



## Using Silver Diamine Fluoride to Arrest Dental Caries: A New Approach in the US

Tarik Y Khamrco Shounia\*, Salwa Atwan and Rehab Alabduljabbar

Department of Pediatric Dentistry, School of Dentistry, University of Detroit Mercy, USA

### Abstract

SDF has been used for decades in many Asian countries, Australia, and South America as an effective measure of arresting active caries. In 2015, the Food and Drug Administration (FDA) in the US cleared SDF for reducing tooth sensitivity for adults 21 years and older. Professionals can use SDF off-label to arrest carious lesions same as using fluoride varnish to prevent caries. In 2016, a CDT code was approved for caries arresting medicaments to facilitate documentation and billing. Due to SDF's safe, effective, inexpensive, and simplicity in application, it is considered an appropriate therapeutic agent to prevent and arrest caries use in community dental health programs. We present this review to summarize the mechanism of action, clinical application, uses, advantages, safety and adverse effects, and codes in dentistry.

**Keywords:** Silver diamine fluoride; Fluoride varnish; Dental caries; Silver

### Introduction

Dental caries is the most common childhood disease worldwide. Between 60% and 90% of children are affected, but the majority of dental decay remains untreated due to inappropriate, unaffordable, or unavailable oral care services [1]. Many studies in developed countries show remarkable improvement in child dental health, but significant proportion of low income, socially vulnerable and minority children continue to be at risk of dental caries [2,3]. These underserved populations mainly receive extractions when they seek dental care. It is difficult to manage many young children when administering local anesthesia or using conventional rotary instrument to remove caries. Also some unique clinical circumstances may not permit traditional cavity preparation and/or placement of traditional dental restorations [4]. Thus, for these circumstances, there are many conventional noninvasive caries management technique such as Atraumatic/Alternative Restorative Technique (ART), and Interim Therapeutic Restorations (ITR). In addition, the World Health Organization (WHO) actively promotes these techniques as an available approach to the need for treatment of dental caries in developing countries where skilled dental personal and other resources are not readily available. More recently, these techniques have become increasingly accepted in developed countries. The application of SDF is a perfect alternative treatment for dental caries for many circumstances. This procedure is painless, does not need local anesthesia, is accepted by children, and can be used without drilling the tooth. Many studies in Asia, Australia, and South America reported that 38% SDF is effective in preventing and arresting dental caries [5-7]. Compared with ART or IRT, SDF has been shown to be more effective in arresting dental caries [8]. Recently, the FDA cleared SDF to be used in the US for reducing tooth sensitivity and can be used off-label to arrest carious lesions similar to using fluoride varnish. The US dental professionals are more enthuse to know more about using SDF as a prophylactic and preventive measure after it was cleared by FDA.

### Silver Diamine Fluoride

SDF 38% is a colorless liquid that at pH 10 is 24.4% to 28.8% (weight volume) silver and 5% to 5.9% fluoride [9]. SDF application is done by using proper isolation of the carious tooth after being dried gently. The tooth is isolated with cotton rolls and the soft tissue is protected with Vaseline or petroleum jelly. Afterwards, 1-2 drops of SDF solution are dispensed into a disposable dappen dish, and gently applied with a micro brush to the affected surface(s) of the tooth/teeth in quadrant. The excess solution is then wiped off to prevent bad taste and ingestion.

### History

Bactericidal activity of silver ion has been known since ancient times around 1000 B.C. [10].

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#### \*Correspondence:

Tarik Y Khamrco Shounia, Department of Pediatric Dentistry, School of Dentistry, University of Detroit Mercy, USA,

E-mail: shounity@udmercy.edu

Received Date: 05 Sep 2017

Accepted Date: 15 Oct 2017

Published Date: 22 Oct 2017

#### Citation:

Shounia TY, Atwan S, Alabduljabbar R. Using Silver Diamine Fluoride to Arrest Dental Caries: A New Approach in the US. *J Dent Oral Biol.* 2017; 2(18): 1105.

ISSN: 2475-5680

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Silver nitrate used in medicine for ages. The first dental use was in 1846, and it was used to treat erosion. In dental field, silver nitrate was applied directly to a carious lesion, and it was found that it prevented caries progression [10]. In 1891, Stebbin [11] reported that teeth filled with amalgam filling displayed black surfaces, while the progress of caries ceased. In 1960, SDF has been accepted as a therapeutic agent for arresting dental caries by the Central Pharmaceutical Council of the Ministry of Health and Welfare in Japan [12]. SDF initial use in Japan was in 1960s and 1970s. After that, it lost its charm and was not used in other countries. Until 21<sup>st</sup> century, it started to be used again in China as well as in many countries such as Japan, Australia, Nepal, Philippines, Cuba and several African countries. In USA, before the FDA cleared SDF, some American dentists sequentially applied silver nitrate followed by applied fluoride varnish to carious lesion as the only available "atraumatic" procedure to treat dental caries [13,14]. In a study for the use of this procedure, the author reviewed of randomly selected charts showed only 7 of 578 treated teeth progressed to the point that extractions were needed within 30 months [14]. Now many dentists in USA use SDF to treat and prevent dental caries and many dental schools have started teaching the next generation of pediatric dentists how to use it.

### Mechanisms of Action

Multiple modes of action have been proposed for SDF on arrested caries.

- The first mechanism is by forming a product which is more resistant to bacterial challenge and increase the resistance of peri-tubular and inter-tubular dentin to acid decalcification and as a result retard the penetration of acid into deeper layers of the dentin [15]. Silver and fluoride ion penetrate 50-200 microns into dentin. A fluoride promotes re-mineralization by formation of fluorapatite which is responsible for increased dentin hardness and preventing dental caries, while silver act as an antimicrobial agent. Yamage et al. [16] considered the combination of fluoride and silver ions may prevent both calcium and phosphate ions from being lost. Also they suggested that a deposit of silver phosphate is the main mechanism of SDF responsible for the increased hardness and black staining of the arrested lesion.

- The second mechanism is by obturation of dental tubules. Therefore acid and cariogenic microorganisms can't invade through this, thus arresting the caries process. By blocking of dentinal tubules, the sensitivity decreases in treated teeth (desensitizing) [17].

- The third action is antienzymatic by inhibiting bacterial enzyme activities, which disrupt the metabolic process causing death of the cariogenic bacteria and reducing their colonization. SDF reduce the colonization of cariogenic bacteria by inhibiting the formation of biofilm on the enamel surface and dextrin induced agglutination of cariogenic strains of *S. mutans* [18,19]. Chu et al. [20] reported that SDF possesses an antimicrobial activity against cariogenic biofilm of *S. mutans* or *A. naeslundii* formed on dentin surface. Also, they showed that SDF slowed demineralization of dentin. This dual activity could be the reason behind the clinical success of SDF.

### Clinical Studies of SDF to Arrest and Prevent Dental Caries

Many clinical trials have found that 38% SDF solution is effective in preventing new coronal caries in primary and permanent teeth, even though blackening of the carious lesion may occur [5,6,21].

A 36-month controlled clinical trial were carried to evaluate the effectiveness of six-monthly application of SDF 38% to arrest the development of caries in the primary teeth of six-year old school children and prevent caries in their first permanent molars. The result indicated that 77% of treated caries was active at baseline became inactive during the study [5]. Also as a result of the fluoride content, SDF has been shown to lower caries risk of the adjacent tooth surface when applied to carious lesion. A study indicated that a single application of SDF 38% is effective in arresting caries lesion, but the effectiveness decreases slowly over time [22]. Other clinical trials on arresting dentin caries in primary teeth of preschool children found that the caries arrest rate of 6-monthly application of SDF was higher than that of 12-monthly application. The clinical trials also found that caries arrest increased dramatically after reapplication of SDF at 6 months or annually [23]. SDF 38% solution has been shown to be effective in arresting caries in primary teeth and thus may be considered as an alternative treatment option when restorative treatment is not feasible [24]. Comparing with other topical fluoride, SDF showed more effectiveness in arresting caries and preventing new caries than other topical fluoride [6,21,25]. A systematic review showed that SDF seems to be more effective than fluoride varnish [25]. This is possibly due to the high concentration of fluoride in SDF (44,800 PPM F), also the effect of silver ions as a potent germicidal effect and the formation of silver phosphate on the tooth surface, which is rather insoluble [16]. Other studies reported that yearly application of 38% SDF to decayed primary anterior teeth have been shown to be significantly more effective in arresting caries and preventing new caries than the application of sodium fluoride varnish (22,600 PPM F) at 3-month intervals [6,21]. Another study reported that when SDF was applied to carious lesions, remarkable prevention occurred to other tooth surfaces [5]. In some countries, when SDF is not cleared to use or not available to arrest or prevent caries, some dental professional have used 25% silver nitrate and 5% sodium fluoride. There is no evidence to show that removal of the carious tooth surface prior to the application of SDF has an effect on their ability to arrest caries. Chu et al. [6] reported no statistically significant differences in the mean number of arrested carious tooth surfaces after 30 months between children who had their caries teeth excavated prior to applied SDF and those who had not. Horst et al. [13] recommended applied SDF twice per year, only to carious lesions without excavation for at least first two years. A study reported that the use of 12% SDF was markedly less effective than 38% [22]. It has also been shown that SDF 38% is effective in treatment of root caries in the elderly. A study reported that annual application of 38% SDF was effective in arresting root caries among community dwelling elders. Also they concluded that oral health education had synergetic action with SDF application to arrest root caries [25]. A randomized study was conducted in elderly center concluded that annual application of SDF or SDF with Potassium iodide are effective in arresting active root caries after 30 months [26].

Other uses of SDF are to treat dentin hypersensitivity. Many studies reported that an effective reduction of dentin hypersensitivity can be achieved by employment of SDF in the affected area [17,27]. One of the main reasons of dentin hypersensitivity is uncovered dentin areas due to exposed dentinal tubules. A study support that SDF seems to be appropriate to reduce pain caused by dentin hypersensitivity by obliteration of exposed dentinal tubules [28]. In a randomized controlled study carried out on 126 adults with at least one tooth sensitive to compressed air were randomly assigned to either SDF or sterile water. The study tested application of SDF

in a single visit and pain was assessed at 24 hours and then again 7 days after the visit. The findings indicated that SDF reduced pain significantly in response to air in 24 hours and were maintained at 7 days. No staining of the gingival tissues was observed, while staining of teeth was found only when surfaces had untreated decay [17].

## Uses

There are many uses for SDF:

- Young children with SECC whose parents did not want them to be subjected to sedation or general anesthesia to have restorative treatment done.
- Patients with multiple carious lesions that may not all be treated in one visit.
- Patients with extreme high caries risk, such as patients with salivary dysfunction.
- Senior citizen patients when extensive restorative procedures needed.
- Patients with difficult to treat carious lesions.
- Patients with treatment challenges due to behavioral or medical issues.
- Patients who are radiation-treated oral cancer survivors.
- Patients with special needs.

## Advantages

The application of SDF has been receiving more attention due to these advantages.

- Arrest and prevent dental caries.
- Non-invasive procedure.
- It is painless; no need for local anesthesia.
- Simple and fast procedure.
- Inexpensive.
- No known side effect.
- No need for sophisticated and expensive equipment.
- Used in communities with limited resources.
- Due to low cost, it can be made available and affordable for many underserved communities.
- Can be carried out by dental auxiliaries or non-dental professionals.

## Safety and Adverse Effect of SDF

Studies that were carried out using SDF found that there were no reported cases about acute toxicity or significant adverse effects. Also, for more than 60 years of SDF use in Japan, no single adverse event has been reported to the Japanese authorities [29]. Other study reported that there were no adverse effects observed or complaints from either parents or children concerning the SDF treatment [22]. Silver diamine fluoride has been shown to be safe to the pulp when placed on exposed dentin, but should not be placed on exposed pulps [5,6]. Some concerns have been raised over dental fluorosis, and accidental toxic overdose from the use of 40% SDF for arresting dental caries [30,31], although these concerns have been refuted [32].

In many cases, mild gingival and mucous irritation can occur, but generally it will heal spontaneously within two days [5,6,13]. The non-medical side effect of SDF is black discoloration of the carious lesions, the color change is a positive indication that the treatment was effective [6]. This staining may be decreased by the application of potassium iodide immediately following SDF treatment [33]. Another side effect is staining of the skin of the body, clothes, and countertops etc. The stain does not come out once it sets. So the person applying it needs to be very careful in handling the material. The only cases where SDF should not be used are if the patient has an allergy to silver. Oral ulceration, stomatitis, or ulcerative gingivitis need to be resolved before the application in order to reduce tissue irritation.

## Effect on Dental Training Programs

Silver diamine fluoride is being rapidly adopted in graduate pediatric dentistry training programs, with the majority expecting to incorporate it into their teaching clinics and curricula [34]. A study conducted to investigate practice, teaching and perceived barriers to use of SDF in 74 US pediatric residency programs. The results indicated that more than a quarter reported the use of SDF, with 68.9% expecting to increase its use, 89.2% felt SDF should be used only with high-risk patients, and 91.8% reported the barrier to use SDF was parental acceptance [34].

## Coding

For insurance reimbursement, there are codes used to arrest dental caries or for the treatment of hypersensitivity (D1208 and D9910). The SDF code that was provided for reimbursement is: Code D1354: Interim caries arresting medicament application. Maximum of 6 applications per lifetime are allowed.

## Conclusion

Silver diamine fluoride has been shown to be a successful treatment for arresting caries and also prevent the occurrence of new carious lesions. It is considered a non-invasive procedure that is cheap, quick and simple to use. It has great potential, especially for early childhood caries, fearful adults, special need children and adults, patients with salivary dysfunction, and patients with treatment challenged by behavioral or medical issues. In addition, SDF application does not require complex training of the dental or health professionals. Silver diamine fluoride is more effective as a preventive measure to dentinal caries compared with other type of fluoride application, ART and ITR. The only disadvantage of using SDF is that the lesion will be stained black.

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