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Silver Diamine Fluoride as a Caries Management Option for the Young Child

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Silver Diamine Fluoride as a Caries Management Option for the Young Child

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Dental caries remains a common and significant problem in childhood; in the United States, about 1 in 4 children ages 2 – 5 years is affected by caries.[1] Untreated moderate/deep caries lesions can lead to oral infection and pain with downstream effects on a child's nutritional intake, sleep difficulties, ability to attend school, and self-esteem.[2] Unfortunately, there are profound disparities in caries experience, with children from low socioeconomic backgrounds and minority groups experiencing significantly higher disease rates.[3] There are also ongoing issues related to access to preventive dental services and care.[4]

Traditionally, the standard of care for caries lesions is focused on dental restorations or extractions.[5] This treatment approach requires a certain amount of behavioral compliance from the patient. Many young children who need extensive treatment are uncooperative, have immature cognitive functioning, disabilities, or medical conditions, and need to be treated under sedation or general anesthesia (GA).[6]

When caries lesions are cavitated and restoration is indicated, many effective options are available, including conservative strategies requiring no or selective caries removal.[7] Providing non-invasive or minimally invasive treatment is recommended for the management of dental caries when significant barriers to traditional restorative treatment exist, such as behavioral challenges, economic concerns, or limited access to care. As a non-invasive treatment, silver diamine fluoride (SDF) is gaining popularity as an alternative agent for treating caries. SDF is a liquid solution with a basic pH that contains a high concentration of silver, fluoride, and ammonium ions.[8] SDF has been used in dentistry for more than 50 years.[9] In 2014, 38% SDF was approved in the United States for use as a dentin desensitizing agent for treatment of hypersensitivity.[10] In 2020, the American Dental Association supported the use of SDF for caries management, and furthermore the American Academy of Pediatric Dentistry recommended SDF to arrest caries in primary teeth as part of a comprehensive caries management program.[11]

As a caries control measure, SDF has been shown to reduce the incidence of dental emergencies in children on GA wait lists by 80%.[12] SDF was also associated with a greater time to first sedation or GA encounter in children under age 5 in the United States.[13] Increasing the time to first sedation or GA results in children who are more mature by the time they are first treated, giving dentists more options in delivering individualized and comprehensive care, and allowing health systems more opportunities to deliver person-centered care.[13]

Abstract

Dental caries is among the most-common childhood diseases around the world, and neglected caries can result in pain, infection, and can have a negative cascading impact on a child's overall well-being. Definitive care of these lesions involves restorative procedures and/or extractions, but these treatment options require some level of child cooperation, which can sometimes be a challenge with very young children.

Silver diamine fluoride (SDF) is a non-invasive treatment intended to arrest the caries process. SDF is a liquid solution that contains a high concentration of silver and fluoride ions and has been used as an alternative agent for treating caries, showing effectiveness in arresting caries lesions in primary teeth and reducing the incidence of dental emergencies in childhood. This paper describes the mechanism of action of SDF; considerations and evidence for use; indications and contra-indications including safety considerations; side-effects and adverse events; and describes the sequence of treatment in four clinical cases.

Keywords: silver diamine fluoride, dental caries, children.

SDF mechanism of action

SDF arrests dental caries by three primary mechanisms of action: (1) remineralization, (2) antiproteolytic

activity, and (3) antimicrobial activity.[14] All of these effects are attributed to the bioavailability of fluoride and silver ions.[15] SDF ions increase the local pH, which promotes remineralization by calcium and fluoride.[10,16] SDF slows caries formation due to the inhibitory effect on matrix metalloproteinases and cathepsins, which are responsible for dentin collagen degradation during the caries process.[10] Silver ions in the SDF solution act on the biofilm, preventing bacterial aggregation of streptococci, actinomycetes, and lactobacilli, which are the primary bacteria responsible for initiating the caries process.[17] Silver ions react with the bacterial cell wall, causing cell lysis and inhibiting bacterial metabolic activity and replication of bacterial DNA.[15,18] Additionally, silver precipitates can reduce the patency of dentinal tubules, preventing microorganisms and their metabolites from reaching the deeper portions of the tooth structure and pulp.[19] Finally, the ammonia acts as a stabilizer, allowing the other ions to remain stable over a longer period of time.[10]

Evidence for use of SDF

Silver diamine fluoride has been used in Japan for more than 40 years to arrest caries and reduce tooth hypersensitivity in primary and permanent teeth.[20] A 38% aqueous solution was commercially made in Japan and used in the treatment of early childhood caries in the 1970s.[21] The use of SDF in Japan has diminished due to esthetic concerns; however, SDF is gaining in global prominence due to an aging population with caries and the COVID-19 pandemic.[18,21]

Clinical and laboratory studies have shown that SDF is effective in arresting caries lesions.[22-24] This effect is demonstrated by limiting the progress of caries lesions, inhibiting demineralization, and preserving collagen in demineralized dentine.[25] Studies consistently conclude that SDF is more effective for arresting dentinal caries than fluoride varnish, and SDF has approximately two to three times more fluoride retained than varnish.[24,26-28]

Systematic reviews, umbrella reviews, and clinical trials have concluded that 38% SDF is effective in arresting cavitated lesions in primary teeth, with arrest rates increasing after multiple applications, ranging from 65% to 91%.[5,11,29-33] Evidence-based clinical practice guidelines in the United States support the biannual application of 38% SDF.[11,29] Additionally, SDF has not been shown to reduce adhesion of resin or glass ionomer restorative materials.[34-38] A new technique in caries intervention and management that combine SDF and atraumatic restorative treatment (ART), known as silver-modified atraumatic restorative technique (SMART), offers children an interim alternative to traditional restorative techniques providing the dual benefits of arresting the caries lesion and temporarily restoring the tooth[18] until definitive treatment can be performed. Placement of a restoration following SDF may prevent the fracture of the remaining tooth structure, prevent space loss,[39] and provide improved access for biofilm removal.[40]

SDF indications and contraindications

SDF is used as an agent to promote the arrest of caries lesions and remineralization of dentin. SDF is effective for active caries, root surface caries lesions, and cavitated caries lesions

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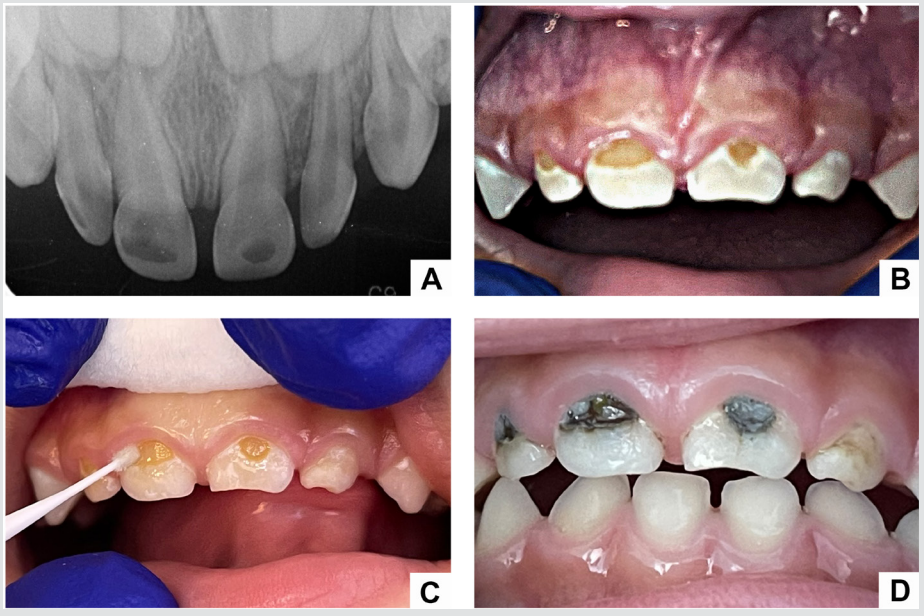
Figure 1 — Application of SDF on a 3-year-old for sedative treatment for early childhood caries.



A) Occlusal radiograph showing caries on #D, #E, #F and #G. No signs of infection such as radiolucency in periapical area, PDL widening, or root resorption. B) Clinical photo showing large cavitated lesions. C) Application of SDF with micro-brush under cotton roll isolation. D) Discoloration of caries lesions after application of SDF.

on any surface which is directly accessible. SDF can also be used on non-carious cervical lesions prior to restoration placement and in molar incisor hypomineralization (MIH) to reduce sensitivity.[41] SDF may be indicated for pre-cooperative children; patients with multiple cavitated caries lesions that may not be all treated in one visit; patients with high caries risk; and those with medical or physiological conditions that limit other treatment approaches. SDF is often used to "buy time" and arrest caries lesions for patients until more definitive care can be delivered.

Contraindications to the use of SDF include clinical signs or symptoms of irreversible pulpitis, or dental abscess/fistula; radiographic signs of pulpal involvement or peri-radicular pathology; silver, fluoride, or ammonia allergy; patients with ulceration, mucositis, or stomatitis; and pregnant or breastfeeding women due to concerns of overloading the developing thyroid with iodide.[15,42]

Side effects, safety, and adverse effects

In previous clinical trials, no deaths or systemic adverse effects were reported in children exposed to SDF when following the manufacturer's recommendations.[11] SDF is safe when used in adults and children in accordance with dosing and application criteria (AAPD 2023) and does not appear to negatively impact oral health-related quality of life in young children.[11,43,44] SDF should be avoided in patients with allergies to silver compounds.[42]

Studies have not found any reduction on bonding strength of resin or glass ionomer restorative materials after SDF application, or pulpal damage due to SDF interactions.[45,46] The main adverse effect of SDF is the undesirable dark discoloration/staining on caries lesions, which does not disappear unless restored. To reduce the negative esthetic effect, potassium iodide (KI) can be applied after SDF to partially mask the unwanted substrate color.[47] The silver ions of SDF react with KI to form a white precipitate, preventing pigmentation and preserving the beneficial properties of SDF; however, more research on this context needs to be done.[48] SDF can also cause a temporary skin stain if it contacts the skin, which usually resolves in 2-14 days.[42,49] Additionally, a metallic/bitter taste and mucosal irritation within 48 hours after SDF application have been reported as well.[42,50]

Informed consent with a full discussion of the risks, benefits, and alternatives prior to use is critical, and illustrating the expected staining of treated lesions with photographs may be helpful.

Assessing SDF treatment success

For caries management, the success of SDF is assessed by arrested caries or no clinical signs or symptoms of pulp pathology.[5] Caries activity is most accurately assessed by how the lesion feels when a ball-ended probe is dragged across it. For enamel, the lesion's roughness and smoothness is assessed, and for dentin the lesion's hardness and softness is evaluated. A caries lesion is considered arrested when checked with a probe, if the enamel surface is smooth and/or dentin surface is hard.[51,52]

Sequence of SDF application and Clinical Cases

The SDF application sequence suggested by the American Academy of Pediatric Dentistry Clinical Practice Guideline[11] includes:

1. Remove gross debris from cavitation.
2. Isolate with cotton rolls to minimize SDF contact with gingiva and mucous membranes.
3. Dry affected tooth surface with gentle flow of compressed air or cotton rolls.
4. Dip a micro-brush into the SDF solution and remove excess liquid before application.

Figure 2 — SDF application on a 3-year-old female patient with fused tooth (#D).

A) Occlusal radiograph showed caries on the fused tooth- #D. B) Clinical photo showing a caries lesion located on incisal-lingual surface of #D, and facial surface of #F. C) Discoloration of after SDF application.

5. Apply SDF directly to the affected tooth surface for one minute. Dry with a gentle flow of compressed air for at least one minute until liquid is dry.

6. Remove excess SDF with gauze, cotton roll, or cotton pellet.

7. Continue to isolate the site for up to three minutes.

Eating and drinking immediately following application is acceptable. However, several SDF clinical trials have recommended not eating or drinking for 30 minutes to one hour following application.[53-55] Patients may brush with fluoridated toothpaste as per their regular routine following SDF application.[11]

SMART technique

After placement of SDF, an opaque glass ionomer cement (GIC) may be placed over the SDF-treated surface immediately after application or in the subsequent appointment. The GIC will serve as a sedative filling until the patient's condition allows definite treatment to be completed.

Clinical cases

Case 1: A 3-year, 0-month female presented with her mother because of concern for decay. Upon clinical examination, #D, #E, #F, and #G showed extensive caries on facial surfaces along the gingival margin (Fig. 1B, see Page 37), while no evidence of infection was seen radiographically (Fig. 1A, see Page 37). SDF was proposed as a caries-arresting treatment before definitive treatment of these and other lesions could be completed under general anesthesia. After discussion with the mother, consent was obtained, and SDF was applied under cotton roll isolation (Fig. 1C, see Page 37). The caries lesions stained after SDF application (Fig. 1D, see Page 37).

Case 2: A 3-year, 7-month-old female presented with her mother for a recall examination. Upon radiographic and clinical examination, tooth #D was found to have fusion and caries on the inciso-lingual surfaces, and tooth #F had caries on the facial surface (Fig. 2A, Fig. 2B). A composite crown on #F and extraction of #D was proposed due to the extent of the caries lesion and questionable restorability considering the altered anatomy of the fused tooth. The mother agreed with the proposed treatment and elected to complete the treatment under sedation. SDF was discussed as caries control until definitive treatment could be scheduled. Both lesions showed staining after SDF application (Fig. 2C).

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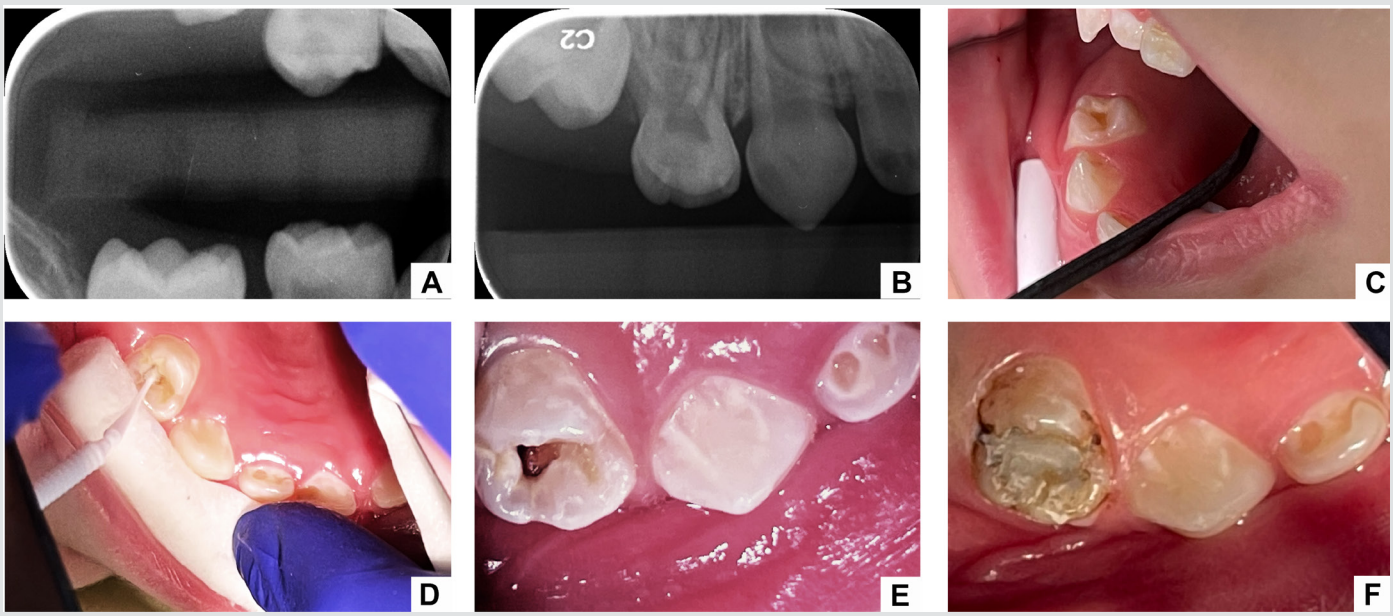
Figure 3 — SMART technique on a 2-year, 1-month-old male for early caries lesion on tooth #B.



A) Bitewing radiograph showing the caries lesion on the occlusal surface of tooth #B. B) Periapical radiograph showing no evidence of furcation involvement or periapical pathology. C) Clinical caries lesion on the occlusal of tooth #B. D) SDF application with micro-brush for 1 minute — cotton roll isolation. E) discoloration immediately after SDF application. F) final sedative filling with glass ionomer — note the presence of pigmentation on the demineralized areas around the tooth.

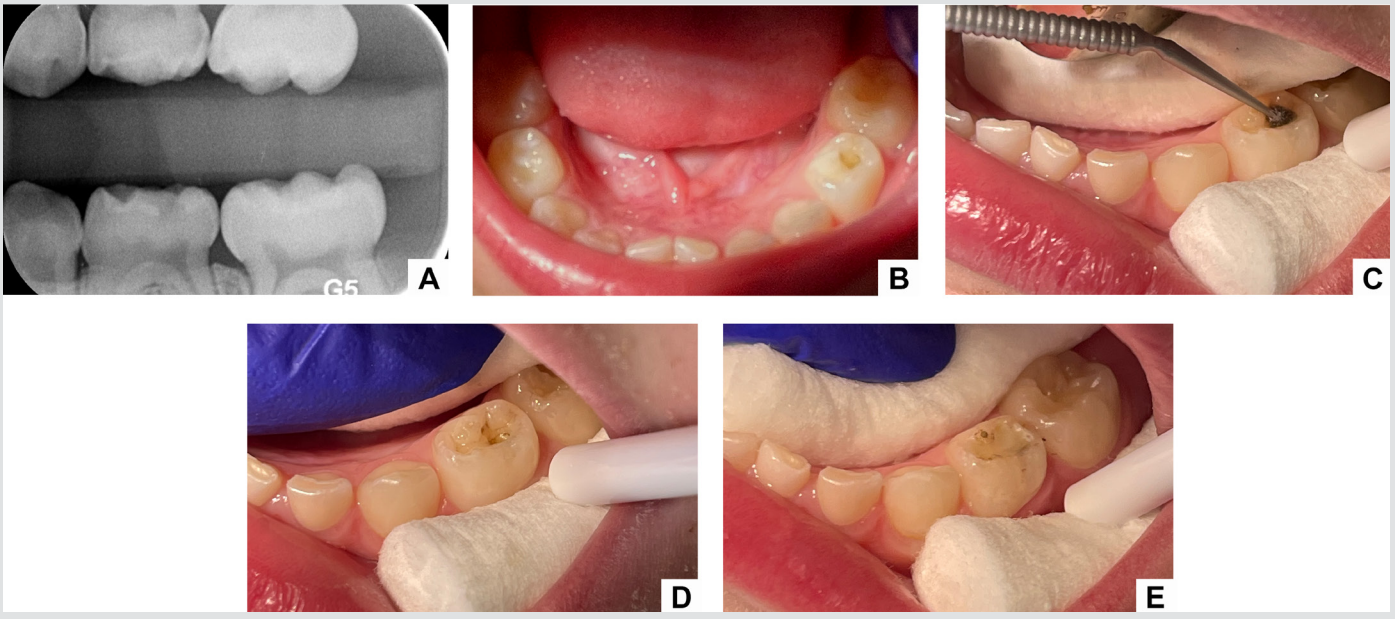
Case 3: A 2-year, 1-month-old male presented with his mother with a concern of decay. Upon clinical examination, severe early childhood caries was noted. A bitewing (Fig. 3A, see Page 39) and periapical (Fig. 3B, see Page 39) radiograph were obtained of #B. Mother opted to complete definitive treatment of all decayed teeth under sedation. SDF was offered as an interim treatment, and an informed consent was obtained. The SMART technique was performed on tooth #B-O (Fig. 3C, see Page 39). Gross debris from the cavitation was removed with a spoon excavator, followed by SDF application with a micro-brush directly to the affected tooth surface for one minute (Fig. 3D, see Page 39); SDF was dried, and the excess was removed (Fig. 3E, see Page 39) with a cotton roll. After three minutes, 20% polyacrylic acid was applied for 10 seconds, rinsed and blot-dried, and a glass ionomer cement (GIC) was placed on the treated surface (Fig. 3F, see Page 39). The GIC in this case serves as a sedative filling until the patient returns for definitive treatment with sedation.

Case 4: A 5-year, 2-month-old male presented with his mother for a recall appointment with concern of new cavities and food getting stuck in a lower left tooth. Upon radiographic (Fig. 4A) and clinical examination (Fig. 4B), caries was noted on distal surface of #I, mesial surface of #J and the occlusal surface of tooth #L. Composite restorations were presented for definitive treatment. SMART treatment was discussed for tooth #L (due to chief concern) and consent was given. Gross debris was removed with a spoon excavator followed by SDF application with micro-brush directly to the affected tooth surface for one minute (Fig. 4C); SDF was dried, and the excess was removed (Fig. 4D) with cotton roll. After three minutes, 20% polyacrylic acid was applied for 10 seconds, then rinsed and blot-dried, and a glass ionomer cement (GIC) was placed on the treated surface (Fig. 4E).

Conclusion

SDF has demonstrated versatility in the field of dentistry, offering a wide range of applications. There is a growing body of evidence supporting SDF's use as a caries-arresting agent. SDF has been successfully used for patients who are waiting for comprehensive and definitive treatment with sedation or general anesthesia. Providers should inform patients and the individuals responsible for their care (such as parents or guardians) about the potential side effect of discoloration in areas affected by decay,

Figure 4 — SMART technique on a 5-year, 2-month-old male on the occlusal surface of tooth #L.



A) Bitewing radiograph showing depth of caries. B) Clinical caries lesion on the occlusal surface of tooth #L. C) SDF application with micro-brush under cotton roll isolation. D) immediately after SDF application – note the discoloration. E) final sedative filling with glass ionomer.

and treatment should be completed in accordance with the ADA or AAPD recommendations. ●

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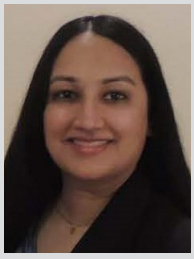
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