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Review Article

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Silver Diamine Fluoride, a Black Magic for Treating Dental Caries: A Systematic Review

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Abstract

According to reports, Dental caries can be described as one of the most familiar and primeval multifactorial diseases that is to be found in humans worldwide, resulting from break down of sugar molecules into acid by the cariogenic bacteria that cling to teeth and gradually demineralizes the tooth structure. Dental cavities can be in control by limiting the utilization of dietary free sugars we eat and by methodically upsetting the dental biofilm. In many situation, people who cannot afford conventional dental restorative treatment for their child, in that condition, a non-intrusive agent has been introduced i.e. silver diamine fluoride. Silver diamine fluoride (SDF) has been recognized as an effective, topical cariostatic and preventative medication for preventing and arresting dental cavities in children and also reduce dentine hypersensitivity.

Keywords: Dental Caries, Dentine Hypersensitivity, Silver Diamine Fluoride

Introduction

Dental caries is a world-wide pandemic illness affecting general health and well-being. Shafer (1993) defined dental caries as an irreversible microbial illness of the calcified tissues of the teeth, characterized by the destruction of the tooth's organic material and demineralization of its inorganic portion, which frequently results in cavitation [1]. Dental caries is a dynamic, multifactorial, non-communicable and biofilm mediated disease. Imbalance between environmental, biological, and behavioural factors can cause carious lesions to develop and will directly affect the diet and hygiene habits [2]. The World Health Organisation (WHO) has reported that around 60-90% of school going children are affected by Dental Caries, which has negatively impacted the quality of their life and their families. It has become a serious health issue particularly for those from low-income backgrounds. When left untreated, it causes tooth ache, inability to eat or sleep, also impacts the daily activities of children [3]. Margolis and Moreno proposed that dental plaque fluid is significant factor that influence tooth decay because the acidic derivatives formed by the metabolization of the biofilm (dental plaque) that covers the affected tooth surface that will cause localised chemical dissolution of dental hard tissues [4]. Dental caries is a preventable disease that can be in control by limiting the utilization of dietary free sugars and by hampering the dental biofilm systematically [2].

In many situations, people cannot afford conventional dental restorative treatment for their child. In such scenario, silver diamine fluoride, a non-intrusive agent has been introduced. It has been determined that Silver diamine fluoride is a potentially useful, affordable, easy to use, painless, simple, safe, non-toxic topical cariostatic medicament. It is also employed as a dentin desensitizer, cavity sterilizer and caries preventive agent [2]. SDF is a colourless alkaline solution that contains silver and fluoride. When combined with ammonia, it creates a mixed heavy-metal halide coordination complex. For a while, ammonia aids in maintaining the solution's concentration at a steady level. Since silver compounds have antibacterial qualities, they have been employed for decades in both dentistry and medicine Several types of fluoride are used to stop and prevent dental cavities. It has been suggested that the combined effects of fluorides and silver may be able to limit the advancement of existing caries and the formation of new caries [4].

The American Academy of Pediatric Dentistry, which released a guideline in 2017 titled "Use of Silver Diamine Fluoride for

Dental Caries Management in Children and Adolescents, Including Those with Special Health Care Needs," suggests an intriguing treatment plan for deciduous teeth [2].

History of Silver Diamine Fluoride in Dentistry

Silver was first used in medicine around 1000 BC, if not earlier. Stebbins postulated that the reduction in caries was caused by antimicrobial activity and the accumulation of a "black crust," which resulted in the formation of a sclerotic protective layer of secondary dentin. Howe's treated carious lesions using an ammoniacal silver nitrate solution, which caused the sclerotic dentin to become black and stopped the growth of new carious lesions. Even though Howe's solution's clinical effectiveness and detrimental effects on pulp were cause for worry, it was widely used until the 1950s as a sterilizing agent for prepared cavities and to disinfect the root canals. AgF was first used as part of the minimum intervention for school dentistry services in Western Australia in the 1970s. As part of his PhD thesis at Osaka University in Japan, Nishino conducted the first investigation on silver diamine in 1969. Afterwards, "diammine silver fluoride" was authorized by the Central Pharmaceutical Council of the Japanese Ministry of Health and Welfare as a cariostatic agent. It was then sold under the brand name Saforide (Toyo Seiyaku Kasei Co. Ltd, Osaka, Japan) [5]. They discussed how it can stop and prevent dental caries in kids, stop cavities from developing again after restorations, and desensitize dentin that is too sensitive.

Following its first usage in Japan, SDF lost its allure in the late 1960s and early 1970s and was not widely used in other regions of the world. However, its usage as a caries arresting agent in schoolchildren began anew in China at the start of the twenty-first century. Australia's Knight et al. conducted a series of in vitro investigations from 2005 to 2009 to ascertain the substance's effectiveness as an antibacterial and caries-arresting agent. 2009 saw the US's Braga et al. and Nepal's Yee et al. successfully employed SDF as a caries arresting agent [6]. Nishino, Yamaga, and associates in Japan were among the first to employ SDF for the management of dental caries in the 1960s.

In the first SDF experiment, the incidence of a new lesion following preventative application was examined in a rat caries model. Compared to littermate controls, SDF in this trial avoided 62% of carious lesions in the treated rats' molars. Lesion severity was also determined; none of the teeth in the SDF group had deep lesions, but 30% of the teeth in the control group did. The advantage of silver and fluoride ions in the preventative impact was partially shown in the second rat model caries study: SDF therapy led to 65% fewer new lesions than no treatment control,10% stannous fluoride (SnF2) prevented only 51%, and 25% silver nitrate had no effect [8].

Development of SDF in Dentistry

SDF is a colourless fluid that has fluoride ions. It is applied in dentistry to promote remineralization of teeth. In early 1970s AgF was used in dentistry. Since the 1960s, SDF has been recognised as a remedial solution for dental therapy by the Central Pharmaceutical Council of the Ministry of Health and Welfare in Japan. In China, caries was similarly stopped using a 38% SDF solution. Plans to stop tooth decay through SDF as Community programs to arrest caries were created for Cuba, Sub-Saharan Africa and other African countries. In 2014, the United States approved SDF to be sold as a product to reduce dentinal hypersensitivity. Health Canada approved it as an anti caries product. SDF has also been recognised by the US Food and Drugs Administration as a treatment option for caries prevention. A recommendation for the "Use of silver diamine fluoride for dental caries management in children and adolescents, including those with special healthcare needs in children and adolescents" was released in 2017 by the American Academy of Pediatric Dentistry. Investigations are underway that might soon lead to a revision in its classification [7].

Composition

Silver Diamine Fluoride is a colourless solution having an alkaline pH ranging from 8–10. Its molecular formula is AgF [NH3]2. Its main constituents are [7]:

a. Silver {antibacterial} 255000 ppm
b. Fluoride{remineralisation} 44800 ppm.
c. Ammonia [stabilizer].

SDF is most commonly found at a concentration of 38% weight/volume, representing 44.800 ppm of fluoride and 255.000 ppm of silver. The other commercially available SDF along with 38% are 10%, 12%, 30%. Due to their high concentration, these two elements Fluoride and Silver, will work in concert to promote mineralization, block demineralization of tooth hard tissues, reduce the breakdown of the organic dentin, and have bactericidal effects on cariogenic bacteria. in such a high concentration enhances synergistic activity and bactericidal action on cariogenic microorganisms, promoting mineralization, inhibiting demineralization of hard tissues of tooth, and decreasing the destruction of the organic portion of the dentin.

The following chemical reaction occurs When SDF is applied to the tooth structure:

$Ca_{10}(PO_4)_6(OH)_2 + Ag + (NH_3)_2 F\ CaF_2 + Ag_3PO4 + NH_4OH$

(Hydroxyapatite SDF calcium fluoride silver phosphate ammonium hydroxide) [9].

Mechanism of Action

Silver diamine fluoride is used preventing caries progression and prevents dentin hypersensitivity. When SDF is applied topically over the exposed sensitive dentin surfaces, squamous layer is formed by partially plugging the dentinal tubules. A squamous layer of silver-protein conjugates formed on degraded surfaces when diamine is applied, strengthening the surface's resistance to enzymatic digestion and acid breakdown. In addition, metallic and silver chloride are present, and hydroxyapatite and fluorapatite develop on the exposed organic matrix. As a result, the treated lesion's mineral density and hardness rise while its depth falls [2].

SDF contains silver ions that have antibacterial properties. SDF's fluoride ion encourages remineralization, and when reacidification releases the silver, it can serve as an antibacterial. Due presumably to residual ionic silver, treating artificial lesions with silver diamine fluoride helps prevent biofilm growth and subsequent cavity formation. The "zombie effect" occurs when bacteria that have been killed by silver ions are combined with living bacteria, reactivating the silver and effectively killing the living bacteria. The prolonged antibacterial effects of silver deposited on bacteria and dentin proteins within a cavity can be explained by this reservoir effect [6].

Indications [7]

a) Patient with high risk caries.
b) To prevent pit and fissure caries.
c) Management of dental hypersensitivity.
d) To arrest secondary caries.
e) Root caries arrest in adult.
f) Control caries lesion prevention.
g) SDF can access area which are not approachable by traditional ways such as partially erupted third molar, furcation and under around existing restoration.
h) As a component of silver modified atraumatic restoration technique [SMART].
i) SDF is an excellent desensitizer often it reduces or eliminates need for local treatment.
j) Large lesions that are not related to spontaneous pain, infection, or both, and that are too large to be restored

Contraindications [7]

a. Silver allergy.
b. Any oral ulcers.
c. Caries with pulpal involvement.
d. Failure in getting parents/guardians consent for using SDF, along with concerns of the colour change.

Advantages [7]

a) SDF is effective in preventing caries progression.
b) Low cost.
c) Procedures are simple.
d) Does not require expensive instrument.
e) Arrest 80% of treated lesion.
f) Minimally invasive and painless.

Disadvantages [7]

a) Causes black discolouration.
b) Gingival and mucosal irritation.
c) Aesthetics is a concern among parents and children.
d) SDF can stain skin and cloth.
e) SDF has a metallic taste which is not pleasant.

Nonmedical Side Effect and Safety and Toxicity

At the time of application, SDF should be restricted to the carious lesion being treated. Expected side effects are darkening of treated lesion and bitter metallic taste. If SDF comes in contact with soft tissue, there is brownish stating on the skin and white or greyish staining in the oral tissues. Staining or any kind of tissue irritation is temporary, which disappears after a few days [10].

Technique

According to AAPD guidelines 2017

1. Protect the counter by covering with plastic and patient are advised to be draped with plastic bib.
2. Use personal protective equipment (PPE) like plastic bib, safety glasses, gown to protect clothes and skin and should be worn by both patient and operator. Operator are also advised to use gloves, mask.
3. One drop of SDF (25 uL/10kg per treatment visit) should be dispensed in plastic dappen dish for instant use.
4. Isolate tooth surface and dry the affected teeth / tooth that is to be treated.
5. Minimal contact with Gingiva and mucous membranes should be in mind to avoid potential pigmentation or irritation.
6. Extraoral protection like petroleum jelly should be applied on Gingiva, lips and the surrounding area.
7. Bend and dip the micro brush and then dab on the side of the plastic dappen dish to remove excess liquid before application followed by Silver Diamine Fluoride application directly to the affected tooth surface.
8. Dry with a gentle flow of compressed air for at least one minute.
9. Excess SDF should be removed with gauze, cotton roll or cotton pellet to decrease systemic absorption.

Practical Recommendation

There is no need for caries removal or surgical intervention (e.g., dentin excavation). SDF therapy is minimally intrusive, simple and easy for both the patient and the operator. It is to be preferred that the caries lesion should be free of gross debris for SDF application so that the affected dentin surface can be in maximum contact [11].

Post-Operative Instructions

Specifically, none of the manufacturers have given the post-operative instructions. However, several studies on SDF have suggested that after SDF application consumption of food and drinks should be controlled for approximately 30- 60 minutes. For recall visits, it is advised to examine the arresting of the treated lesions is to be done at 2–4 weeks after the initial SDF treatment. SDF application can be reapplied at recall visits. Re-application is done according to the hardness and colour of the cavitated lesion or evidence of lesion progression. After SDF treatment, the caries lesions can be restored with resin modified glass ionomer or composites and is termed as SMART. If not restored after SDF application, biannual reapplication is advised to increase the caries arrest rate [12].

Follow-up

a) After the initial treatment, Follow-up should be done at 24 weeks to examine the arrest of the treated carious lesions.
b) SDF can be reapplied if the treated carious lesions don't appear arrested.
c) SDF treated carious lesions can be restored.
d) SDF treated carious lesions When not restored, then biannual reapplication of SDF will increase the arresting rate of carious lesion compared to single applications7.

Conclusion

SDF is an efficacious and non-intrusive therapy to control of dental caries in children. Due to its simplicity and safety, it can be used individually or at a collective level to control and manage tooth decay. It can be related with other non-intrusive, micro-intrusive or minimally intrusive strategies. It can be an effective method of caries management in individuals who are incapable to undertake conventional restorative treatment, cannot approach dental care benefits and those with special or certain health care needs. Information drawn from all these evidence, many authors suggest yearly application of SDF to uncertain surfaces in patients having high caries risk. The usage of SDF attains the WHO Millennium Development Goals for Health and

help in the cutback of the unfairness in oral health all over the world additionally proceeds towards for the favorable treatment in the daily pediatric dentistry practice.

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