

Stretching New Boundaries of Caries Prevention with Silver Diamine Fluoride: A Review of Literature

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Abstract

Silver diamine fluoride can arrest dental caries and prevents its progression. By doing so, it provides an alternative care path for those patients in whom traditional restorative treatment cannot be done, for example, children lacking cooperating ability. Although silver diamine fluoride had been used as a caries preventive measure in 1970s in Japan, it had not become popular in the other part of the world. Now, many countries have recommend the use of 38% silver diamine fluoride solution for caries prevention as well as for caries arrest. Recently, The American Academy of Pediatric Dentistry provided the guidelines regarding the use of silver diamine fluoride for dental caries management in children and adolescent including those with special healthcare needs.

Keywords: Adverse effect, caries, caries arrest, caries prevention, clinical recommendations, silver diamine fluoride

INTRODUCTION

Dental caries is an irreversible microbial disease of the calcified tissue of teeth, characterized by demineralization of the inorganic portion, and destruction of organic substance of tooth, which often leads to cavitation.^[1] It is one of the most prevalent disease affecting human population.^[2] The traditional conservative treatment of dental caries involve mechanical cavity preparation and restoration with suitable material.^[3] However, this kind of treatment requires clinical skills, costly instruments, materials, and patient's cooperation. In young children, behavioral issues or lack of cooperation often complicate this kind of traditional restorative treatment of carious tooth and often leads to disease progression and subsequent loss of tooth.^[4] In developed countries, uncooperative children have the option of conscious sedation or general anesthesia, whereas in many developing countries due to barrier of accessing dental care, low socioeconomic populations go through life with untreated dental caries.^[5] There are many preventive interventions that can be used as an alternative to traditional restorative procedure, and one of them is the use of silver diamine fluoride. Silver diamine fluoride can halt the caries progression and prevent new lesion development. It appears to be almost twice as effective as fluoride varnish.^[6]

EVOLUTION OF SILVER DIAMINE FLUORIDE IN DENTISTRY

In 1970s, Craig *et al.* reported the use of AgF solution in dentistry.^[7] Silver diamine fluoride was accepted in Japan as therapeutic agent for management of dental caries in 1960s. Silver diamine fluoride has an alkaline pH between 8 and 9. It is more stable than AgF solution and can be kept at a constant concentration. It also does not require any reducing agent. Silver diamine fluoride was first used in dentistry at a concentration of 38%.

A lower concentration of 12% is also available, but it is not as effective as 38% in arresting dental caries in children.^[8,9]

MECHANISM OF ACTION

Topical application of silver diamine fluoride on exposed dentinal surface results in the formation of a squamous layer, partially plugging the dentinal tubules.^[10] Silver in silver diamine fluoride interacts with sulfhydryl groups of proteins and

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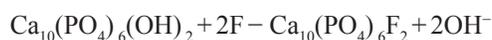
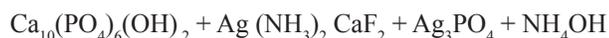
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with deoxyribonucleic acid (DNA), altering hydrogen bonding and inhibiting respiratory processes, DNA unwinding, cell wall synthesis, and cell division.^[11,12] It has also been demonstrated that silver diamine fluoride can inhibit biofilm formation and this inhibition is quite prominent in the first 7 days after application.^[13] Silver diamine fluoride has also shown to have an inhibitory effect on matrix metalloproteinase and thus reduces the degradation of organic collagen matrix.^[14,15]

Shimooka found that F⁻ ion of silver diamine fluoride applied to dentin under *in vivo* conditions penetrated to a depth of 50–100 μ.^[16] It reacts with tooth mineral hydroxyapatite to release calcium fluoride and silver phosphate, which are responsible for the prevention and hardening of dental caries. A simplified chemical reaction was suggested as,^[17,18]



The Ag₃PO₄ precipitates on tooth surface are insoluble and the CaF₂ acts as reservoir of fluoride for the formation of fluorapatite, which is more resistant to dissolution caused by various organic acids in oral environment than hydroxyapatite.^[19]

Mineral content of dentin has a direct effect on its microhardness. So by measuring the change in microhardness, one can assume the loss or gain in mineral content of dentin. Studies have reported that microhardness of previously carious dentin was increased after it has been treated with silver diamine fluoride.^[20] There is the formation of less soluble or virtually insoluble calcium fluoride, silver phosphate, and silver protein which are precipitated on dentin surface and thereby reduces calcium and phosphorous loss from carious lesion.^[21]

The antibacterial effect of silver diamine fluoride originates from the inhibition of enzyme actions and dextran-induced agglutination of *Streptococcus mutans* cariogenic strains.^[22] Silver diamine fluoride can inhibit cariogenic strains of *S. mutans* at a concentration of 0.12 micromole/ml or more. It can inhibit dextran-induced agglutination of *S. mutans* at 0.59 micromole/ml. Silver ion present within silver diamine fluoride is responsible for these anti *S. mutans* effect.^[22]

CARIES ARREST

Caries arrest increases significantly if silver diamine fluoride is reapplied from 1-year posttreatment.^[8,9,23] The effectiveness of one-time silver diamine fluoride application in arresting dental caries ranges from 47% to 90%, depending on the lesion size, tooth location, and lesion location.^[24] Anterior teeth have higher rates of caries lesion arrest than posterior teeth.^[25] The effectiveness of caries lesion arrest decreases over time.^[24] After a single application of 38% silver diamine fluoride, 50% of arrested surfaces at 6 months revert back at active lesion on 24 months.^[9] Gupta *et al.* in their *in vitro* study found the highest zone of bacterial inhibition with silver

diamine fluoride.^[26] Sinha *et al.* mentioned the remineralizing, rehardening, and antimicrobial abilities of silver diamine fluoride in *in vivo* study.^[27]

CARIES PREVENTION

When silver diamine fluoride was applied only to carious lesions, impressive prevention is seen for other tooth surfaces.^[25,28] Fluoride-releasing glass ionomer cement (GIC) can have this effect; however, it is limited to surfaces adjacent to the treated surface and of short duration. Direct application to healthy surfaces in children also helps prevent caries.^[27-29]

Annual application of silver diamine fluoride prevents many more carious lesions than four times per year fluoride varnish in both children and elders.^[30]

EARLY CHILDHOOD CARIES AND SILVER DIAMINE FLUORIDE

Conventional treatment of early childhood caries in young children involves many difficulties like behavioral issue and lack of cooperation. Hence, majority of patients are left untreated, which ultimately result in loss of teeth. Loss of deciduous teeth mainly upper anteriors may cause psychological trauma to the patient or phonation problems.^[31] Deciduous teeth are also important for normal growth of jaw bone and timely eruption of permanent teeth. From such point of view by the application of silver diamine fluoride, caries can be arrested, and above-described problems can be overcome.

AS DESENSITIZING AGENT FOR SENSITIVE TEETH

Silver diamine fluoride forms squamous layer when applied on dentinal surface and thereby occludes dentinal tubules. For this effect, silver diamine fluoride can be given in hypersensitive dentin. In a lesion like erosion or abrasion where dentinal hypersensitivity is precipitated by mechanical and thermal sensation, application of silver diamine fluoride can be an effective alternative treatment.^[32-34]

SILVER DIAMINE FLUORIDE IN ROOT CANAL TREATMENT

When used as 3.8% solution for irrigation of root canal, silver diamine fluoride has shown potent antimicrobial effect.^[35] It can be used as canal irrigant where blackening of dentin by silver component is not a major issue. Because of its inhibitory effects on bacterial cell wall synthesis, DNA unwinding, and cell division, it can effectively reduce microbial load within a root canal. Mathew *et al.* found that silver diamine fluoride is very effective in reducing bacterial load from canal wall and circumcuspulpal dentin.^[36]

DIFFERENT STUDIES ON SILVER DIAMINE FLUORIDE IN RECENT YEARS

- Braga *et al.* – ^[37] an *in vivo* study was conducted on 1st permanent molars in Brazil showed silver diamine

fluoride was more effective in caries arrest than cross tooth-brushing and Fuji-III GIC after 3 and 6 months. Whereas after 30 months all were equally effective

- Yee *et al.* – [38] an *in vivo* study was conducted on primary dentition in Nepal showed 38% silver diamine fluoride was more effective in arresting caries than 12% silver diamine fluoride and application of tannic acid with 38% silver diamine fluoride had no additional effect
- Liu *et al.* – [10] annual application of 38% silver diamine fluoride was compared with 5% NaF varnish semiannual application and resin sealant, and it was found that all are effective in caries prevention
- Monse *et al.* – [39] study conducted on permanent 1st molars in Philipinnes. Single application of 38% silver diamine fluoride is not effective in the prevention of caries as compared to atraumatic restorative technique sealant
- Dos Santos *et al.* – [40] it was an *in vivo* study done on primary dentition to compare 30% silver diamine fluoride and intermediate restorative technique. It was found that silver diamine fluoride was more effective
- Duangthip *et al.* – [41] this study was conducted in Hong Kong on primary anterior and posterior teeth. Annual application of 30% silver diamine fluoride and weekly application of the same for consecutive 3 weeks are much more caries arresting than fluoride varnish
- Fung *et al.* – [25] this study was conducted in China on primary dentition. It came with the conclusion that semiannual application of 38% silver diamine fluoride is more effective than annual application of the same. In this study, it was also found that semiannual and annual application of 12% silver diamine fluoride is not beneficial in comparison to 38% solution.

ADVERSE REACTIONS SAFETY MARGIN

There is approximately 24%–28% (w/v) silver and 5%–6% (w/v) fluoride present in silver diamine fluoride.^[42] There is no reported deaths or systemic adverse effects in published clinical trials using topical silver diamine fluoride as per the manufacturer's recommendation. However, the maximum limit is recommended as one drop per 10 kg of body weight per treatment visit at weekly intervals.^[43] On application of silver diamine fluoride pulpal damage is unlikely; however, it should not be placed on exposed pulp, lesion close to pulp should be monitored periodically after application of silver diamine fluoride.^[24]

Main disadvantage of silver diamine fluoride is black discoloration of arrested carious lesion on which it was applied. This is because of formation of silver phosphate which turns black on reduction in oral environment. Because of this black discoloration esthetically, it is not acceptable particularly for anterior teeth. This discoloration is permanent until restored.^[24]

Silver diamine fluoride is contraindicated in patient who is allergic to silver. Other drawback of silver diamine fluoride includes staining of clothes and skin. It has a metallic taste

which is unpleasant. It can cause gingival and mucosal irritations which usually resolve within 2 days.

CLINICAL RECOMMENDATION

Excavation of carious dentin before silver diamine fluoride application is not always needed. Carious dentin excavation only reduces the black discoloration after it has been arrested. Hence, it is only considered for esthetic reason. The application time ranges from 10 s to 3 min with an ideal value of 1 min, using a gentle flow of compressed air drying.^[24] In case of shorter application period, postoperative evaluation and reapplication should be considered.^[24] No eating or drinking after application of silver diamine fluoride for 30 min to 1 h is recommended in several literature.^[24]

The following steps should be taken into consideration when silver diamine fluoride is applied:^[24]

- Gross debridement of carious lesion, so that silver diamine fluoride can come into contact with denatured dentin
- An application time of 1 min is usually recommended and before application affected tooth surface should be dried with either by cotton roll, gauze piece, or by compressed air
- Gentle flow of compressed air should be used to dry the silver diamine fluoride liquid
- Contact of silver diamine fluoride liquid with surrounding gingival tissue and mucosa should be avoided using rubber dam or cotton rolls, otherwise irritation of these tissues will be a common finding
- Any excess silver diamine fluoride liquid should be removed with a cotton pellet and isolation of operating site should be continued for 3 min after application
- A plastic dappen dish should always be used for silver diamine fluoride as it corrodes metal and glass.

Silver diamine fluoride is an effective caries arresting agent which can be used for those patients who have difficulties in accessing proper dental care. It is also very useful in high caries risk patients with active carious lesions in both anterior and posterior teeth and also for medically and emotionally challenged children.

CONCLUSION

Available literatures suggest that 38% silver diamine fluoride is effective in caries prevention. It halts the caries progression. According to different studies, silver diamine fluoride does not produce any pulpal damage. It is simple to use, cost-effective and can be stored in a constant concentration. It is very useful for the management of caries in young children. Still more studies required on silver diamine fluoride to prove it as an ideal caries preventive measure.

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