Silver Diamine Fluoride in Clinical Pediatric Dentistry

Sarjana Mishra[1], Susant Mohanty[2]

[1]Postgraduate Trainee, [2]Professor & Head, Department of Paediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be University), Bhubaneswar 751003, Odisha, India

Abstract

Silver diamine fluoride is the most recent advancement in the field of dentistry. Its history dates back to the 1960s and since its invention there was no looking back. People across the globe and different races and cultures have benefitted from SDF. With almost no adverse reactions, pocket-friendly, and highly effective qualities in its stride, SDF has emerged as a powerful tool in caries prevention, especially in a county like India where the oral health of a child is neglected. This review focuses on the history, indications, contraindications, mechanism, and safety margin of SDF as a dental material.

Keywords: *Silver diamine fluoride; Mechanism of action; Oral health, Child.*

Introduction

The field of dental sciences has witnessed plenty of changes to techniques, materials and concepts. With the advent of the 20th Century, a number of researchers began focusing on new materials that could be used to prevent dental caries. Unlike G.V. Black's concept of "extension for prevention", new age concepts focuses primarily on conservation and regeneration. The face of dentistry has changed since the concept of dental caries being a disease and not a lesion has emerged. The more we understood the mechanism of the disease process, the more we, as dentists began accepting a more medical approach towards treating dental caries. This involved the various caries risk assessments of the child patient followed by counseling the patient/parent regarding all the possible preventive methods deemed fit.[1]

One such concept which has gained popularity among dentists and researchers across the globe is Silver Diamine Fluoride (SDF). Since its invention in 1969, it has proven to be an effective and reliable alternative to other invasive treatment options.

History: Silver Diamine Fluoride was first invented by a Ph.D. Graduate named Mizuho Nishino at Osaka University, Japan in 1969.[2] She came up with the idea of using silver as an antimicrobial agent in combination with the remineralizing properties of fluoride. The product that resulted was a substance with additional properties like obliterating dentinal tubules by forming a precipitate, hence reducing dentinal hypersensitivity. Eventually, SDF was approved as a marketable product by the Central Pharmaceutical Council of the Ministry of Health and Welfare of Japan.[1] Since then, it is considered as a cariostatic agent. Toyo Seiyaku Kasei Co. Ltd., Osaka, Japan began marketing this product under the brand name Saforide.

The Food and Drug Administration (FDA) approved to release the first silver diamine fluoride product into the market in August 2014. In October 2016, SDF was awarded as the "breakthrough therapy" of the year, based on its efficacy in arresting dental caries in children as well as in adults. What followed next was the recognition of oral disease as a major medical condition and a serious public health issue.

Mechanism of action of SDF: SDF is a clear liquid product primarily made up of water, 25 % silver,

Corresponding Author:
Dr. Sarjana Mishra
Postgraduate Trainee, Department of Paediatric and Preventive Dentistry, Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be University), Bhubaneswar 751003,Odisha, India
e-mail: mishra.sarjana@gmail.com

8% ammonia and 5.5% fluoride. This results in a 38% SDF.[3]As the name suggests, Silver Diamine Fluoride contains silver, which acts as an antimicrobial agent, fluoride which contains remineralizing properties and ammonia which helps in stabilizing the solution at high concentrations. SDF was first invented to arrest dental caries and prevent dentinal hypersensitivity. As the carious process begins, the dentin undergoes demineralization leading to exposure of the organic matrix. After applying a preparation of silver diamine fluoride on a carious lesion, the formation of a squamous layer containing silver-protein conjugate occurs. This layer acts as a shield against acid dissolution and enzymatic digestion.[4] Eventually, there is formation of hydroxyapatite and fluorapatite, including silver chloride and metallic silver on the exposed surface of the organic content.[5] Once applied, lesion depth begins to decrease, while at the same time mineral density and hardness increases. SDF promotes inhibition of those proteins which split the exposed organic matrix of dentin: metalloproteinase, cathepsins and collagenases.[4]

Silver ions have anti-microbial and antirheumatic properties. It acts by breaching bacterial membranes and denaturing the proteins, thus inhibiting the process of DNA replication.[6] SDF surpasses all other bacteriostatic medicaments in destroying caries causing bacteria in the dentinal tubules.[7] Silver and fluoride ions can penetrate upto 25 microns into enamel[8] and nearly 50-200 microns into dentine.[9] Carious lesions arrested due to Silver diamine fluoride are nearly 150 microns thick.[10] Lesions that are artificially treated are defiant towards the formation of a biofilm and additional cavity formation, apparently because of the presence of residual silver ions.[11,12] It is found that more amount of silver and fluoride is deposited on demineralized carious dentin as compared to non-demineralized dentin as a result of which, demineralized dentin treated with SDFis better resistant to further caries attack than sound dentin treated with SDF.[13]

Due to the action of Silver ions, some amount of bacteria is killed. When these are supplemented to the living group of bacteria, the silver ions which were present are replenished and reactivated. As a result, the dead bacteria successfully kill the living bacteria as well. This process is coined as a "zombie effect".[14] This explains as to why the silver ions applied to a lesion within a cavity demonstrates sustained antimicrobial activity. While treating hypersensitivity, the application of topical SDF promotes the formation of a squamous protective layer on the exposed dentin matrix, eventually obliterating dentinal tubules.[6] This mechanism of action of SDF is in agreement with the Hydrodynamic theory of dentin hypersensitivity.[15]

Indications:

1. **Active carious lesions:** Both silver and fluoride ions display potential to prevent the formation of cariogenic biofilms. Increased concentration of fluorides can unite to the cellular components of cariogenic bacteria and regulate enzymes that help during glucose metabolism and also sucrose uptake.[16] Simultaneously, silver ions denature the bacterial cell wall, control enzyme activities,sway metabolic processes and hinder the replication of bacterial DNA.[16]
2. **Remineralization:** Fluoride acts as a remineralizing agent of hydroxyapatite in enamel and dentin. This takes place when SDF reacts with hydroxyapatite of teeth forming calcium fluoride and silver phosphate.[5] This calcium fluoride thus formed, is a reservoir of pH regulated fluoride on the surface of the decayed tooth. 38% SDF contains 44,800ppm of fluoride.[8]
3. **For caries prevention:** Topical application of SDF on healthy tooth surfaces prevents caries in children.
4. **Dentinal Hypersensitivity:** SDF promotes obliteration of dentinal tubules thereby reducing hypersensitivity.[18]
5. **Root caries:** Because of the virtue of SDF to arrest active caries, it can be annually applied on cariously exposed root surfaces, without any toxicity.[19]

Contraindications:

1. It cannot be used in patients prone to silver allergy.
2. SDF tends to irritate sensitive open pores. Hence, it cannot be used.
3. SDF cannot be applied to teeth that require endodontic therapy.

Clinical application of SDF: A study of extracted teeth treated by SDF found that the application of 38% SDF increases the remineralization process of initial carious lesions. The University of California, San Francisco (UCSF) designed a clinical protocol for the clinical application to maximize the safety and effectiveness of SDF in clinical settings[20].

1. Counter top and the patient should be covered with plastic.
2. Personal protective equipment (PPE) should be provided for the patient and the clinician.
3. In a dampen dish, take one drop of SDF. Simultaneously take one drop of SSKI in a separate dampen dish.
4. Using a saliva ejector, remove the excess bulk.
5. Isolation of the selected tooth from the tongue and cheek should be done using gauze or cotton rolls.
6. Use petroleum jelly if the affected tooth surface is close to the gingiva.
7. Use a triple syringe or dry cotton to dry the affected tooth surfaces
8. Using a microsponge, bend it, dip it into the dampen dish containing SDF, and squeeze the excess on the side.
9. Apply the microsponge directly onto the affected tooth surface(s).
10. Leave the SDF to soak up for one minute, then wipe the excess material using gauze or cotton roll. (In case of SSKI, use a separate micro sponge and apply onto the affected tooth surface. Repeat for one to three times till no more white precipitate appears. Wait five to ten seconds between the applications. Wipe the excess with cotton/gauze.)
11. After one minute, rinse with water.
12. Discard the used materials into plastic waste bags.

Many clinicians prefer application of SDF first during the initial appointment, then at one and/or three-month follow-up, then at every 3 months.

Side Effects: No adverse event has been reported since the approval of silver diamine fluoride as Saforide which was marketed more than 50 years ago.[21] Silver diamine fluoride causes darkening of carious lesions although it doesn't discolour sound enamel; it will cause some degree of darkening of early non-cavitated carious lesions. It is found that due to the formation of insoluble silver phosphate, the lesion treated with SDF turns black on exposure to sunlight. To surmount this shortcoming, potassium iodide was used after the topical application of SDF.

Maximum recommended dose and safety margin: Calculating the maximum recommended dose and the margin of safety of any drug is of utmost importance. Research conducted in this aspect yielded that an average Lethal Dose orally was 520 mg/kg and 380 mg/kg via subcutaneous route. One drop (25 µL) is sufficient to treat five teeth since it contains 9.5 mg of SDF. Assuming the youngest child with caries would be about 10 kg, 0.95 mg/kg SDF would be required for the child.[23]

Conclusion

Silver Diamine Fluoride has emerged as an exceptional treatment method in the field of dentistry. No material to date has reached up to it in terms of safety, efficacy and affordability. It is primarily indicated as a means of caries prevention for children, especially those who are terminally ill or too weak to be conventionally treated. It halts the disease process. SDF application is recommended twice annually, which surpasses all invasive conventional attempts at caries prevention. In a developing country like India, where the majority of the population cannot afford professional healthcare, this new-age material is a powerful tool that would help reach out to the masses. Children with a high caries burden are advised for SDF application on all teeth until they are restored or exfoliated. More research and refinement with regards to technique needs to be conducted to improve caries prevention modalities and provide quality healthcare.

Conflict of Interests: None

Ethical Permission: Approved

Funding: None

References

1. Peng JJ, Botelho MG, Matinlinna JP. Silver compounds used in dentistry for caries management: a review. J Dent. 2012;40(7):531-541.
2. Nishino M, Yoshida S, Sobue S, Kato J, Nishida M. Effect of topically applied ammoniacal silver fluoride on dental caries in children. J Osaka Univ Dent Sch 1969; 9:149–155.
3. Safety Data Sheet Advantage Arrest Silver Diamine Fluoride 38%, Elevate Oral Care EOC 1025 Rev 01 8/29/16

4. Mei ML, Li QL, Chu CH, Yiu CKY, Lo ECM. The inhibitory effects of silver diamine fluoride at different concentrations on matrix metalloproteinases. Dental Materials. 2012; 28(8):903–908.
5. Mei ML, Ito L, Cao Y, Li QL, Lo ECM, Chu CH. Inhibitory effect of silver diamine fluoride on dentine demineralization and collagen degradation. Journal of Dentistry. 2013;41(9):809–817.
6. Youravong N, Carlen A, Teanpaisan R, Dahlén G. Metalion susceptibility of oral bacterial species. Lett Appl Microbiol. 2011; 53(3):324–328.
7. Hamama HH, Yiu CK, Burrow MF. Effect of silver diamine fluoride and potassium iodide on residual bacteria in dentinal tubules. Australian Dental Journal. 2015; 60(1):80-87.
8. Suzuki T, Nishida M, Sobue S, Moriwaki Y. Effects of diamine silver fluoride on tooth enamel. J Osaka Univ Dent Sch. 1974;14:61–72
9. Chu CH, Lo ECM. Microhardness of dentine in primary teeth after topical fluoride applications. Journal of Dentistry. 2008; 36(6):387–391.
10. Mei ML, Ito L, Cao Y, Lo ECM, Li QL, Chu CH. An ex vivo study of arrested primary teeth caries with silver diamine fluoride therapy. Journal of Dentistry. 2014; 42(4):395–402.
11. Knight GM, McIntyre JM, Craig GG, Mulyani, Zilm PS, Gully NJ. Inability to form a biofilm of Streptococcus mutans on silver fluoride- and potassium iodide-treated demineralized dentin. Quintessence Int. 2009; 40(2):155–161.
12. Knight GM, McIntyre JM, Craig GG, Mulyani, Zilm PS,Gully NJ. An in vitro model to measure the effect of asilver fluoride and potassium iodide treatment on thepermeability of demineralized dentine to Streptococcusmutans. Australian Dental Journal. 2005;50(4):242–245
13. Knight GM, McIntyre JM, Craig GG, Mulyani, Zilm PS, Gully NJ. Differences between normal and demineralized dentine pretreated with silver fluoride and potassium iodide after an in vitro challenge by Streptococcus mutans. Australian Dental Journal. 2007;52(1):16–21
14. Wakshlak RB-K, Pedahzur R, Avnir D. Antibacterial activity of silver-killed bacteria: the "zombies" effect. Sci Rep. 2015; 5:9555.
15. Markowitz K, Pashley DH. Discovering new treatments for sensitive teeth: the long path from biology to therapy. J Oral Rehabil. 2008; 35(4):300–315.
16. Mei ML, Li QL, Chu CH et al. Antibacterial effects of silver diamine fluoride on multi-species cariogenic biofilm on caries. Ann Clin Microbiol Antimicrob 2013 12: 4.
17. Peng JJY, Botelho MG, Matinlinna JP. Silver compounds used in dentistry for caries management: A review. J Dent2012; 40(7):531–541.
18. Castillo JL, Rivera S, Aparicio T, et al. The short-term effects of diamine silver fluoride on tooth sensitivity: a randomized controlled trial. J Dent Res. 2011; 90(2):203-208.
19. Tan HP, Lo EC, Dyson JE et al. A randomized trial on root caries prevention in elders. J Dent Res. 2010 89:1086-1090
20. Horst JA, Ellenikiotis H, Milgrom PM. UCSF protocol for caries arrest using silver diamine fluoride: rationale, indications, and consent. J Calif Dent Assoc 2016 Jan;44(1):16-28
21. Chu CH, Lo ECM. Promoting caries arrest in children with silver diamine fluoride: A review. Oral Health Prev Dent 2008;6(4):315-321
22. Chu CH, Lo ECM, Lin HC. Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dentin caries in Chinese preschool children. J Dent Res 2002; 81(11):767-770.
23. Vasquez E, Zegarra G, Chirinos E, et al. Short-term serum pharmacokinetics of diamine silver fluoride after oral application. BMC Oral Health 2012; 12(1):60.