

Silver diamine fluoride for treatment of caries in the primary dentition

Learning outcomes

- To understand the mode of action and clinical indications for the use of 38% silver diamine fluoride (SDF) in primary dentition; and,
- to be aware how to apply 38% SDF in a safe and effective manner.

Introduction

Silver diamine fluoride (SDF) is an increasingly popular and highly effective technique for caries arrest in the primary dentition. SDF is a clear, odourless liquid that flows just like water.¹ It is a solution containing silver, fluoride and ammonia,¹ and the most commonly used concentration is 38%, which contains 44,800ppm of fluoride.¹ While there are many formulations of SDF available worldwide, the only product available in Ireland is Riva Star (SDI Limited). SDF was licensed by the US Food and Drug Administration (FDA) in 2014 for use as a desensitising agent, and this paved the way for its use off label for caries arrest.^{1,2} While SDF has been used for many years, it had a resurgence during the recent Covid-19 pandemic, as it could be used as a non-aerosol-generating procedure (AGP) option for dentine caries management.³ Furthermore, with the increasing focus on minimal intervention dentistry in children, SDF has been included as a viable option in a number of recent policies² and best practice guidelines for management of cavitated caries in primary teeth.^{4,5} Since 2021, 38% SDF has been included in the World Health Organization's Lists of Essential Medicines for caries management, along with fluoride toothpaste and glass ionomer cement.⁶

How does SDF work and is it effective?

SDF has a number of mechanisms of action that work synergistically to arrest caries and desensitise once the solution contacts the tooth. The antibacterial effects of silver act synergistically² with the remineralising ability of fluoride;⁷ bacteria are killed, demineralised tooth tissue is remineralised, dentine is hardened, and dentine tubules are blocked by the silver precipitate.¹ As the carious lesion arrests, it will be stained black due to precipitation of the silver byproducts.⁷ SDF has been proven to be highly effective in arresting coronal caries in the primary dentition, arresting approximately 80% of treated lesions.⁷⁻⁹ It is more successful when used in accessible areas of the mouth⁹ and on lesions that can be kept clean.⁸ It is recommended that 38% SDF should be applied twice a year for maximum efficacy.^{7,8} As yet, there is insufficient evidence for using SDF to arrest caries in permanent teeth



FIGURE 1: Post treatment with 38% SDF on tooth 84 with black discolouration. Note that the non-cavitated demineralised enamel on tooth 85 (mesially and buccally) is also stained after application.

in children.⁸ Aside from being highly effective, SDF has a number of other advantages: it is quick and easy to apply with no caries removal required in advance, and as it requires little co-operation it is ideally suited for younger children.

Are there any disadvantages?

The main disadvantage of SDF is the distinctive permanent black discolouration of the carious enamel and dentine following its use. Although sound enamel will not stain, even non-cavitated demineralisation and white spot lesions will become black.¹ It is important to consider this possibility in relation to teeth adjacent to the treated tooth (**Figure 1**). Caution must be taken during SDF application to avoid temporary staining of the skin and mucosa, which, if it occurs, will resolve in one to three weeks and does not require treatment.¹ SDF must be handled with care in the dental surgery as accidental spillage on worktops and clothes will cause permanent staining. Tooth staining may be unacceptable to parents, particularly in the anterior area.^{7,10} Studies have shown that acceptability of SDF-induced tooth discolouration is dependent on the particular tooth, the situation and the invasiveness of proposed alternatives.¹¹ Some parents will accept SDF if it avoids treatment under general anaesthesia for example; however, 30% of parents will not accept SDF under any



Rona Leith

Assistant Professor in Paediatric Dentistry
Division of Public and Child Dental Health
Dublin Dental University Hospital
Trinity College Dublin

Isabel C. Olegário

Assistant Professor in Paediatric Dentistry
Division of Public and Child Dental Health
Dublin Dental University Hospital
Trinity College Dublin

Corresponding author: Rona Leith, Dept. of Public and Child Dental Health,
Dublin Dental University Hospital – Trinity College Dublin

E: rona.leith@dental.tcd.ie

Table 1: Indications and contraindications for SDF.^{4,5,10}

Indications	Contraindications
- Active cavitated carious lesions not encroaching on the pulp - Cavitated lesions accessible to microbrush - Where other treatment is challenged by behavioural or medical management - Patients with limited access to dental care	- Clinical or radiographic signs of irreversible pulpitis or pulp necrosis - Caries into pulp clinically or radiographically - Allergy to silver, fluoride or ammonia - Ulcerative gingivitis or mucositis - Insufficient compliance - Patients undergoing thyroid gland therapy or on thyroid medication (only if using potassium iodide)

**FIGURE 2:** Riva Star (SDI) 38% SDF single-use capsule kit.

circumstance, and therefore it is essential to obtain robust consent using pre and post-operative photographs.¹¹ Other than minor side effects such as transient mucosal irritation and a metallic taste, no serious adverse events, such as allergic reactions or acute toxicity, have been reported when SDF is used as recommended.^{7,8,12}

SDF is not licensed in Ireland and its use for caries arrest is 'off label'.¹ While use of a product 'off label' can be acceptable in certain circumstances,¹ detailed consent and documentation is advised in this regard, as well as employer support. A comprehensive overview of the use of a SDF 'off label' in the UK is provided by Seifo *et al.* (2020).¹

When is SDF indicated and how is it used?

Prior to application, the pulp status of the primary tooth needs to be correctly diagnosed. SDF is indicated for vital teeth with cavitated dentine caries, which are accessible to a microbrush. A comprehensive history, and clinical and radiographic examination are essential, especially for deep caries.⁴ There is recent evidence that SDF should not be placed on very deep lesions adjacent to the pulp, or on exposed pulps, as it may produce toxic effects, pain, inflammation or pulp necrosis.^{11,13,14} A summary of indications and contraindications for SDF is shown in **Table 1**.

Riva Star is available as a two-step bottle kit or a two-step single-use capsule kit, and both should be stored in the fridge. The authors recommend use of the single-use capsules (**Figure 2**) as there is potentially more risk of accidental staining of hands, worktops, etc., when manipulating the bottle kit. The Riva Star capsule kit also comes with a light-cured gingival barrier that can be applied to the gingiva around the tooth for optimal isolation. When using Riva Star, the grey capsule or bottle containing SDF

Table 2: Step-by-step application of 38% SDF (Riva Star capsules).^{7,16}

Steps	Description
Before use	Consent and pre-treatment checks Remind any assisting staff of the potential for staining and cover worktops with plastic-lined bib. Ensure parent is on board and obtain written consent. Ensure the child has plastic-lined bib and safety glasses. Prepare the tooth Protect exposed soft tissue (gingiva/lips) with petroleum jelly. Clean the teeth and remove debris – there is no need to remove caries. Isolate tongue/cheeks from the area to be treated with gauze or cotton rolls. If using a gingival barrier, light cure in a fanning motion to avoid hot spots.
During use	Apply SDF Pierce silver capsule with silver microbrush, bend brush and wet tip. Remove excess liquid from microbrush with gauze or on the inside rim of the capsule. Dry tooth with 3-in-1 or gauze. Apply to dentine caries lesion – no need to agitate. Allow to dry for one minute – do not let it come into contact with gingiva, tongue or lips. Blot excess (note: caries may turn black immediately). Continue to isolate the tooth for up to three minutes if possible. Cover with toothpaste to mask the metallic taste (optional). Rinsing afterwards is not necessary.⁷ Apply KI (optional) Use immediately following SDF application. Pierce green capsule with green microbrush. Apply KI to SDF until creamy white precipitate turns clear. Blot excess. Allow to dry completely.
After use	Post-treatment instructions Dispose of all materials carefully after application, including gloves. The patient should avoid eating/drinking for one hour. Instruct the patient to keep the teeth as clean as possible and organise review appointment.

is used first, followed immediately by the green capsule or bottle, containing potassium iodide (KI).¹⁵ The use of the KI was thought to reduce staining following SDF application, but there is little evidence for its effectiveness, so this step might be considered optional. Clinicians must be mindful when treating young children to use the minimum amount of SDF possible, and the American Academy of Pediatric



FIGURE 3a: Cavitation into dentine on tooth 53 with no clinical signs of pulp pathology. Note that lesion is accessible to microbrush and cleansable.
FIGURE 3b: Application of 38% SDF. Note that gingival barrier has been applied in this case (optional).
FIGURE 3c: Tooth 53 after 38% SDF application. Note enamel demineralisation on the buccal surface has also stained black.

Dentistry (AAPD) specifies that no more than one drop of SDF should be used for the entire appointment.^{10,16,17} This amount would be ample to treat five teeth,¹⁷ which would rarely be indicated in a single visit.

The step-by-step application of SDF is detailed in **Table 2** and **Figure 3**. There are a number of free resources available to the clinician, including chairside guides,¹⁶ specific consent forms,^{17,18} and YouTube demonstration videos for clinicians and videos for children.

When do I follow up?

The patient should be reviewed after two to four weeks to assess caries arrest.¹⁰ Arrested carious lesions should be free of plaque and on probing should feel hard like stone. Hardness rather than colour is the most important factor in assessing caries arrest.^{1,5} The carious lesions can be restored if desired to improve aesthetics or if adequate cleaning is not maintained or possible. There is no evidence that SDF adversely affects the bond strength of composite or glass ionomer cement to dentine.^{1,10,19} However, if lesions are left unrestored, SDF should be reapplied biannually. All patients who receive SDF are determined to be high caries risk, and should be reviewed every four to six months.²⁰

Conclusion

Application of SDF requires little skill but correct pulpal diagnosis of the tooth is crucial. SDF is indicated for asymptomatic, vital primary teeth with cavitated caries into dentine. The only significant disadvantage is the tooth discolouration, which necessitates a comprehensive discussion with parents prior to use. SDF is highly effective for caries arrest and is safe when used according to the manufacturer's recommendations. It is more effective on anterior teeth but parents are more likely to consent for use on posterior teeth. There is evidence that SDF is an extremely useful option for caries management in primary teeth, but it is important to remember that it must be used as part of a holistic caries management plan including dietary counselling and biofilm control.

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