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Review Article

The Effectiveness of Arresting Caries Using Silver Diamine Fluoride: A Review

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Abstract

Dental caries is the most common childhood chronic disease worldwide. Early childhood caries (ECC) is the presence of 1 or more decayed, missing, or filled tooth surfaces (dmfs) in any primary tooth in a preschool-aged child, it has been recognized by the American Dental Association as an important public health issue. Silver diamine fluoride (SDF) has been used as an alternative method for caries prevention and arrest. In 2014, SDF was approved by the US Food and Drug Administration as a treatment for dentinal sensitivity. SDF had been used off-label for caries arrest; however, it was recently approved (code D1354) as an interim caries arresting medicament. The use of SDF poses little toxicity or fluorosis risk when used in adults and children. No adverse effects of using silver compounds have been reported in more than 80 years of use in dentistry. Silver allergy is the only known contraindication. Although not significant, SDF was more efficient in reducing the number of new carious surfaces when compared to fluoride varnish and APF Gel.

Keywords: Silver Diamine Fluoride; Dental Caries; Children

Introduction

Dental caries is the most common childhood chronic disease worldwide [1]. Early childhood caries (ECC) is the presence of 1 or more decayed, missing, or filled tooth surfaces (dmfs) in any primary tooth in a preschool-aged child, it has been recognized by the American Dental Association as an important public health issue [2]. If ECC remains untreated, oral health–related quality of life, body weight, growth, school attendance, and school performance can be affected [3]. In addition, children with ECC treated under general anesthesia have a higher predisposition to develop dental caries in the permanent dentition [4]. Because a severe ECC experience is an important predictor for adult caries, strategies to prevent and control ECC are important to improve general and oral health [5]. Effective ECC preventive measures include the use of fluoride varnish—such as 5% sodium fluoride (NaF)—and the use of fluoridated toothpaste [6,7]. It has been recommended in the management of cavitated ECC, and atraumatic restorative treatment (ART). Silver diamine fluoride (SDF) is a colorless liquid containing silver particles and 38% (44,800 ppm) fluoride ion at pH 10 is 25% silver, 8% ammonia, 5% fluoride, and 62% water. SDF has been widely used in Japan for prevention and arresting caries in children since the 1960s. It has been also used in other countries like Australia, China, Cuba, and Nepal. Interest in the use of silver diamine fluoride (SDF) has been growing. SDF has been used as an alternative method for caries prevention and arrest [8]. In 2014, SDF was approved by the US Food and Drug Administration as a treatment for dentinal sensitivity [9]. SDF had been used off-label for caries arrest; however, it was recently approved (code D1354) as an interim caries arresting medicament [10].

Mechanism

SDF also has antibacterial properties. Silver ions bind with negatively charged peptidoglycans in bacterial cell walls and disrupts the membrane transport function, which in turn leads to cellular distortions and loss of viability. Binding to sulphydryl groups (thio group of cystine), which is essential for enzyme activities, can inhibit bacterial enzyme activities, disrupt metabolic processes, and eventually cause death of the microbe.

In vitro studies have demonstrated that SDF increases the pH of biofilm, reduces dentin demineralization, and has antimicrobial action against cariogenic bacteria [11]. However, treated teeth sometimes develop black stains as a result of silver phosphate

precipitation [12]. *Ex vivo* and *in vivo* studies on cavitated extracted teeth from children receiving semiannual applications of SDF have shown effectiveness in arresting lesions and also higher fluoride uptake compared to fluoride varnish and acidulated phosphate fluoride gel [13,14]. *In vitro* studies suggested that silver fluoride regimens inhibit *Streptococcus mutans* growth [15] and penetrate enamel to a depth of 25 microns, and that approximately two to three times more fluoride is retained than that delivered by sodium fluorophosphates (NaF-PO4), sodium fluoride (NaF), or stannous fluoride (SnF2) [16]. The *in vitro* studies suggest that the effect of SDF may be greater than that of NaF or SnF2. The creation of a silver nitrate fluoride construct - silver diamine fluoride (SDF) - combines these two preventive agents [17].

The overall reaction can be summarized as:

$$Ca_{10}(PO_4)6(OH)_2 + Ag(NH_3)2F = CaF_2 + Ag_3PO_4 + NH_4OH$$

SDF is thought to arrest and prevent decay progression by

(1) Killing the causative bacteria,

(2) Depositing a layer of protective silver phosphate that resists further decay, and

(3) Converting the more acid soluble hydroxyapatite to the less soluble fluorapatite

The specific interest in silver diamine fluoride (SDF) centers around its five presumed attributes [15]:

(1) Control of pain and infection;

(2) Ease and simplicity of use (paint on);

(3) Affordability of material (pennies per application);

(4) Minimal requirement for personnel time and training (one minute, once per year); and

(5) The fact that it is non-invasive.

Discussion

The purpose of arresting caries treatment is to halt or slow down caries progression in order to minimize the discomfort and potential pulpal damage. When fluoride is introduced into the oral cavity it is cleared with passage of time; hence a continuous supply of fluoride is essential for anti-caries effect. Studies have shown that Silver diamine fluoride greatly outperformed fluoride varnish for caries arrest and was equivalent or better than glass ionomer cement. Different concentrations of SDF (10%, 12%, 30%, and 38%) are available. SDF review articles have recommended the use of a 38% concentration intervention for prevention and arrest of dental caries in children [18,19]. In a review by Contreras *et al*. the use of SDF at concentrations of 30% and 38% was more effective for arresting caries [20]. SDF is used as an alternative treatment for controlling dental caries when other approaches are not available. It is a minimally invasive, low-cost, and simple method that can reduce fear and anxiety in young children. In addition, it could be applied in community settings [21,22]. The main adverse events associated with SDF applications are pulpal irritation, dental staining, and oral soft tissue irritation [17]. Skin pigmentation is temporary as the silver does not penetrate the dermis. Desquamation of the skin with pigmentation occurs when keratinocytes are shed over a period of 14 days [26]. SDF has been reported as harmless to the dental pulp. Several studies have highlighted the black dental stains that appear after SDF application as one of its disadvantages [12].

Zhi., *et al.* found that the caries arrest rate of 38% SDF was higher with biannual application than with annual application [24]. Llodra., *et al.* used biannual application of 38% SDF and also observed significant caries arrested on primary molars of children [25]. It has approximately 2-3 times more fluoride retained than delivered by sodium fluoride, stannous fluoride, or acidulated phosphate fluoride (APF) commonly found in foams, gels and varnish. Moreover, the use of SDF has not shown to reduce adhesion of resin or glass ionomer restorative materials. The use of SDF poses little toxicity or fluorosis risk when used in adults and children [19]. No adverse events using silver compounds have been reported in more than 80 years of use in dentistry [17,23]. Silver allergy is the only known contraindication.

Conclusion

In conclusion, arresting caries treatment with SDF can be used as a method to prevent caries from progression. Black staining of the carious lesions is a major disadvantage of SDF treatment. Mild but transient gingival irritation can also occur in the gingival margin, which usually heals spontaneously in two days. Enamel fluoride content was increased significantly even after 6 months of application of SDF compared to Fluoride Varnish and APF Gel. Although not significant, SDF was more efficient in reducing the number of new carious surfaces when compared to fluoride varnish and APF Gel.

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