Applications of Silver Diamine Fluoride in Pediatric Dentistry- A Review

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Abstract:
Minimal intervention dentistry is a modern dental practice designed around the principal aim of preservation of as much of the natural tooth structure as possible. Silver diamine fluoride is one such approach that is effective in arresting the progression of carious lesions which also aids in the remineralization of the tooth structure. The procedure being quick and simple to use is being preferred as a treatment plan especially for pre cooperative children and in children with special healthcare needs. In the present review, several insights over the years on the applications of SDF in pediatric dentistry have been discussed.

Keywords: Silver diamine fluoride, dental caries, minimally invasive technique
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Introduction:
Use of silver in dentistry dates to 659 AD, owing to its antimicrobial properties.[1] It is a topically applied antimicrobial solution with remineralization potential.[2]It has the capacity to stop the caries progression and to arrest the formation of new carious lesion.[3]SDF was first introduced in Japan by the Central Pharmaceutical Council of the Ministry of Health and Welfare in 1960. It was seldom known outside Japan. [4] Its use was popularized after the approval from the Federal Drug Administration (FDA) in the year 2014 and is also mentioned as an essential

medicine, effective and safe for use by the World Health Organization.[5] SDF has proved effective as a minimally invasive treatment strategy for young children in the pre-co-operative stage and for medically compromised children. [6]

Composition-

SDF is a colourless, odourless, and alkaline topical solution with a combination of silver- an antimicrobial agent, fluoride- a remineralizing agent and ammonia- as a stabilizing agent. [7]

Several available concentrations of SDF are as below.

38% SDF- 44,800 ppm F; 249,000 ppm of Ag
30% SDF - 35,400 ppm F; 213,000 ppm of Ag
12% SDF - 14,150 ppm F; 79,000 ppm of Ag.[8]

The AAPD guidelines of 2017, recommend the use of 38% SDF for arresting carious lesions. [9]

Mechanism of action-

The bactericidal action of SDF is due to interaction of silver with sulfhydryl groups of proteins and deoxyribonucleic acid (DNA) of the bacteria. This inhibits the respiratory processes, cell-wall synthesis, and cell division of the bacteria thereby killing it and inhibiting biofilm formation.[10] Three possible mechanisms of action of SDF on caries were described by *Shimizu and Kawagoe (1976)*. The first mechanism proposed by *Shimizu* may be due to the obturation of dentinal tubules by silver and its compounds. Therefore, diffusion of acid and invasion of microorganisms through the dentinal tubules is blocked. [11] The second mechanism proposed is the cariostatic action caused due to the reaction between SDF and mineral component of the tooth. SDF ($Ag(NH_3)_2F$) reacts with hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) to release calcium fluoride (CaF_2) and silver phosphate (Ag_3PO_4).

$Ca_{10}(PO_4)_6(OH)_2 + Ag(NH_3)_2 \rightarrow CaF_2 + Ag_3PO_4 + NH_4OH$

The Ag_3PO_4 precipitates on the tooth and the CaF_2 forms fluorapatite which is more resistant to decalcification.

$CaF_2 \rightarrow Ca^{++} + 2F^-$

$Ca_{10}(PO_4)_6(OH)_2 + 2F^- \rightarrow Ca_{10}(PO_4)_6F_2 + 2OH^{-12}$

The third mechanism is the anti-enzymatic action of SDF on the bacterial enzymes. This disrupts the metabolic process leading to death of the cariogenic bacteria. SDF reduces the colonization of cariogenic bacteria by dextrin induced agglutination of cardiogenic strains of *S. mutans*. [13]*Chu et al, 2012*, reported the antimicrobial activity of SDF against *S. mutans* and *A. naeslundii* formed on dentin surface.[14]

Clinical application of silver diamine fluoride

1. Arresting caries in primary teeth

SDF is effective in arresting decay in primary teeth.[15] According to the AAPD guidelines of 2017, SDF can be applied on cavitated lesions not involving the pulp and with no signs of pulp inflammation and or spontaneous pain.9 Lesions with visible plaque have a lesser likelihood for caries arrest.[16]

2. Sedation free treatment in very young pediatric patients.

In recent times, parents opt for minimally invasive techniques for their children. SDF acts as a stop-gap treatment for the younger patients until they turn older or become more cooperative.[17]

3. SDF modified Hall technique.

Professional application of SDF with a micro brush over the cavitated lesion over a period of 1 min helps in saturation of the lesion. This is followed by application of stainless-steel crown.[17]

4. SDF application in molar incisal hypomineralization lesion.

Many non-invasive and minimally invasive procedures have been proposed for treatment of hypomineralized molars. Silver diamine fluoride (SDF) by virtue of the remineralizing effect and relief of hypersensitivity by blocking the dentinal tubules poses a good treatment option for MIH lesions. [18]

Discussion-

The non- invasive property and simple application technique makes SDF extremely beneficial in the treatment of children with

special healthcare needs and those with other complex conditions viz chronic diseases, immunocompromised patients, salivary dysfunction, or those on chemotherapy.[19]*Contreras et al, 2017* in a systematic review concluded that 30% and 38% SDF showed potential for caries prevention in primary teeth and permanent first molars. [20]*Llodra et al, 2005*, found that 38% of SDF showed 80% reduction in new caries formation when compared to the water control group over a period of 36 months. They also stated that the SDF showed better efficacy to arrest decay in primary dentition than permanent first molars.[21] The incidence of root caries increases with age and its prevalence is high in elders.[22] Studies by *Tan et al, 2010* and *Zang et al, 2013* concluded that annual application of SDF is quite effective in arresting root surface caries.[23] SDF blocks dentinal tubules and create barrier which helps in reducing hypersensitivity. In a study, SDF showed greater efficacy in reducing short- tern sensitivity when compared to either placebo or an oxalic acid-based preparation. *(Craig et al., 2012, Castillo et al., 2011)*. SDF is useful in managing the symptoms occurring as a virtue of hypo mineralized molars (primary or permanent) in children, *(Gamboa, 2017; MacLean, 2018)*.The survival rate of SMART sealants on occlusal and palatal surfaces was 88.7% and 58.8%, respectively *(Ballikaya et al, 2022)*.[24] SDF is a cariostatic agent and it restores mineral content of the tooth. *(Chu, Lo, & Lin, 2002; Yokoyama, Kimura, Matsumoto, Fujishima, & Miyazaki, 2001).* In a study done by *Shah et al, 2020*, a clinical and radiographic success rate of 100% in SDF and 93.75% in calcium hydroxide as an indirect pulp capping agent was observed.[25] In an invitro study, a 1:10 dilution of 38% SDF solution was 100% efficacious against *E. faecalis* strains. *(Al-Madi et al, 2019)*[26] SDF when coupled with Hall's crown shows better coronal seal in comparison to the conventional restorations in children with high caries risk. [27]

Conclusion

SDF at 38% can be a non-invasive treatment option to arrest dentinal caries. The synergistic effect of silver and fluoride inhibits bacterial growth and helps in remineralization. Its short and easy application makes it useful especially in cases of early childhood caries, children with special healthcare needs and the ones where the treatment is challenged by behavioural or medical issues.

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