

Silver Diamine Fluoride

Introduction

- Dental caries is a multifactorial disease that results from an imbalance between pathological and protective factors.
- Common non-operative treatments for incipient enamel caries include: fluoride applications, fissure sealants, and behavioral modifications, such as increasing the frequency of brushing and flossing.
- The effectiveness of topical fluoride, which acts as a cariostatic agent, has been well established, and fluoride is considered the most effective method for preventing or arresting the development of caries.
- Studies have shown that silver diamine fluoride (SDF) is an effective agent against dental caries
- In 2014, The U.S. Food and Drug Administration approved the use of SDF as a desensitizing agent
- In 2016, a new Code on Dental Procedures and Nomenclature (CDT) D1354 allowed billing claims for off-label use of SDF as an interim caries arresting medicament in the USA.

Silver Diamine Fluoride (SDF)

- 38% SDF is an alkaline (pH 10) colorless solution, containing 24%-27% silver (Ag), 8.5%-10.5% ammonia (NH_3) and 5.0%-6.0% fluoride.
- The recommended safe maximum dose of SDF per visit is 1 drop/10 Kg
- Since 1970, a solution of 38% SDF has been widely used outside the United States and Canada, primarily for caries prevention and arrest in children
- SDF's effect on enamel is primarily due to fluoride, while the effect on dentin is predominantly due to silver.
 - Fluoride inhibits the demineralization and promotes the remineralization of dental tissues, mainly enamel
 - The deposition of silver salt and the antibacterial effect of silver ions are the two main mechanisms related to the effect of silver in SDF in preventing and arresting caries in dentin
 - When SDF is applied onto the surface of dental hard tissues, silver salt will form and precipitate on the surface. The permeability of the tooth surface will be decreased due to the blocking effect of the insoluble silver apatite, and formation of sclerotic or calcified dentin will be stimulated

Application

- Excavation of caries is not required prior to application. Teeth are air-dried, and SDF is applied to the carious lesions using a micro-brush for 1 minute and rinsed. The effect of SDF diminishes over time, therefore follow-up applications are required, as the lesion can begin demineralization within 24 months
- Professional application of SDF is considered safe. No serious adverse

effects are reported from clinical studies on SDF.

- Vasquez et al studied the safety of SDF, and reported that the serum concentrations for fluoride and silver were significantly lower than the U.S. Environmental Protection Agency's oral dose for daily fluoride exposure and lifetime silver exposure.
- There is no established frequency for SDF application. Suggested frequencies in children range from annual/biannual to three consecutive weekly applications followed by semi- annual recall applications.
 - Increased application frequency is linked to a greater caries arrest rate over the first 6-12 months in children. Annual application of SDF effectively prevents and arrests root caries in older adults who are capable of self-care and are not affected by serious medical conditions

Effectiveness

- A systematic review by Rosenblatt et al concluded that SDF is more effective than fluoride varnish and may be a valuable caries-preventive intervention
- A review by Chen et al confirmed the efficacy of SDF for treatment and prevention of dental caries in children aged 0–18 years.
- SDF was shown effective in the prevention of root caries, and application of 38% SDF in adults and vulnerable elderly is recommended.
- SDF treatment showed higher success rates (65-91%) when compared with no treatment (34%), sodium fluoride varnish (38-44%) and interim GI restorations (39-82%).
- SDF does not affect the bond strength of composite resin to non-carious dentin but may reduce bond strength to caries-affected dentin.
- Application of SDF had a superior effect on caries arrest than interim GI restorations.
- SDF is compatible with glass-ionomer cements and may increase resistance of GIC and composite restorations to secondary caries.
- Application of NaF varnish (4 times a year) seems to be less effective than application of SDF solution (once a year) in arresting active dentin caries
- SDF is inexpensive relative to other caries preventive agents.
- SDF application on coronal surfaces may help retention of natural teeth and increase their resistance to many of the risk factors for caries such as: xerostomia, poor oral hygiene and low pH that are more prevalent in older adults coping with chronic diseases and functional impairments.
- Evidence suggests SDF is effective in reducing pain in hypersensitive dentin
 - Castillo et al reported significant reduction in the pain response of hypersensitive teeth, 24 hours after initial SDF application. Sensitivity continued to diminish further during the 7-day study period.

Disadvantages

- Formation of silver phosphate turns SDF-treated carious lesions black.
 - Black staining was reported to be acceptable by parents and young children, possibly because primary teeth exfoliate.
 - To prevent such staining, ammonium hexafluorosilicate (SiF) solution, which contains silica rather than silver, has been suggested to prevent caries progression.
 - Several studies have indicated that SiF treatment did not produce tooth staining.
 - The antibacterial activity of SiF solution is not as high as SDF, due to the lack of silver ion
 - The addition of several antibacterial agents increased the low antibacterial activity of the solution, the most effective being cetylpyridinium chloride (CPC)
 - CPC is an effective antibacterial agent that exerts its antibacterial action by combining with negatively charged proteins on bacterial cells and destroying their cell membrane by disturbing the electric balance.

Alternative Cariostatic Agents

Ammonium hexafluorosilicate (SiF)

- SiF is an effective agent for preventing dental caries and inducing dentin tubule occlusion due to its ability to induce apatite formation and mineralization.
- SiF is an acidic solution that dissolves enamel, leading to the formation of firmly bonded fluoridated apatite
- This type of bonded fluoride has an anti-caries effect, and it is not washed away easily in the oral environment.
- Fluoridated apatite increases the acid resistance of teeth.
- SiF contains silica:
 - Silica-containing compounds cause rapid silica-Ca-P precipitation and induce apatite formation, increasing the hardness of the enamel

Curodent Repair (CR)

- CR, is a self-assembling peptide. Studies have indicated that this peptide diffuses into a lesion and induces the buildup of a three-dimensional scaffold, enabling the growth of new hydroxyapatite crystals.
- The enamel matrix can be regenerated with Ca and P ions from saliva.
- Unlike fluoride containing solutions with a low pH, peptides have no solvent effect on dental hard tissues, and salivary-derived components accumulate slowly in the skeletal
 - structure following the application of CR.
 - This mechanism explains the significantly higher enamel hardness after a 30-day treatment with CR

- 7-day application of CR resulted in significantly lower enamel hardness than post 30-day treatment

Acidulated phosphate fluoride (APF)

- APF is an effective cariostatic and caries-prevention agent
- Like SiF, APF is acidic in nature
- Studies have shown that the low pH of APF gels had the potential to result in etching of surface enamel and increased surface roughness soon after its application
- Solutions with a low pH (APF and SiF) etch the surface of the enamel and cause quick precipitation on the enamel surface due to the formation of calcium fluoride, which resists demineralization.

Take Home Message

- SDF has been shown to be an effective cariostatic agent
- There are other agents, such as CR, SiF, and APF, which have all been shown to aid in remineralization of dentin and enamel
- Future *in vivo* comparative studies are required to evaluate the efficacy of the above agents, specifically in arresting caries progression, relative to each other over a long-term period

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