

# Silver Diamine Fluoride

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## Objectives

- Learn the history of silver compounds in Dentistry
- What is Silver Diamine Fluoride (SDF)?
- What does SDF do?
- What are the indications/contraindications for using SDF?
- How do I use SDF with patients?
- Is there evidence to support its use?
- How do I bill for SDF?

## Silver compounds

- Used historically to treat colds, infections, tetanus and rheumatism
- Prior to invention of antibiotics, used to treat Gonorrhea
- Silver sulphadiazine used as topical agent to treat burns
- Peng JJ et al. J Dent. 2012 Jul;40(7):531-41
- Paul Dirkes, DDS (Poarch Band of the Creek Indians)

## History of Silver Compounds

- Dr G.V. Black used multiple applications of silver nitrate solution to slow the progression of caries.
- 1920's ammoniacal silver nitrate used by Dr Howe for caries, the chemical precursor of SDF.

## Silver Nitrate

- Prior to FDA approval of silver diamine fluoride in the US, silver nitrate was combined with sodium fluoride varnish to reduce the need for hospital dentistry in EEC patients

## Silver Nitrate

- J Calif Dent Assoc. 2012;40(11):852-8.
- Dr Duffin reports on use of silver nitrate + fluoride varnish:
- 25% silver nitrate with 5% NaF varnish
- 5000 children over a five year period
- 7 of 578 teeth treated had to be extracted
- 98% of lesions remain inactive after 4 years
- Same magnitude expected in root caries
- Pulpitis is not an issue

## What is Silver Diamine Fluoride?

- 24.4-28.8% (w/v) silver and 5.0-5.9% fluoride (~44800 ppm)
- Ammonia and silver fluoride combine to form a diamine silver ion complex  $[Ag(NH_3)_2^+]$ 
  - Ammonia helps stabilize the solution at a constant concentration for longer time
- pH 10
- Silver and fluoride ions penetrate ~25 microns into enamel, and 50-200 microns into dentin.
- Silver is antimicrobial and inhibits enzymes that breakdown dentin organic matrix
- Fluoride aids in remineralization of lesion

• Horst et al, J Calif Dent Assoc. 2016 January ; 44(1): 16-28

## How it works

- Forms silver-protein conjugates in decayed surfaces
- Increases resistance to acid dissolution and enzymatic digestion.
- Hydroxyapatite and fluoroapatite form on the exposed organic matrix, along with the presence of silver chloride and metallic silver.
- Increases in mineral density and hardness while the lesion depth decreases.
- Inhibits the proteins that break down the exposed dentin organic matrix: matrix metalloproteinases; cathepsins; and bacterial collagenases.

## How it Works

- Silver ions act directly against bacteria in lesions by breaking membranes, denaturing proteins, and inhibiting DNA replication.
- Ionic silver deactivates nearly any macromolecule.
- Silver diamine fluoride outperforms other anti-caries medicaments in killing cariogenic bacteria in dentinal tubules.
- Silver and fluoride ions penetrate ~25 microns into enamel, and 50-200 microns into dentin.
- Fluoride promotes remineralization, and silver is available for antimicrobial action upon release by re-acidification.

## Silver Diamine Fluoride

- Effectiveness established based on a 30-month prospective controlled clinical trial (Chu et al., 2002)
  - 376 pre-school Chinese children with caries in their maxillary primary anterior teeth.
  - Subjects were sequentially assigned to:
    - excavation + 38% silver diamine fluoride (SDF) applied every 12 months;
    - SDF applied every 12 months (no excavation)
    - excavation + 5% NaF varnish applied every 3 months;
    - 5% NaF varnish applied every 3 months (no excavation)
    - water control

## Silver Diamine Fluoride

- Annual application of SDF was more effective in arresting dentin caries than application of fluoride varnish every 3 months.
- The removal of caries tissue did not improve the effectiveness of SDF or fluoride varnish to arrest dentin caries.
- For fluoride varnish only, caries excavation improved esthetics

Chu et al., 2002. J Dent Res 81:767-770

## Silver Diamine Fluoride

- Silver diamine fluoride was found to be effective in arresting dentin caries in permanent first molars in school-aged children.
- Mechanism is thought to be anti-microbial activity against *S. mutans*
- SDF recently approved by FDA for dentin sensitivity
- Advantage Arrest given designation as "breakthrough therapy"

• J.C. Llodra, A. Rodriguez, B. Ferrer, V. Menardia, T. Ramos, and M. Morato. J. Dent. Res., August 1, 2005; 84(8): 721 - 724.

## Indications for Use

- High caries risk
- Behavioral or medical management issues
- Dentinal hypersensitivity
- Caries stabilization
- Xerostomia from cancer treatment or medications
- Difficult to treat caries lesions – crown margin, furcation
- Patients with dental phobia
- Patients with limited access to restorative services
- Physical or cognitive disabilities
- Very young/very old

## Contraindications

- Silver allergy
- Ulcerative gingivitis/stomatitis
- Abscessed tooth needing extraction
- Irreversible pulpitis

## Side Effects

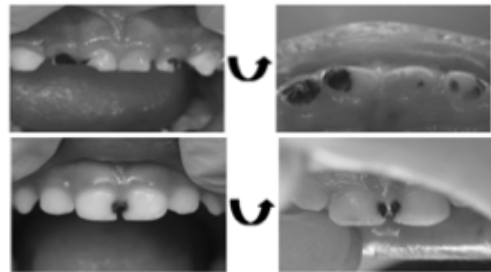
- Metallic taste
- Decayed teeth turn black
- Transient gingival irritation
- Stains clothes, skin, floor – must use meticulous technique

## Advantages of silver solutions

- Controls pain by arresting caries
- Affordable for any community
- Procedure is fast
- Minimal support in staff or equipment needed.
- Non-invasive and safe

## Informed Consent

- May use a separate form or incorporate into clinic consent document
- Photos showing how teeth will look after applying SDF may be helpful
- Parent, grandparent, other family members may have strong opinions



University of Washington Pediatric Dentistry  
Advanced Caries Arrest (SDF) is an evidence-based medication. It is used to stop or slow down (arrest) tooth decay. This medication can be used when a child is apprehensive or is unable to tolerate dental treatment. It may allow the dentist to perform or postpone restorative treatment until a time when the child can more easily accept care.

SDF Pediatric Dentistry would like your parental consent to perform the following procedure:

To: The tooth  
 1. Silver Diamine Fluoride (SDF) is an evidence-based medication.  
 2. Silver Diamine Fluoride (SDF) is used to stop or slow down (arrest) tooth decay.  
 3. Silver Diamine Fluoride (SDF) is used when a child is apprehensive or is unable to tolerate dental treatment.  
 4. Silver Diamine Fluoride (SDF) is used to allow the dentist to perform or postpone restorative treatment until a time when the child can more easily accept care.

Benefits:  
 • SDF may stop or slow down tooth decay.  
 • SDF may help reduce sensitivity.

Possible Risks and Complications:  
 • The staining and other reactions will occur permanently on the decay-prone areas. Healthy tooth structure will not be stained. Stained tooth structure can be covered or replaced with filling or a veneer.  
 • Tooth-colored fillings and veneers may also develop if SDF is applied to them. Normally this is temporary and can be polished off.  
 • If SDF comes in contact with other dental work, temporary discoloration may occur. It will disappear in 1-2 weeks.  
 • Heavy respiratory effort will be made to ensure the success of SDF placement, but there is a risk that the procedure will not stop the decay and the progression of cavities to pulpitis or infection.  
 • This treatment is only to slow decay and will not prevent the tooth from growing. In that case the tooth may require further treatment such as repeat SDF, filling or crown, full dental treatment, or extraction.  
 • The concentrations listed above may not include all of those reported by the drug's manufacturer. If you notice other effects not listed above, contact your dentist at 206.

Alternatives to SDF:  
 • No treatment. This may lead to continued deterioration of the tooth structure and poor cosmetic appearance. Sensitivity may increase in severity.  
 • Other treatment may include placement of fluoride varnish, a filling or crown, or extraction. For some children, anesthesia or general anesthesia may be required to provide care.

I hereby give permission for the patient listed here to receive Silver Diamine Fluoride treatment. I have read the form, understand the possible risks associated with the treatment, and am willing to ask questions of the dentist and feel the questions fully answered.

Patient Name \_\_\_\_\_ Date \_\_\_\_\_  
 Patient Signature or Legal Guardian \_\_\_\_\_ Date \_\_\_\_\_  
 Address \_\_\_\_\_ Date \_\_\_\_\_

## Parental Perception

- Crystal et al, JADA 2017
- Staining on posterior teeth was more acceptable than on anterior teeth
- Most parents preferred staining rather than treatment with GA or sedation

## Clinical Issues

- In vitro studies show no effect on bonding to non-carious dentin (Quock et al, 2012)
- Bonding of a crown to SDF treated dentin may be compromised, so recommend excavation of treated dentin prior to cementation (Soeno et al, 2001)
- SDF effective for secondary caries prevention when placed under amalgam (Shimizu and Kawagoe, 1976)
- 40% AgF placed on deep caries in primary teeth planned for extraction; 91% showed favorable pulp response (Gotjamanos, 1996)

## Advantage Arrest

Silver Diamine Fluoride 38%



## Advantage Arrest

- FDA cleared as a dentinal hypersensitivity treatment (*similar to fluoride varnishes*)
- 50+ years of use in Japan, China, India, New Zealand, Australia and many others as **Caries Arresting Agent**

## Breakthrough Therapy

- Recently, FDA gave Advantage Arrest the designation of 'breakthrough therapy'
- The breakthrough therapy designation represents the FDA's effort to expedite the development and review of drugs that are intended to treat a serious condition; it is granted when preliminary clinical evidence indicates the drug may demonstrate substantial improvement over available therapies.

- From Decisions in Dentistry. December 2016. 2(12):10.

## Toxicity

- One drop is approximately 25  $\mu$ L and should be sufficient to treat 1-5 teeth and contains about 11.88 mg of SDF. LD of oral administration is approximately 520 mg/kg body weight; while LD subcutaneous administration is 380 mg/kg body weight. A child of 10 kg would receive 1.185 mg/kg.
- If you use the 380mg/kg number being overly cautious, that is a 400 fold safety margin. The EPA has also set short term silver exposure levels in drinking water at 1.142 mg per L for 1-10 days.
- Typical application is once per year

## Toxicity

- Applications greater than one week apart fall in line with these recommendations. The EPA long term exposure limits have been set at 1 gram to safely avoid argyria.
- According to Vasquez et. al, the highest applied dose of 2.37 mg would enable 400+ applications over a lifetime.
- Vasquez et al, BMC Oral Health. 2012 Dec 31;12:60.

## Protocol

- Cover counters and patient with plastic lined bib/towel
- Use standard PPE for provider, assistant and patient
- Place 1 drop of SDF into disposable plastic dish
- For single use ampule, have 2x2 gauze available to prevent splashing when opening
- Use saliva ejector to remove bulk of saliva
- Isolate tongue and cheek from affected area with gauze or cotton rolls
- If lesion is near gingiva, consider applying vaseline to tissue in advance

## Protocol

- Dry affected tooth surface(s) with air/water syringe or cotton pellet
- Dip applicator into dish and remove excess on side of dish
- Apply SDF to affected tooth surface
- Allow SDF to absorb into tooth surface for 1 minute if possible
- Remove excess with gauze or cotton
- Rinse with water
- Discard all items in plastic bag

## To Light Cure or Not?

- Light curing SDF is not recommended
- It does speed the drying process so dark stain is visible immediately
- Light curing takes free silver ions and causes them to oxidize rapidly.
- Once oxidized, they are no longer able to bind with the collagen or phosphates in the tooth, effectively weakening the SDF.

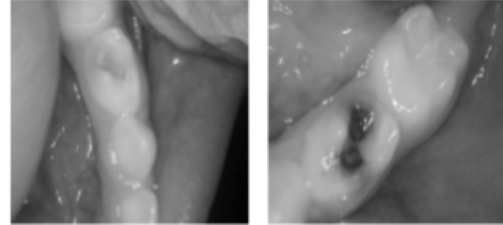
## Advantage Arrest

- If stain is an issue, can be covered with Glass Ionomer.
- Potassium Iodide has also been used to reduce the staining
  - Research is inconclusive about KI reducing stain, or reducing efficacy
- Excess can be rinsed away after application
- Can be reapplied at intervals of > one week; one application per year is normally sufficient
- Clear liquid, Light Sensitive
- 10 ml bottle filled to **8 ml**/also available as unit dose
- 3 year shelf life

## Oops, I spilled – Now what?

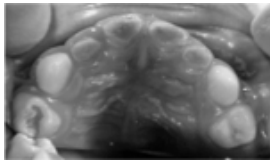
- Before it dries, use an ammonia based cleaner such as Windex, or Lysol wipes.
- For dried and set SDF stains,
  - Mr. Clean Magic Eraser
  - Bleach
  - Bar Keepers Friend and Comet
- For skin, water and salt slurry as well as hydrogen peroxide have been effective to some extent.

## Before and After SDF



## Case #1

- 16 month old child presents to your clinic with ECC
- Child is healthy but parents don't have insurance to pay for GA and don't want child to be asleep for treatment
- Options:
  - Apply fluoride varnish and put on 3 month recall
  - Attempt to place glass ionomer restorations
  - Place SDF



## Case #2

- An 8 year old girl with a lymphatic malformation involving her tongue, face, mediastinum and mandible
- Until recently, she was 100% G-tube fed but now eats a variety of food by mouth
- Any trauma to her tongue causes excessive bleeding
- She has extensive caries with some primary teeth and permanent teeth needing to be extracted
- Definitive treatment under general anesthesia is recommended with possible admission for observation
- The current backlog for the OR for dentistry is 1 year

## Case #2

- Treatment options:
- See for frequent recall appointments and apply F varnish
- Attempt to place glass ionomer restorations
- Apply SDF and expedite OR case
- In addition:
- Manage diet to decrease sweetened beverages and foods
- Regular 2 times daily brushing with F toothpaste

## Case #3

- 45 year old male with a history of bisphosphonate treatment and non-restorable molar. Extraction not recommended due to risk for osteonecrosis.
- Options to consider:
  - SDF application
  - Decoronation and replacement root resorption
  - RCT and decoronation
  - Other ideas?

## Case #4

- Frail, elderly patient with root caries who is unable to travel to clinic for routine care.
- Possible options:
  - Glass ionomer – ART
  - SDF application
  - F varnish

## SDF + Glass ionomer =SMART

- Silver modified atraumatic restorative treatment (SMART)
- If GI is placed the same day as SDF, will have staining of the restoration
- Some insurance won't pay for SDF and GI done on the same day
- Some providers recommend placing GI one or two weeks later – may still have a dark margin due to SDF

## SMART

- After placing SDF following previous protocol
- Clean margins of the cavitated lesion with slow-speed round bur or spoon excavator
- Apply conditioner (20% polyacrylic acid) for 10 seconds and then rinse for 10 seconds
- Blot dry but don't dessicate
- Mix GIC and apply to lesion
- Shape and remove excess
- Don't light cure
- After 2.5 minutes, place anatomy, adjust occlusion with water spray

## SDF use on proximal lesions

- No clinical studies to date
- Some providers recommend applying SDF using superfloss
- Other providers suggest separating teeth with orthodontic elastics and then applying SDF directly
- More studies needed

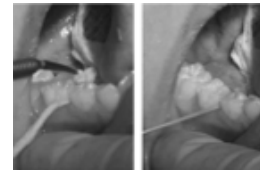


Photo courtesy of Dr. Jason Hirsch

## SDF and GI


- Bendit and Young, Silver Diamine Fluoride: The newest tool in your caries management toolkit. CE course available at:
  - <https://www.dentalacademyofca.com/>
- CE course by Dr. Jeanette MacLean and Dentaltown
  - <http://www.dentaltown.com/onlinece/details/803/silver-is-the-new-black-improving-your-practice-with-silver-diamine-fluoride>



Stains skin, clothes, floors, counters.

## Advantage Arrest

- Per application cost
- \$149 = 8 mL bottle = 250 drops = \$0.60/Drop
- \$11.25 for 100 Applicators – \$0.11 per app.
- One drop application = \$0.71 per application
- Two drop application = \$1.42 per application
- Unit dose = \$4 per application
- *Equal or less than Fluoride Varnish*



**Advantage Arrest Silver Diamine Fluoride 38% - Bottle**  
Each bottle contains 8 mL of Tinted SDF

| Quantity | Price    |
|----------|----------|
| 1        | \$162.50 |
| 2        | \$149.50 |
| 3 - 11   | \$141.50 |
| 12 +     | \$129.00 |

**Advantage Arrest Silver Diamine Fluoride 38% - Unit-Dose Ampule**  
Box of 30 Ampules - Tinted, plus 30 each small and large applicators

| Quantity | Price    |
|----------|----------|
| 1        | \$122.50 |
| 2        | \$116.50 |
| 3 +      | \$109.00 |

[www.elevateoralcare.com/dentist/AdvantageArrest](http://www.elevateoralcare.com/dentist/AdvantageArrest)

## Billing

- In 2016, new code established: D1354 – interim caries arresting medicament application
- Some Medicaid programs reimburse but not all
- Washington HCA will reimburse starting in January 2018

## Washington HCA

- The agency covers silver diamine fluoride per application as follows:
  - When used for stopping the progression of caries only;
  - Two times per client per tooth in a twelve-month period; and
  - Cannot be performed and billed with interim therapeutic restoration on the same tooth.
- Provider must have signed informed consent that includes:
  - Benefits and risks of silver diamine fluoride application;
  - Alternatives to silver diamine fluoride application; and
  - Color photograph example that demonstrates the post-procedure blackening of a tooth with silver diamine fluoride application.
- Reimbursement = \$3.00/tooth
- D1354 code now requires a tooth number

## Questions?

- If unsure of billing protocol, contact HCA
  - Dental-related services program billing guide
    - <https://www.hca.wa.gov/assets/billers-and-providers/Dental-related-services-billing-guide-20181801.pdf>
- May also contact Dr. Jon Gibbons (ADA trustee and a pediatric dentist)
  - [jkgib@Comcast.net](mailto:jkgib@Comcast.net)
  - Dr. Rebecca Slayton – [rslayton@uw.edu](mailto:rslayton@uw.edu)