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Applications of Silver Diamine Fluoride in Dentistry

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Various studies published in the literature around the world indicate a significant prevalence of early childhood caries (ECC). Treatment of early childhood caries (ECC) using silver diamine fluoride (SDF) has become a viable alternative, particularly for young and anxious children, because traditional restorative treatments is unlikely to combat this prevalent condition. Arrested caries is identified by the hardening of teeth and it changes its color from dark brown to black. More restorative treatments can be performed if necessary. Traditional ECC restorative treatments are not always inexpensive or feasible, as they involve patient cooperation to achieve a satisfactory result. Japan was the first country to promote silver diamine fluoride in 1960. SDF has been used to prevent the spread of caries in various Asian nations, including Japan and China. It was enacted as a fluoride to treat sensitive teeth in the United States by Food and Drug Administration (FDA). For young children or individuals with specific needs, it is painless and simple to use .The fluoride in SDF stimulates remineralization while the silver ions act as an antimicrobial agent when applied to

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carious lesions and stop cariogenic biofilms from growing. SDF also prevents future degradation of the dentin's collagen. With a 38 percent use rate, SDF has been utilized in a number of nations. According to a review, SDF is a harmless, economical caries control agent with a wide utilisation in dentistry, and it may meet the WHO Millennium Development Goal (MDG) as well as the United States Institute of Medicine's criteria. The applications of SDF in dental treatment are discussed in this article.

Keywords: Dental caries; oral health; early childhood caries; silver diamine fluoride.

1. INTRODUCTION

The widespread use of water fluoridation and fluoride-containing oral products produced significant decreases in the prevalence and severity of dental caries over the last 70 years [1]. ECC (early childhood caries) is an infectious dental disease that affects children. It is caused by a variety of circumstances and is linked to weak, unemployed, and economically challenged groups. According to the Global Burden of Disease Study, which was conducted in 2015, it was also the most common disease, impacting 560 million children and ranking 12th for deciduous teeth [2]. If the caries in children are not treated at its initial stage it can lead to caries in the primary and permanent teeth which leads to infections, discomfort, and delayed schoolwork, emergency procedures, limited growth and development of the teeth [3]. As a result, neglected caries and improper use of dental treatments are more significant community health issues impacting young children in emerging and developing countries [4]. Silver diamine fluoride (AgF(NH3)2) is a promising substance with clinical dental applications. It's a colorless, alkaline (pH 10) substance that's been utilized in dentistry for 50 years. It comes in an 8-mL vial with a 38 percent SDF concentration [5]. To reduce the burden of neglected caries, it is critical to find an economic approach of managing dental caries in young children who are at increased rate of caries and have minimal access to dental health care services [6]. A carious tooth is conventionally treated by extracting decayed tooth structure and then doing restorative procedure. Furthermore, dental caries treatment can be difficult, and may necessitate a high level of dental competence, as well as considerable equipment and restoration costs [7]. In addition, the patient's cooperation is required. Due to their low adaptive potential, this is especially problematic for extremely young children. As a result, dealing with a carious tooth in such a child can be a conundrum for the dentist. To handle untreated decay in such circumstances, halting caries treatment has been advocated [8]. In the year 1960 Japan legalized the treatment of caries in young children by SDF as a therapeutic agent. Due to its cost-effectiveness and ease of use, SDF has gained popularity in a number of other nations, including Argentina, Brazil, China, Portugal, and Australia [9]. The Food and Drug.

Administration (FDA) approved the initial use of SDF to treat dental hypersensitivity and prevention of pits and fissure caries in erupting permanent molars, root caries in the elderly, sterilize infected root canals, and control ECC (early childhood caries) [10]. SDF can also be utilized in children who are too young for typical procedures of tooth restoration. Moreover, for many children from low-income families or those who live in places with limited access to dental services, SDF application can be an economical option to manage tooth decay [11].

2. HISTORY

Silver has a lengthy history of application in medicine. Silver was probably first used in medicine for water disinfection and storage [12]. The Greeks, the Romans, and Alexander the Great (335 BC) all stored water in silver cups to keep it fresh. More recently, German obstetrician Karl Crede discovered that dilute AgNO3 (silver nitrate) solution lowered the frequency of newborns eye infections from 10.8% to less than 2%. In the nineteenth century, silver nitrate was widely used to treat burns [13]. Since 1000 years, Japanese have been using silver as tooth cosmetics to prevent dental caries. Caries arresting properties of silver amalgam and nitric acid were discovered in 1891 when they were employed on carious teeth [14]. Around 1000 years ago, in Japan, it was customary for women to dye their teeth black, a practice known as "Ohaguro," to symbolize their marital status [15]. Although it was designed to improve the appearance of teeth, it was also designed to prevent dental cavities [16]. Stebbins treated carious teeth with silver amalgam restoration

and nitric acid application and concluded that caries was successfully inhibited [17]. Howe next used $AgNO_3$ (silver nitrate) directly to carious lesions with comparable outcomes, coining the term "Howe's solution." For the next 50 years, it was used to prevent caries.

SDF has been employed in a variety of public health care programmers in various countries like India, Japan, Brazil, France and Spain [18]. SDF had little exposure to other regions of the world until the late 1960s and early 1970s. 11 SDF has also been used to prevent dental decay in Australia12 and China13 for decades [19]. Although it was stated in a 1995 article in an American journal that certain dental health care practitioners in Southern California used silver diamine fluoride to stop further progression of dental caries pr in children with arresting caries [20]. On the other hand silver diamine fluoride was not widely available in various European and American countries [21]. The US Food and Drug Administration authorized SDF in 2014 [22,23]. Though its widespread usage as a caries-preventive agent in school-aged children began in China around the turn of the century, a series of in vitro experiments were undertaken in Australia from 2005 to 2009 [24]. Silver diamine fluoride was employed as an anticarious agent by Yee et al. in Nepal and Braga et al. in the United States in 2009 [24]. SDF was first used to prevent root caries in the elderly in 2013. Silver diamine fluoride (SDF) was first used in treatment of root caries in young children and adults in 2013 [25]. In India, 24 studies were undertaken to provide literature on the effective usage of SDF as a caries arresting agent. Silver diamine fluoride (SDF) was proven to be efficient in halting active caries in deciduous teeth of young children in the United States, according to a study published in 2018 [26]. Parents were also in favor of this treatment, despite this, multiple studies are being conducted in many countries around the globe in order to prove silver diamine fluoride as a tool for dental practitioners to use in preventing caries [27].

2.1 Comparing Silver Diamine Fluoride with Silver Fluoride

Silver fluoride (SnF2) contains silver and fluoride ion solution with a neutral color. It is alkaline in nature with a PH of 11. A two stage procedure is used to apply SDF, in which the reducing agent is SnF2. SDF is less reactive when compared to silver fluoride and it maintains its constant concentration. When compared to silver fluoride SDF is less alkaline with a pH of 8-9 and it does not require the reducing agent. Though SnF2 is more water soluble it converts to colorless cubic crystals. Silver diamine fluoride (SDF) is a combination of NH3 (ammonia) ions and SnF2 (silver fluoride) ions .Ammonia ions and silver ions combines and forms, a complex ion which is also known as the diamine–silver ion [Ag (NH3)2] +. This reaction is reversible and is stable in nature. AgF is not easily accessible as compared to SDF. The commercial preparation of SDF is more easily available as 38% solution as Saforide in Japan. Saforide consist of 380 mg water-soluble SDF in 1 ml colorless aqueous solution, and 44,800 ppm of fluoride ions. SDF is available commercially as Fluoroplat in South America. A 38% SDF solution is also used in Australia. It is sold in India under the brand name FAgamin in a concentration of 38 percent.

3. MECHANISM OF ACTION

Various mechanism of action has been proposed for silver diamine fluoride. According to various studies, it is indicated that the reaction of silver with sulfhydryl groups of proteins and deoxyribonucleic acid alters the bonding of hydrogen ions [8,1]. The effects like bacterial killing and inhibition of biofilm formation is caused by changes like DNA replication, cell-wall biosynthesis, and mitosis on macro level. Following are the three mechanisms of action of SDF on caries given by Shimizu and Kawagoe (1976) [28].

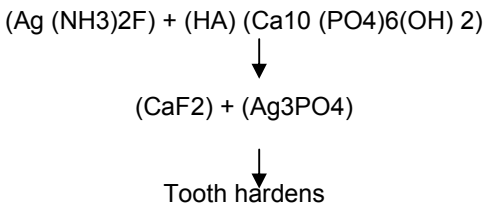
3.1 Obturation of Dentinal Tubules with Silver

As stated by Shimizu, after applying SDF on the surface of dentine, the SDF becomes less permeable and electric impedance is increased. He also stated the blockage of acid by diffusion and invasive microorganisms by silver and its compounds due to application of SDF [29]. Silver's oligodynamic action also prevents microorganisms from growing further. Due to blocking of the dentinal tubules the surface area of dentin also reduces and it becomes vulnerable to caries. It was also discovered that using 38 percent SDF slowed demineralization and protected collagen from degradation in dentin that had been demineralized [30].

3.2 The Reaction between SDF and Minerals of the Tooth Leads to a Cariostatic Action

SDF contains fluoride which results in lesser diffusion of acidic content into the dentinal tubules. After the application of SDF to the dentin, the fluoride ions present in SDF enters to a depth of 50–100 μ [31]. SDF when combined with the hydroxyapatite crystals of the tooth release calcium fluoride (CaF2) and silver phosphate (Ag3PO4), which leads to the hardening of affected dentine [32].

3.3 Chemical Reaction



The Ag3PO4 formed after reacting with calcium fluoride becomes insoluble and resistant to diffusion of acid. During the synthesis of fluorapatite, calcium fluoride (CaF2) formed as a reaction product becomes a source of fluoride ions [33]. Fluoride ions leads to the calcification of tooth, it improves lattice imperfection, and enhances the crystalline structure of hydroxyapatite crystals of the tooth [34].

3.4 The Reaction Byproducts between Ag (NH3)2F and the Organic Component of the Tooth Leads to Enzyme Inhibitory Effect

Due to the enzyme inhibitory activities and dextran-induced coagulation of cariogenic strains of Streptococcus mutans it attributes the antibacterial properties [35]. When SDF is applied on tooth surface, the dentin becomes highly resistant to trypsin. According to a study, after treating a tooth with SDF, the resistance to collagenase and trypsin for dentin protein increases [36].

4. CLINICAL APPLICATIONS

4.1 As an Agent to Prevent Pit and Fissure Caries

Due to morphological factors, pits and fissure caries are more prevalent than the smooth surface caries. Tooth brushing technique alone is not efficient to clean pits and fissures [37]. While it is difficult to detect incipient lesions at pits and fissures. Also the fluoride application is less effective in preventing pit and fissure caries. Due to anticarious properties of SDF it is effective in preventing pits and fissure caries [38].

4.2 As an Agent to Prevent Secondary Caries

Oral fluids, bacteria, and food remnants get between the cavity walls and the restorations. As a result, the cavity wall may be at risk of recurrent caries. The cavity wall's resistance to caries must be improved to prevent recurrent caries [39]. Dental practitioners in today's time use restorative materials which adhere to the tooth structure or are totally insoluble in oral fluids. Some researchers have discovered that no recurrent caries on amalgam restorations can be identified on primary teeth that had been pre-treated with SDF [40].

4.3 As an Agent to Arrest Root Caries

Root caries is more prevalent in elderly people. SDF acts as an anti carious agent even on the root surfaces of the teeth and hence hampers the formation of caries on roots; therefore annual application of SDF is advised to older individuals [41].

4.4 As an Agent to Desensitize Sensitive Teeth

SDF has the ability to occlude the dentinal tubules; therefore it can be used as a desensitizing agent for the people who suffer from dentin hypersensitivity [42].

4.5 As an Agent to Treat Infected Root Canals

Ammoniated silver nitrate solution is used while treating infected root canals. According to Tanaka, an aqueous solution of silver fluoride contains strong disinfecting agent and protein-coagulating properties; also it is potential to occlude the dentinal tubules present in root canal walls [43]. Okamoto et al stated that the use of SDF solution reduced the number of dental appointments and dental treatments [44]. SDF can be used to overcome the caries related problems In Public dental health programmes held in various developed nations.

Bedi and Infirri (1999) have states some advantages of SDF which are as follows [45].

•SDF controls the pain and infection.
. SDF acts as an effective agent in arresting caries
• SDF treatment is cost effective and affordable.
• The procedure of SDF treatment is simple.
. Due to simple treatment procedure, it is easy for nondental professionals including primary health care workers to apply SDF to children's teeth and Minimal support is required.
• SDF treatment does not require high cost equipments or support infrastructure.
• SDF treatment is non-invasive therefore there is less risk to spread infections.

. SDF is used for the management of patients with high caries prevalence like xerostomia and children with behavioral problems.
. It is used as an anti-caries agent in anterior and posterior teeth of children.
. Earlier zinc oxide eugenol was used as a temporary restoration to treat rampant caries. SDF acts as a better substitute for the patients with irregular caries pattern.

4.6 Contraindications[46]

1.Allergy to silver or silver-containing compounds.
2. Pregnant women.
3. Lactating mothers.
4. SDF may aggravate open mouth sores which are sensitive (e.g. herpetic gingival stomatitis, ulcerative gingivitis).
5. Teeth that require pulpal therapy.
6. Where sufficient isolation of a tooth and oral tissues cannot be achieved
7. Individuals at risk for developing a silver allergy from other medical conditions (e.g. in burn patients silver sulphadiazine is used for treatment procedures).

4.7 Safety [47]

The dental services of Western Australia's health department conducted a study and got no proof to substantiate the claim that using Ag (NH3)2 F causes fluorosis.

Vasquez et al. also made a brief study that revealed that plasma fluoride and silver concentrations following topical administration of SDF represent no toxicity risk.

Oral administration yields an LD50 of 520 mg/kg, while subcutaneous administration yields an LD50 of 380 mg/kg. One drop of 9.5 mg SDF (25 L) is enough to treat five teeth. If the young patient weighs 10 kilograms, the dose would be 0.95 mg per kilogramme of body weight. As a result, using a full drop on a 10kilogramme child has a relative safety margin of 380 mg/kg LD50 / 0.95 mg/kg dosage = 400-fold safety margin.

4.8 Steps for Application of Silver Diamine Fluoride

1. Counter should be covered with plastic and put a plastic bib over the patient.
2. Both the patient and the provider must wear standard personal protective equipment.
3. In a dappen dish, put one drop (25 uL/10kg each treatment visit) of SDF [47].
4. Isolate the impacted tooth or teeth.
5. Apply Vaseline on your gums.
6. using the tiniest micro sponge, apply SDF to the teeth.
7. Wait for 1 minute after applying the product before removing the unwanted material with a cotton gauge [7].
8. Wash well with water.
9. Carry out the operation once after six months [47].

4.9 Adverse Effects of SDF

When SDF was applied to particular teeth to arrest or prevent dental decay in several investigations, the only adverse effect was a minor, moderately painful white patch in the mucosa that resolved after 2 days without any therapy after 3 years. There was no evidence of a negative pulpal reaction [4, 5].

4.10 Other Side Effects of SDF

1. Carious lesions blacken by SDF.
2. Patients may have a metallic or bitter taste for a short period of time [5].
3. A small amount of SDF can cause a "temporary tattoo" on the skin, but this is not harmful.

In 2-14 days, the stain on the skin will fade due to natural skin exfoliation [9,24].

4. While using SDF, it leaves the color on surrounding surfaces and clothes. Spillages should be cleaned up as soon as possible with plenty of water, ethanol, or bleach.

5. CONCLUSION

According to this review, SDF inhibits the growth of cariogenic bacteria. The silver ion has antibacterial properties.

Both enamel and dentine cavities can be rematerialized using SDF. SDF's ability to prevent caries may be ascribed to its ability to block mineral demineralization, promote mineral remineralization, and protect the collagen matrix from deterioration.

When SDF is applied twice a year, it exceeds all other non invasive treatments.

Apart from other dental sealants, which are more expensive and require professional follow-up, SDF is more effective as a primary preventive material than other restorative materials available.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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