

Silver Diamine Fluoride – the magic bullet! Is it really a magic alternative in caries management

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ABSTRACT

The goal of modern dentistry is to treat cavitated or non-cavitated teeth through non-invasive remineralization to prevent further progression of caries and to improve the function of teeth. Many preventive interventions have been put forward as an alternative to conventional restorative procedures; silver diamine fluoride (SDF) is one amongst them. SDF can arrest progression of carious lesion at a concentration of 12% and 38% preventing further caries growth. The aim of this paper is to consider whether SDF is really a magic alternative in caries management or not.

Keywords

Silver diamine fluoride; magic bullet; caries management; untreated caries

Non-preventive method encompasses mechanical cavity preparation followed by restoration with a more suitable material that is not only expensive, but also depends on the clinical skills of the operator and patient cooperation and the children with special needs to a great extent.^{1,6,8}

Preventive caries control protocol includes nutritional counseling, use of fluoride, oral hygiene instructions, topical application of antimicrobial agents and SDF. SDF is a recently approved topical medicament used as non-invasive treatment that is cost effective,

INTRODUCTION

One of the most common oral diseases affecting human population is dental caries with a prevalence of 69-79%. It progresses from the external surface of a tooth to the inner most vital part of it by demineralizing the tooth structure with organic acid producing microorganisms. If left untreated, it can lead from mild symptoms to severe disturbances such as pain, sleeping disturbances, difficulty in eating and drinking, poor school performance, infection and swelling. Untreated caries affects not only the oral health but also the overall general health and wellbeing of the children.¹⁻⁷

The traditional way of dental caries management involves preventive and non-preventive methods.

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antimicrobial, and remineralising agent in arresting carious lesions.^{1,4}

It is a neutral colored ammonia solution containing silver (Ag) and fluoride (F) ions that has an alkaline pH below 10. Silver ions acts on the inhibition of caries growth causing bacterial biofilms; fluoride ions have the ability for remineralization of dental hard tissue. SDF not only inhibits the caries progression but also prevents the development of a new carious lesion. It is two times more effective than fluoride varnish.⁸ A highly remineralized zone rich in calcium and phosphate have been reported in post-treated cavitated carious lesions with SDF.³

Studies showed a 38% SDF to be very effective in inhibiting demineralization of dentine and preserving degradation of collagen than at 12% concentration.^{9,10} When the caries is arrested, a primary tooth acts as a natural space maintainer, can sustain its masticatory function until a permanent successor tooth replaces it.^{4,7} However, SDF treated tooth develops black stains because of formation of silver phosphate precipitation but according to some studies, application of potassium iodide solution (KI) immediately after SDF treatment results in the formation of a yellow precipitate on the dentin in the form of silver iodide, thereby decreases the availability of silver ions that is staining the dentin black.^{11,12}

Which patients are candidates for sdf use?^{13,14}

- Anterior or posterior teeth with high active cavitated caries lesions.
- Multiple cavitated caries lesions that requires multiple dental visits.
- Pit and fissure caries of first molar.
- Dentinal hypersensitivity.
- Very young children where treatment of active caries lesions are very difficult.
- Patients with special health care needs and
- Can be used in community based caries control program especially in low income or in developing countries.

Mechanism of action¹⁵⁻¹⁸

Studies showed that SDF acts in many ways against arrest of caries:

1. The first mechanism is by formation of silver phosphate that is more resistant to bacteria;

increases the resistance of peri-tubular and inter-tubular dentin to acid decalcification by slowing down the acid penetration into deeper layers.

2. The second mechanism is by blocking the dentinal tubules thereby arresting the caries progression. The acid and caries causative microorganisms can't invade through dentinal tubules.
3. The third action is by disrupting the metabolic process of bacteria leading to the death of the causative microorganisms by inhibiting its bacterial enzyme activity.
4. SDF also has antimicrobial properties. Silver ions can bind with negatively charged peptidoglycans in bacterial cell walls which in turn lead to cellular distortion and loss of its viability.

Various studies on silver diamine fluoride against carious lesion in recent years

Uchil *et al.*,¹⁹ conducted a study on carious primary teeth to evaluate the effect of the application of SDF, with and without acid etching and KI on the bond strength of resin-modified glass ionomer cement. They concluded that, application of SDF with or without acid etching and KI does not affect the bond strength of resin-modified GIC to carious dentin of primary teeth. Pre-treatment with SDF and KI may be considered after selective caries excavation to arrest caries, as it does not interfere with the bonding of RMGIC to carious dentin in primary teeth.

According to Zhao IS *et al.*,²⁰ because of the bactericidal action of silver ions present in SDF, it helps in reduction of growth of cariogenic bacteria. The possible mechanism of action of SDF in caries arrest may be due to protection from degradation of collagen matrix by its inhibiting action on mineral demineralization, and thereby promoting the mineral remineralization.

Tarik *et al.*,²¹ demonstrated a new approach in arresting caries lesion which is non-invasive, cheap, quick and simple procedure by using SDF. They opined that it also promotes remineralization there by prevents the occurrence of new carious lesions.

Duangthip *et al.*,²² conducted 18 month clinical study on dentin caries arrest in preschool children. They concluded that weekly application of 30% SDF for 3 consecutive weeks is more effective than fluoride varnish.

Mei *et al.*,²³ conducted a study on antibacterial

effects of SDF on biofilm of cariogenic multi-species (*Streptococcus mutans*, *Lactobacillus acidophilus*, *Lactobacillus rhamnosus*, *Streptococcus sobrinus* and *Actinomyces naeslundii*). They concluded that 38% SDF inhibits the biofilm formation and also reduces the demineralization process.

Liu *et al.*,²⁴ conducted a study on the comparison of annual application of 38% SDF with semiannual application of 5% NaF varnish and resin sealant. They found that all the compared methods and materials are effective in caries prevention.

Castillo J *et al.*,¹⁶ did a study on tooth sensitivity concluded that staining of teeth was found only when the surfaces had untreated decay and found no staining on the gingival tissues.

Lidora J *et al.*,²⁵ conducted a 36-month controlled clinical trial on six year old school children to evaluate the effectiveness of semiannual application of 38% SDF in arresting the caries in primary teeth and prevention of caries in first permanent molars. They found SDF solution to be effective both in arrest of caries in primary teeth as well as in caries prevention of first permanent molars.

Method of application¹⁴

The following steps should be taken into consideration when SDF is applied:

Rubber dam or cotton rolls isolation should be advised to avoid contact of SDF liquid to the surrounding gingival tissue and mucosa, as irritation of these tissues is a common finding. Gross excavation of carious lesion should be done so that SDF solution can come in direct contact with denatured dentin. A plastic dappen dish should always be used as it corrodes metal and glass. An application time of 1 minute is usually recommended and before application, the affected tooth surface should be dried either by cotton roll, gauze piece, or by compressed air. Gentle flow of compressed air should be used to dry the SDF liquid. Any excess liquid should be removed with a cotton pellet and isolation of operating site should be continued for 3 minutes after application. No eating or drinking for 30 min to 1 hour is recommended after application of SDF in the literature.

Advantages of SDF²¹

1. Arrests and prevents dental caries.
2. Non-invasive procedure.

3. It is painless; no need for local anesthesia.
4. Simple and fast procedure.
5. Inexpensive.
6. No known side effect.
7. No need for sophisticated and expensive equipment.
8. Used in communities with limited resources.
9. It can be made available and affordable for many underserved communities due to its low cost.
10. Can be carried out by dental auxiliaries or non-dental professionals.

Disadvantages of SDF^{8,13,10,26}

1. Reported pulpal and oral soft tissue irritation.
2. Black staining of teeth involved.
3. Cannot be used during pregnancy and breastfeeding.
4. Patient's allergic to silver.
5. Cannot be used in ulcerative gingivitis and stomatitis.
- 6.

Drawbacks and possible solutions

Though SDF is considered safe even on young children, silver allergy is a complete contraindication to SDF. There are few negative side effects, most common being irreversible black stain on and around the applied area of the tooth, adjacent tissue and clothing.²⁷ In a study by Marcela Baraúna Magno *et al.*, and Woo *et al.*, they opined that the aesthetic perception of black staining is not directly related to the acceptability and satisfaction of patients and parents, but rather to the less acceptance by professional's because of its infrequent use.¹

Parental acceptance is related to the location of the teeth; more accepted in posterior teeth than in anterior's. Pre-operative instructions had significantly improved its acceptance for treatment.²

A temporary staining called 'Henna appearance' is found on the exposed oral mucosa to SDF. To overcome this, application of saturated potassium iodide (KI) immediately after SDF placement was advised by Knight *et al.* KI should be used cautiously in pregnant and lactating women as it may cause abnormal thyroid function and harm to foetus. In another study, use of nano-silver fluoride (NSF) to limit the black staining is advised.^{28,29}

However, superficial staining of oral mucosa and skin tends to resolve within days as epithelial cells slough off but unrestored caries lesions remains permanently

black which is a significant aesthetic problem especially in anterior teeth. SDF is contraindicated to those allergic to silver, have gum disease, oral ulcerations or canker sores, and exposed pulp tissue in case of extensive decay as it can cause painful reaction with acid or ammonia. Rubber dam isolation if not done to the soft tissue may cause ulcerative gingivitis, but these symptoms will subside within 48 hours.^{30,31}

Application of SDF is more effective in arresting dentin caries of maxillary anterior primary teeth compared to posterior teeth. As posterior teeth have deep curvatures, pits and fissures that tend for more retention of plaque leading to formation of more active caries lesions may be one of the cause. A thorough and proper diagnosis is indispensable during SDF usage in arresting the caries on vital teeth and is contraindicated on non-vital teeth. As mentioned earlier that ideal application time should be one minute with a flow of air to dry the SDF liquid and the subjects should not eat or drink or rinse their mouth at least for one hour after its application, this can be difficult in very young patients due to lack of cooperation. Careful monitoring at the follow up visit has to be done to reassess the need for SDF reapplication.^{30,32}

Early detection through non-invasive modality will lessen the chances of malocclusion, otherwise may need orthodontic treatment or prosthesis in future to improve the function of teeth. This leads to the dental anxiety for the children as well as for the parent's which has a negative influence on the quality of life related to dental health.^{33,34}

Parental acceptance

Parent's acceptance to SDF staining is better for posterior teeth than for anterior teeth. Kyoona et al., in their study emphasized that, as SDF is non-invasive and painless in treating early childhood caries the acceptance rate is high (79.5%).³⁵

Conclusion

Considering the available literature and its advantages, 38% SDF is effective in arresting and in preventing the development of new carious lesions. It is simple to use, inexpensive, painless and no sophisticated equipment is necessary. So, SDF can be considered as a magic bullet. Though it is very useful for individuals with high caries risk and multiple cavitated carious lesions on maxillary or mandibular teeth, further studies may be needed on silver diamine fluoride to develop evidence based guidelines to use in children as a caries management measure.

Author's contributions

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