5. Arresting caries to maintain the teeth nearing exfoliation
6. For management of patients with high caries prevalence like with xerostomia.
7. 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.

ADVANTAGES OF SDF[1,12]

Control of pain and infection, ease of application, low cost, minimal application time and training required, and as a non invasive method of caries arrest.

DISADVANTAGES OF SDF[1,16]

- Pulpal irritation: SDF has been reported as innocuous to the dental.
- Dental staining and gingival staining: Several studies have highlighted the black stains that appear after SDF application as one of its disadvantages.
- Does not fill the lesion and, therefore, cannot restore the form of the tooth. \
- Requires repeated applications over multiple appointments. However, follow-up for subsequent treatment is difficult.

CONCLUSION

SDF is a promising nontoxic material which can prove be a turning point concerning conservative dentistry if the patient and dental practitioners are adequately educated regarding it. Several advantages have been reported related to the use of silver diamine fluoride including the procedure being pain free and drill-free, patient and doctor-friendly caries control strategy, and management of dentinal hypersensitivity. However, the main drawback of SDF is the staining of carious dentin. Therefore, case selection is an essential aspect of this method.

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