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Review Article

Silver diamine fluoride for managing carious lesions: A literature review

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ABSTRACT

Though the prevalence and the severity of dental caries is decreased in past few years, still children from low socioeconomical status in many industrialized or developing countries are still suffering from ill-effects of dental caries. The antimicrobial effect of silver compounds has been proven by the 100-year-old application of silver compounds. Silver diamine fluoride (SDF) has been used to arrest dental caries during 1970s in Japan, but it was not exposed much to other parts of the world. Today in many countries a 38% (44,800 ppm fluoride) SDF solution is commonly used to arrest caries and also to reduce hypersensitivity in primary and permanent teeth. Application of SDF to arrest dental caries is non-invasive procedure and is quick and simple to use. Reports of available studies showed that there is no severe pulpal damage after SDF application. However, it has some drawbacks like black discoloration of the carious teeth and an unpleasant metallic taste. But, low cost of SDF and its simplicity in application suggest that it is an appropriate agent for use in community dental health programme. Thus, SDF appears to meet the criteria of both the WHO Millennium Goals and the US Institute of Medicine's criteria for 21st century medical care, that is, it is a safe, effective, efficient, and equitable caries preventive agent.

1. Introduction

Teeth loss from an early age has emerged as one of the most common oral diseases in children and adults. Dental caries is a bacterial process, usually a disease, site, multifactorial, a dynamic disease process caused by an imbalance of the balance between tooth water and plaque fluid; which means that, when the pH decreases, it results in mineral loss over time.[1] They are the most common diseases that affect every second child in the community. International data on caries epidemiology confirms that tooth decay remains an important childhood disease found in developing and developed countries. The development of Caries in its crust and dentine is different. Enamel caries refers to the destruction of mineral-rich tissue due to bacterial acid attack, and that in dentine includes both mineral minerals and the matrix damage of the collagen fiber network.[2] However, the treatment of dental caries can be a challenge that requires advanced medical expertise and high cost of equipment and building materials and good patient cooperation.

When tooth decay is found in very young children because of their limited ability to cope, it can be confusing for a doctor to remove all caries and restore it properly.[1] Proper dental treatment for untreated children is disadvantage in many communities. Concerns can be prevented both and can be treated with fluoride-based materials such as technological varnishes. The fluoridated agent of silver diamine fluoride's agent (SDF) has been suggested to have the ability to stop the caries process and

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at the same time prevent the formation of new caries. The SDF after its first use in Japan in the late 1960s and 1970s disappeared and was not widely reported in other parts of the world. However, in the early 21st century, its use began again in China as caries binding agent in school children. From 2005 to 2009 K Knight et al. in Australia conducted a series of in vitro studies and proved its effect as binding caries and antimicrobial agent. In 2009 Braga et al. in the US and Yee et al. in Nepal the SDF has been used as caries binding agent successfully. However, there are many ongoing studies in different parts of the world about the various clinical outcomes of the SDF.

Although studies have shown that the SDF is effective in arresting dental malformations, the mechanism is not yet clear. Studies that investigated the effectiveness of the SDF differ in terms of observation, delivery, objectives, strategies, test conditions, test model and conclusions. Since SDF has been widely used in dentistry in Argentina, Brazil, China, and Japan for many years, many SDF-related studies were published in Spanish, Portuguese, Chinese, and Japanese. To date, there has been no comprehensive review of the textbooks, published in various languages, to investigate the SDF's actions. The purpose of this paper was to review the evidence for the mechanisms of action of SDF in dental caries in terms of its effect on chemical lesions, including its action on cariogenic bacteria.

1.1. *History of use of silver compound*

Nearly 1,000 years ago, in Japan, it was customary for girls to brush their black teeth called "Ohaguro," indicating that they were married. Although, it was a dental cosmetic that, at the same time, was conceived to prevent tooth decay. The first use of silver treatment appeared about 1000 BC back then. The current use of silver chemicals uses silver nitrate, silver foil, and silver sutures. Von Naegeli found silver nitrate to be an effective antibacterial agent. Some scientists have used silver amalgam and nitric acid in toothpaste and found that prevention of caries existed. Subsequently, silver nitrate applied to wounds with similar effects was called "Howe solution." It has been used for the purpose of binding caries for the next 50 years.[1]

1.2. *Development of silver diamine fluoride in dentistry*

Craig et al. reported that AgF solution was used in dentistry in the early 1970's. The same component, SDF, has been adopted as a medical agent in Japan since the 1960s in dentistry. A 38% SDF solution has also been used in China to bind caries. Also, a few dentists in Southern California use the SDF to bind caries to young children with childhood caries. Community projects were planned using the SDF to bind caries to Cuba, Sub-Saharan Africa and many African countries. The use of SDF is extremely limited at this time.[1]

1.3. *Physical Characteristics*

Silver fluoride is a colorless solution consisting of silver ions and fluoride ions. Alkaline has a pH 11. Silver diamine fluoride is said to be more stable and can be stored in continuous concentrations. It has been used in many countries, including China and Japan, to bind toothpaste for many years. SDF is not as alkaline as AgF. It does not require a reducing agent.[2]

2. Mode of Action of Silver Diamine Fluoride

2.1. *Mechanism of action of silver*

Many working methods are raised for silver. Studies have shown that the silver interacts with sulfhydryl protein and deoxyribonucleic acid (DNA), which alters hydrogen binding, and inhibits DNA disintegration, cell wall integration, and cell division. At the macro level, this interaction affects the disinfection and prevents the formation of biofilm. The central mechanism of these various effects is proposed to be the interaction of silver with thiol groups as follows:

1. $A/N - SH + AgX \rightarrow A/N - S - Ag + HX$
2. A/N represents — amino (A) or nucleic (N) acids (respectively),
3. SH represents — thiol group,
4. Ag represents — silver, and
5. X represents — anion (in the current example, diamine fluoride).

This interaction indicates how silver containing compound, mediate caries arrest through bacterial killing and inhibit caries progress through the inhibition of biofilm formation.

Three possible mechanisms of action of SDF on caries were described by Shimizu and Kawagoe (1976):

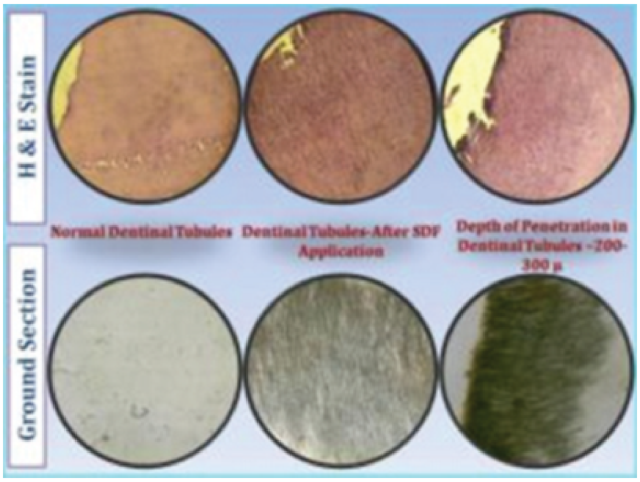

Fig. 1: Depth of penetration of silver phosphate crystals

1. The first method would be the detection of dental tubules. Highway for caries attacks dentin dental tubules. SDF-treated Dentin reduced dye availability and increased electrical resistance. Consequently, silver and its components were present in the dental tubules. Therefore, the spread of acid and the invasion of microorganisms through the dental tubules can be prevented. Even if microorganisms attack the dental tubules, their growth will be inhibited by oligodynamic silver action. Due to the presence of dental bone, the surface area of the dentin, which is not affected by caries will decrease, and the peritubular area, the easily pulled part of the dentin can be covered with acquired material (silver particles). These factors in conjunction with the discovery of dental tubules should contribute to an increase in resistance to recurrent caries. 38% SDF inhibits the use of chemicals and preserves collagen from demineralized dentin degradation [Figure 1].
2. The second method would be the cariostatic action of the reaction products between the SDF and the mineral part of the tooth. Fluoride treatment increased peri- and inter-tubular dentin resistance to acid decalcification and, consequently, delayed acid penetration into deeper parts of the dentin. SDF F− ion embedded in dentin under vivo conditions penetrates to a depth of 50-100 μ. SDF (Ag (NH3) 2F) was reported to react with tooth mineral hydroxyapatite (HA) (Ca10 (PO4) 6 (OH) 2) to release calcium fluoride (CaF2) and silver phosphate (Ag3PO4), which is responsible for the protection and strength of teeth. Simplified chemical reactions are suggested as shown below. Ag3PO4 that breaks down on the surface of molten teeth. The synthetic CaF2 provides a fluoride retention in the formation of fluorapatite (Ca10 (PO4) 6F2), which is more resistant to acid attack than HA (Ca10 (PO4) 6 (OH) 2). Fluorapatite is so stable that it is highly resistant to decalcification by acid and deceptive agents. In addition, it is known that F− promotes calculation, and also restores lattice imperfection, and enhances HA splendor.
3. A third method would be the antienzymatic actions of the reaction products between Ag (NH3) 2F and the active part of the tooth. Its antibacterial properties are derived from inhibition of enzyme activity and dextran synthesis by cariogenic strains of Streptococcus mutans. Sunada et al. found that dentin, treated with Ag (NH3) 2OH by ionophoresis increased resistance to trypsin. They said it was probably due to the reaction of Ag and the living component of dentin. These actions of Ag and Ag (NH3) 2F in the living parts of the tooth can also contribute to the prevention of caries.

$$\text{Ca10 (PO4)6(OH) 2} + \text{Ag (NH3)2} \longrightarrow \text{CaF2} + \text{Ag3PO4} + \text{NH4OH}$$

$$\text{CaF2} \longrightarrow \text{Ca++} + \text{2F−}$$

$$\text{Ca10 (PO4)6(OH) 2} + \text{2F−} \longrightarrow \text{Ca10 (PO4) 6F2} + \text{2OH−}$$

Suzuki et al. studied the anti plaque activity of diamine silver fluoride (Ag (NH3) 2F). This agent has shown excellent antibacterial action against cariogenic S strains. mutans (low concentration, 0.12 μmole / ml), and completely prevent the dextranindosed increase of S. mutans at 0.59 μmole / ml and sucrase activities of S. mutans at 0.2 μmole / ml. These effects were obtained as a result of the action of the silver ion. These results suggest that the silver ion may inhibit the formation of S-colonies. mutans on its cover and provide a possible explanation for the anti-agent action.[3]

It was also shown that glucan binding to HA was inhibited by HA treatment with a fluoride solution, but that was slightly enhanced with a silver solution. Advertising for HA protein was inhibited by HA treatment with Ag (NH3) 2F. This is due to fluoride and silver ions. Therefore, the inhibitory capacity of mutans S. is higher than that of SDF than any other fluoridated solution. Also, Mei et al. (2013) have shown that 38% SDF inhibits the biofilm formation of many types of dentin carious lesions and reduces the process of mineral extraction.

Suzuki et al. showed that after the application of the SDF, fluoride ions penetrated into the crust in approximately 25 μ, while the silver ions were deposited mostly on the surface and some penetrated up to 20 μ in their crust.

Understanding these SDF operating procedures will help determine its clinical effectiveness. The following is the clinical outcome of SDF in dental treatment

3. Clinical Application of Silver Diamine Fluoride

3.1. The ability of SDF to arrest caries in anterior primary teeth of young children

In pre-school children, many of the invading teeth become infected with caries, and a very large number of children have what is called "early childhood rot" which takes a sharp course. However, the treatment of such abnormal teeth involves many complications, so most patients are left untreated at present. Tooth decay not only plays an important role in the eruption and growth of permanent teeth, but it is also important for the growth of jaw bone, that is, on the growth and development of the face. From such a perspective, it would make sense to sacrifice a measure of beauty to some degree, if the continuation of the teeth could be bound by the use of a solution. A previous method of highly contagious chemicals was to remove possible dentin and to use zinc oxide eugenol as a temporary replacement. Unfortunately, the pattern of caries is not so common that zinc oxide eugenol cannot be maintained. SDF can provide some of the same benefits [Figure 2].

Fig. 2: Black discoloration in anterior teeth after application of silver diamine fluoride

Nishino et al. (1969) and Moritani et al. (1970) found a small increase in children receiving SDF compared with those without SDF therapy, and in more rare cases complaining of pain in the cool or warm air, or the contradiction that the pores were closed continuously.[4] Chu, Lo and Lin (2002) found that SDF is effective in binding dentin to the inner teeth of pre-school children in the Community Caries Management System.

3.2. *To prevent pit and fissure caries*

Pits and fissures are more affected by tooth decay than a smooth surface for behavioral reasons. It is also difficult to clean holes and cracks with a toothbrush. Although it is difficult to obtain incipient lesion in holes and crevices, the application of topical fluoride is shown to be less effective in protecting the cavity and cracks than in the smooth surface. According to Sato et al. (1970), due to its anti-antibacterial and caries protective properties its SDF may be effective in preventing cavities and cracks in the first molar teeth. Nishino and Massler (1977) in their study noted that the points of dental caries treated with Ag (NH3) 2F were significantly lower than those treated with SnF2 8% or Ag (NO) 3.[5] Precautionary measures: Due to the gray and black color in the hole and the formation of the SDF can be confused with undetectable detection, so the application should be recorded [Figure 3].

3.3. *To prevent secondary caries*

True adherence has been a "sacred grail" for decades. As many restorative substances used in conventional dentistry today are either completely attached to the tooth structure or cannot be completely dissolved in the oral fluid; saliva, bacteria and food debris enter the space between the walls of the pit and the building materials that restore it. Therefore, the pit wall may always be vulnerable to recurring signs.

Fig. 3: Black discoloration in pit and fissure after application of silver diamine fluoride

Prevention of recurrent caries, therefore, resistance to the pit wall in caries should be improved. Shimizu and Kawagoe (1976) did not find recurrent decay in the restoration of amalgam to baseline teeth previously treated with SDF after 26 months.

Clinical implications and mechanism of action of SDF are summarized inFigure 4.

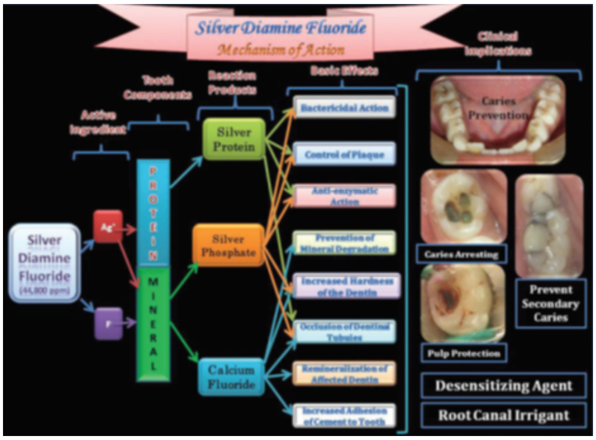

Fig. 4: Summary of mechanism of action and clinical application of silver diamine fluoride

4. Drawback of Silver Diamine Fluoride

Going back to using SDF to bind caries that the lesions will have dark spots; therefore, some children and their parents may be unhappy about the quality of the treatment. It has been suggested that when centous dentin was treated with SDF, silver phosphate was formed, and this did not dissolve. Silver phosphate is yellow when it is first formed, but turns dark under the sun or the influence of reducing agents.

Overcoming this limit K Knight et al. proposed use of Potassium iodide after the inclusion of SDF in the formation of remaining teeth of silver ions in solution will react with Potassium Iodide to reduce the greenish white silver crystals.[6] Therefore, free silver ions are no longer available to react with sulfur and other oral reagents to form black holes in the teeth. More research in this way is still needed.

In addition, SDF can contaminate body skin and clothing. The stain caused by SDF on the skin, although not causing any pain, cannot be washed away, and it takes a long time to remove. If the skin or clothes are stained, the following procedure is recommended: (a) Wash with running water, soap, or ammonia, as soon as possible after staining. (b) If the color change cannot be removed and continued, use a solution of sodium hypochlorite or powder bleaching (with caution with dyed cloth). SDF solution also has an unpleasant metallic taste.

In addition, gingival and mucosal irritation is possible. In most cases, the damage goes away and the affected tissues become white, but they will heal within 1-2 days. If the solution is to be applied to wounds that are very close to the gingiva, use a rubber pool, or protect the gingiva with Vaseline or cocoa butter.[7]

5. Conclusion

Although, there are not many studies in the literature in the SDF, the available study reports suggest that 38% SDF could be an effective agent in binding caries in the first teeth. The study also found no significant damage to the pulp after SDF requests. In addition, the SDF is simple and quick to implement and is an affordable treatment in developing countries. However, further studies are needed in this approach to validate silver diamine fluoride as an option in the 21st century that will help achieve the 2021 goals by WHO.[8,9]

6. Source of Funding

None.

7. Conflict of Interest

None.

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