SDF FOR HYGIENISTS

Introduction

Dental caries, one of the most common chronic diseases, remains a significant problem across all age groups\(^1\). For over a decade, science has been searching for an alternative paradigm to manage this disease where the causative pathogenic factors are treated based on the unique caries risk of the individual\(^2\). To effectively arrest, reverse, and treat all aspects of caries lesions (non-cavitated and cavitated) more precise terminology was established\(^3\). Recently the ADA Caries Classification System (ADA CCS) was published to provide oral healthcare professionals the terminology to classify all stages of caries lesions (non-cavitated and cavitated) based on the site, extent, and activity\(^3\).

Caries management by risk assessment example protocols have been published and updated for children\(^4\) and adults\(^5,6\). These protocols have focused on modifying the patient risk factors using a combination of chemical therapeutic interventions coupled with behavioral modification targeted at altering the microbiota, halting further demineralization, and supporting remineralization.

Recently, silver diamine fluoride (SDF) emerged as a new chemotherapeutic option for caries management and has demonstrated great promise. In 2009, a systematic review suggested that SDF is a safe, effective, efficient, and an equitable caries-preventive agent that appears to meet both the World Health Organization Millennium Goals and the United States Institute of Medicine's criteria\(^7\). In addition, a significant advantage of using SDF to chemically arrest an active lesion, is avoiding dental injections and minimizing use of dental drills. This alone can transform a child’s first dental experience from traumatic to pleasant and instills trust and makes subsequent interactions with dental professional more successful.

In the July 2015 edition of Dimensions of Dental Hygiene, SDF was announced as a newly available tool in the U.S. caries prevention armamentarium. This paper will review the scientific properties of SDF and then focus on the “how to” clinical applications of SDF for caries arrest of particular interest to dental hygienist. There is currently one SDF product available in the U.S., which is currently FDA approved for treating dentinal hypersensitivity. As such, protocols presented in this manuscript for caries arrest, are consistent with, but may differ slightly to the printed manufacturer’s instructions.

Science and History

SDF (38% w/v Ag(NH\(_3\))\(_2\)F, 30% w/w) is an inexpensive colorless topical agent that has been
used extensively outside of the US to treat and prevent dental caries. The silver acts as an antimicrobial with substantivity, preventing reinvasion of cariogenic bacteria after application. The fluoride promotes remineralization with the highest fluoride concentration of any available material. Silver diamine is a metal complex that dramatically stabilizes the high concentrations of silver and fluoride in solution. Upon application of SDF to a decayed surface, a silver-protein conjugate layer forms and increases resistance to acid dissolution and enzymatic digestion. Treated lesions increase in mineral density and hardness while lesion depth decreases.

In August 2014, SDF was cleared by the FDA for marketing as a Class II medical device to treat tooth sensitivity. SDF became commercially available in the U.S. in April 2015. In a recent publication, a working group composed of national experts on use of silver diamine fluoride recommended widespread off-label use for treating and preventing caries in the U.S. In January 2016, the CDT billing code (D1354) for caries arrest by medicament became active, and Medicaid immediately started reimbursing this code in multiple states.

Several randomized clinical trials evaluated the efficacy of SDF in treating dental caries. Two studies in children demonstrate 91-93% caries arrest after 2-3 years with twice per year application. Two studies show 65-79% arrest after 2-2.5 years with once per year application. A dose-effect was seen with higher frequency of application. Reapplication seems to be required: after 1 year, the roughly 50% arrest plummets without reapplication, or rockets with reapplication. This pattern challenges dentists to consider patience towards operative care to allow time dependent remineralization to occur.

The studies on prevention demonstrate better caries prevention with once per year application of SDF than any other topical medicament treatment, such as 4 times per year fluoride varnish or chlorhexidine varnish.

Two reports using silver compounds (SDF or silver nitrate plus fluoride varnish) have shown the potential for a dramatic reduction in the need to treat children with early childhood caries in the hospital setting with general anesthesia. The first report was made from a private practice setting where Medicaid eligible children comprised a large percentage of the patient population. The second report comes from a large Medicaid Managed Care organization in Oregon with hundreds of thousands of enrollees.

SDF has a highly impressive safety profile. Based on a 500-fold LD50 safety margin and 100% absorption, a single drop (25 ul) results in a reasonable dose limit of 1 drop/10 kg (~ 22 lbs) child per visit. The side effects are blackening of the treated lesion, bitter metallic taste, short-term temporary staining of soft tissues, and staining of clinic surfaces and residual SDF left on tray. Thus reasonable caution should be taken to avoid touching patient soft tissues and clinical surfaces, and patients should be counseled to expect the lesion to darken substantially over a week.
**Possible Uses of SDF in Clinical Practice**

Before placing SDF, dental healthcare providers should consider factors that determine if the patient is appropriate for this treatment. As mentioned earlier, SDF is FDA approved for addressing dentinal hypersensitivity and being used “off label” for arresting caries lesions especially in certain populations. Populations where SDF may benefit are patients diagnosed with salivary dysfunction, special healthcare needs, the underserved, medically compromised patients, severe early childhood caries, and lesions that may be difficult or impossible to treat using traditional methods. Furthermore, SDF is considered for the pits and fissures surfaces for high caries risk patients who may not be able to have sealants, or can be used in conjunction with sealants when a lesion is suspected but may not be visually detected.

Once determined that a patient is a candidate for SDF treatment, dental healthcare providers need to have transparent informed consent discussions with the patients or guardians about the potential outcomes regarding the application of SDF including documenting risks, benefits, and alternatives.

When treatment planning, oral healthcare providers should consider whether repeated SDF application is appropriate. For example there may be a situation where the patient is not likely to return for subsequent treatment or have the ability to receive treatment elsewhere. In this case, the healthcare provider has the following options: 1) no SDF placement at all (do nothing), 2) place SDF one time only with the understanding the patient may not return for subsequent applications of SDF, or 3) place SDF and glass ionomer cement (GIC) sealant/restoration during the same appointment. The later will be discussed subsequently in this article.

**When should we not use SDF?**

The safety factor of SDF is very high. Even so, it would be prudent to exercise caution in situations that are questionable. For teeth that are symptomatic, partially necrotic, or pulpally involved, SDF may not be of benefit and immediate traditional treatment may be the best approach. If the gingiva or mucosa (gums and cheek) are damaged, SDF may sting, and petroleum jelly should be used for protection. With careful application, minimal SDF will not go anywhere besides the treated site.

Patients who refuse fluoride treatments, are against water fluoridation, or otherwise have concerns about fluoride, may require extended discussions for informed consent. We recommend mentioning that this material is twice the concentration of fluoride varnish, thereby lowering the volume used and consequently a lower fluoride dose.

**Why use SDF+GIC together**

Light curing after SDF placement will potentiate undesirable darkening of the lesion and resin-based restorative materials, and possibly the surrounding areas. The exact chemical mechanism
of this darkening secondary to light exposure has not yet been characterized. The decision to use pure conventional GIC restorative materials where light curing is not indicated for sealants and restorations will help reduce the discoloration effects of SDF. Light curing which is required for resin modified glass ionomer but not for pure glass ionomers. A meta-analysis of long-term clinical trials demonstrate that heavy body (low viscosity) GICs are at least as effective in preventing caries in permanent molars than resin sealants. With pure conventional GIC, maximum remineralization process will occur at the tooth interface. Future research is needed to investigate the effects of SDF on long term dental material properties and placement techniques however, it is logical to assume that SDF+ GIC in combination can have the potential to provide additional remineralization vs. either material used alone. That said, more studies need to be done.

In some situations when patient behavioral situations dictate, it may be necessary to use a light cured resin modified glass ionomer vs. a pure conventional glass ionomer because setting with a light is faster. As mentioned, light curing after SDF placement will darken the RMGI (but will not make it as dark as an amalgam).

**Who can Place SDF, Sealants, and Restorations?**

Providers are encouraged to verify state dental board regulations to determine who can lawfully place SDF, sealants, and non-surgical restorations. It is anticipated that those with permission to place fluoride varnish should also be able to place SDF. Hygienists, expanded function registered dental assistants, and dental therapists can place GIC sealants/restoration.

**Patient Communication**

After completion of a thorough exam, charting, and caries risk assessment, treatment plan options may now be discussed with the patient. With guidance from the healthcare provider, the patients may ultimately choose the best SDF option as determined by their wants and needs, financial constraints, and ability to cooperate with proposed treatment. Appropriate transparent discussions presented to the patient, parent, or guardian can motivate and encourage preventative treatment with the primary intention of halting and preventing disease progression, resulting in less need for surgical restoration in the future.

**Multiple Applications of SDF Technique (without restoration) (Figure 1)**

Arresting a caries lesion with SDF may be beneficial when traditional methods are not likely to be successful. In the case of a patient with multiple caries lesions that cannot all be restored immediately due to patient cooperation, cost or anticipating long operating room wait times; SDF can be applied to slow the disease process, decrease sensitivity and pain until surgical restorative care can be achieved. This concept also applies with patients who have too many lesions to restore during a single visit and the patient is unable to proceed or tolerate restoration of all the lesions. By applying SDF to arrest caries lesions, we give the patient a better chance to conserve tooth structure through less traumatic and minimally invasive procedures. In such cases, re-application has been recommended at least twice per year until a tooth exfoliates/extracted or the
caries lesion is restored\textsuperscript{8}. In situations where restorations are not an option, multiple applications of SDF may be the best option.

**Applications of SDF Technique (with GIC sealant/restoration)**

The mechanics of how practitioners are currently coding and billing for SDF application with restoration is still evolving. The following are clinical applications where SDF may be combined with GIC sealant/restoration.

- Multiple applications of SDF followed by GIC sealant/restoration after lesion arrest (Figure 2)
  
  *Ideally, multiple applications of SDF confirming lesion arrest followed by subsequent restoration (if needed) is preferred\textsuperscript{8}, however there are situations where the practitioner will only be able to see the patient once. Some examples include:*
  
  - **Underserved populations with limited access to care**
  - **Patients with special healthcare needs**
  - **Dentistry in operating room setting**
  - **Patients unable/unwilling to return for care**

- Single Application of SDF with immediate GIC sealant/restoration (Figure 3)
  
  *If there is concern during the informed consent process, that the patient may not return for multiple SDF applications, the patient has excessive numbers of active lesions and it is not practical to restore them all without progression of the caries lesion, then transforming strategies to less time consuming techniques such as SDF in combination with immediate GIC sealant/restoration placement on the same appointment may be considered\textsuperscript{22} This is also appropriate in large cavitated lesions when it is not practical to send the patient home without addressing a large cavitation (i.e. esthetics, large food trap, or chance of pulp injury) and in addition, it is possible it may also entrap more SDF for longer periods of time compared to applying SDF without a restoration to seal it in\textsuperscript{22}. *caution: restorations placed at the same appointment with SDF application could cause darkening of the margins or the restoration itself.*

- Arrest and Repair secondary caries with SDF
  
  *At an already existing restorative margin interface, SDF can be applied to arrest secondary caries along margins followed by restorative repair if appropriate rather than replacement of the entire restoration and is consistent with tooth preserving strategies\textsuperscript{23}.*

**Conclusion**

The science and versatility of SDF makes a strong case for adoption into the present day dental armamentarium. The use of SDF does not preclude the option of placing traditional restorations for purposes of restoring esthetics, form and function. SDF offers unique disinfection and remineralization properties that may reduce the need for traditional invasive operative procedures. Combining the synergistic compatibility of SDF and conventional GIC offers new
optimism to empower and motivate healthcare professionals and patients to transform disease to health.

**Appendix 1**

**SDF Application Steps**

1. Plastic-lined cover for counter, plastic-lined bib for patient.
2. Standard personal protective equipment for provider and patient.
3. 1 drop of SDF into the deep end of a plastic dappen dish.
4. Remove bulk saliva with saliva ejector.
5. Isolate tongue and cheek from affected teeth with “2x2” gauze or cotton rolls. A device such as Isolite®/Isodry® may have certain benefits.
6. Dry affected tooth surfaces with triple syringe, or if not feasible dry with cotton.
7. Bend microsponge, immerse into SDF, remove excess on side of dappen dish.
8. Apply directly onto the affected tooth surface(s) with microsponge.
9. Allow SDF to absorb for at least for 1-2 minutes if reasonable, then remove excess with gauze or cotton roll.
10. Some find it helpful to cover the treated area with fluoride varnish in attempts to keep the SDF in contact with the lesion longer as well as disguise any bitter metallic taste.
11. Place gloves, cotton, and microbrushes into plastic waste bags. Clean away any excess SDF found on other clinical surfaces.

**Appendix 2**

**GIC Sealant/Restoration Placement Steps (immediately after SDF)** *caution:* restorations placed at the same appointment with SDF application could cause darkening of the margins or the restoration itself.

- Clean the entire tooth (especially the pits and fissures) with grey pumice, air polisher or defocused air abrasion so any GIC flash is chemically bonded to tooth mineral (there is no chemical bond to biofilm or pellicle).
- Note: If cavitation is present and traditional tooth preparation is not feasible due to poor patient cooperation then minimal tooth preparation with clean perimeters (2mm) for a proper chemical seal may be attempted by a dentist (tooth preserving with proper chemical seal).
- Condition the entire surface and immediate surrounding areas with polyacrylic acid (scrub 10 sec, rinse 10 sec, & blot dry). This cleans the smear layer off and provides a proper chemical bond if there is excess flash. It is important that the tooth surface be slightly moist (shiny appearance) before placement of GIC.
- During rinsing from step 3, begin mixing GIC. (Some GIC mixing capsules require one click on the dispenser before mixing for 10 sec)
- Place SDF per Appendix 1

- In the next 10 sec apply GIC without voids into the preparation and over all pits and fissures in the area.
  Note: If placing sealants, the thin, less viscous GIC made specifically for sealants is more
ideal. GIC restorative material can also be used for sealants but placement is slightly more difficult. Excess is sometimes unavoidable and can be removed with a ball burnisher slightly lubricated with unfilled resin (i.e. wetting resin) or manufacturer’s coat. Alternatively when doing multiple teeth some use the “finger push” technique with a gloved finger slightly lubricated with unfilled resin (i.e. wetting resin) or manufacturers coat is used to push the GIC in the pits and fissures and at the same time to remove excess. To avoid adjusting the occlusion you can mark the occlusal contacts (including excursions) prior to GIC placement with articulating paper then avoid applying GIC to those areas. If you see some GIC in the marked areas you have 10 sec to carve it off and remove any unwanted excess.

Avoid touching or moving the GIC after 30 sec from start of mix.

- Set time is about 2 minutes from start of mix. Protect the surface from water loss or water gain in the initial setting by coating with unfilled resin (i.e. wetting resin) or manufacturer’s coat. Note: Do not light cure coat. If GIC turns “frosty”, wet with saliva.
- After 2 minute set time, if any excess must be removed it can be easily done with slow speed rubber abrasives such as Ultradent Jiffy Kit® (Ultradent Products Inc., South Jordan, UT), with an assistant spraying profuse water spray. Never dry the surface of GIC as it will surface crack and become unaesthetically opaque. Alternatively, if there is a lot of overfill high speed burs may be used with profuse water spray prior to slow speed rubber abrasives.

References

7. Rosenblatt A, Stamford TC, Niederman R. Silver diamine fluoride: a caries


Figure 1: SDF placement post op 8 weeks – provided by Dr. Steve Duffin

Figure 2: GIC sealant placement after caries arrest from SDF application – 8 weeks post SDF application – provided by Dr. Steve Duffin

Figure 3: Immediate GIC restoration after SDF application (Marking in central pit in post op is articulating paper, not SDF.)