SILVER DIAMINE FLUORIDE FOR CHILDREN

GARY BADGER DDS, MS

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Disclaimer

• Neither I nor my immediate family have any financial interest in any of the materials presented.
Objectives

• Participants should be able to:
  
  • Understand What Silver Diamine Fluoride (SDF) can do.
  
  • Be familiar with the technique of application
  
  • Be able to apply behavioral techniques to facilitate SDF application
History

• Stebbins (1891)- Noticed black surfaces on Amalgam surfaces where caries progress had ceased; and mixed nitric acid with amalgam scraps and applied to 35 children. Results: 3yrs later 61% caries reduction in 35 children.

• Howe in 1917 applied silver nitrate to carious lesions with similar results. “Howes solution” used for 50 years

• Silver Diamine Fluoride (SDF) has been a cariostatic agent since the 1960s, and used in many other countries. Various studies researched over the next forty years.

• It has been in use in England, Japan, and Australia for several decades after Hyde (1973) and Green (1989) showed arrest of proximal lesions. Using Ag(NH₃)- then AgF with SnF2 respectively.

• The FDA approved it for use as a desensitizing agent in 2014.
Recent History


- In an artificial mouth, a cariogenic biofilm was generated containing Streptococcus mutans/sobrinus, Lactobacillus acidophilus/rhamnosus, and Actinomyces naeslundii to form carious lesions with a depth of 70 microns on dentin blocks from 3rd molars. 38% SDF application was compared to water (control) for 21 days and CFU viability every 7 days. Resulted in fewer CFU in the test group compared to water, Microhardness and weight percentages for Ca and P were higher than the controls in the outer 50 microns.
**Mei et al 2013**

Bacterial count (log CFUs) and red/green in test (SDF-treated) and control (n=10)

<table>
<thead>
<tr>
<th></th>
<th>Log CFUs</th>
<th>Red/Green (CLSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total bacteria</td>
<td>Mutans streptococci</td>
</tr>
<tr>
<td><strong>Test</strong></td>
<td>0.65±0.71</td>
<td>0.27±0.65</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>8.66±0.30</td>
<td>5.63±0.87</td>
</tr>
<tr>
<td><strong>Day 7</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Test</strong></td>
<td>4.94±0.07</td>
<td>3.99±0.08</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>10.29±0.38</td>
<td>7.71±0.08</td>
</tr>
<tr>
<td><strong>Day 14</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Test</strong></td>
<td>5.72±0.19</td>
<td>4.39±0.42</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>12.20±0.84</td>
<td>8.11±0.11</td>
</tr>
<tr>
<td><strong>Day 21</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
SE view of active vs arrested images from Mei, et al

Active Caries

Arrested caries
Pediatric Dentistry Programs

• The purpose of this study was to investigate practice, teaching, and perceived barriers to the use of silver diamine fluoride and other caries control agents in U.S. pediatric dentistry residency programs.

• Results: Surveys were completed by 74 directors or associate directors (87 percent adjusted response rate). More than a quarter (25.7 percent) reported use of silver diamine fluoride, with 68.9 percent expecting to increase use. Most felt silver diamine fluoride should be used only with high-risk patients (89.2 percent), and the majority agreed it could be used in primary and permanent teeth. The most frequently reported barrier to use of silver diamine fluoride was parental acceptance (91.8 percent).
Package Insert

• Ag+ (NH3+)2 F- Silver Diamine Fluoride 38%
• Approved by the FDA in 2014
• Advantage Arrest: Tooth Desensitizer
• “Product forms insoluble precipitates with Calcium or Phosphate in the dentinal tubules to block nerve impulses.” “for use in adults over the age of 21”
• Contraindicated in patients with ulcerative gingivitis or stomatitis or known sensitivity to silver or other heavy metal ions.
• Use of petroleum jelly or cocoa butter and use cotton rolls/dental dam to protect gingival tissues.
Precautions

- SDF will stain skin, clothes, countertops, floors and instruments brown or black.
- To remove stain wash with soap and water mmonia or iodine
- Clean container after use

**USE**: For up to 5 treated sites/patient use 1 drop from disposable dappen dish; transfer using an applicator-air-dry. 1 drop (25microL) per 10 kg with weekly intervals.
- A curing light will help change color rapidly for 20 sec.
What is Silver Diamine Fluoride?

• Silver Diamine Fluoride-Ag(NH$_3$)$_2$F  Silver diamine fluoride (SDF) is a colorless liquid that at pH 10 is 24.4% to 28.8% (weight/volume) silver and 5.0% to 5.9% fluoride.

• Advantage Arrest™ (Elevate Oral Care, L.L.C.) is the only commercially available SDF product for dental treatment in the U.S., although other brands are available in other countries.

• Its downsides include a reportedly unpleasant metallic taste, potential to irritate gingival and mucosal surfaces, and the characteristic black staining of the tooth surfaces to which it is applied. It can be used for elderly as well.

-ADA
Silver Diamine Fluoride. This Changes Everything.

Advantage Arrest. Silver Diamine Fluoride 38%

Advantage Arrest Silver Diamine Fluoride 38%
Each bottle contains 8 mL

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Price</th>
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<tbody>
<tr>
<td>1</td>
<td>$129.00</td>
</tr>
<tr>
<td>2</td>
<td>$122.75</td>
</tr>
<tr>
<td>3 – 11</td>
<td>$116.50</td>
</tr>
<tr>
<td>12 +</td>
<td>$102.75</td>
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</table>
Considerations

• Patient selection:
  Incipient/carious lesions with no history of pain and lesion has not progressed within one mm of the pulp.
  Patients cooperation permits safe application

Safety:
  Apparent 400-fold index of safety (Horst UCSF 2016)
  Color of tooth changes to black from immediately to delayed change (2-3 weeks)
  Normal enamel and dentin is not discolored.
  Staining of gums, skin is transient (3 weeks)
  Clothes and counter tops may stain
Considerations

- Silver Allergy
- Ulcerative Gingivitis
- Stomatitis
- Vasoline to gingiva
- ADA procedure code D1354
• Strong Ammonia scent
• Stains
• Reacts with metal resulting in hydrogen gas and contact with glass creates silicone tetrafluoride; Store in cool, dark, dry place in plastic
Nobody looks forward to having a cavity drilled and filled by a dentist. Now there's an alternative: an antimicrobial liquid that can be brushed on cavities to stop tooth decay — painlessly.

The liquid is called silver diamine fluoride, or S.D.F. It's been used for
Prevention

• Dental Disease is an infection caused by bacteria.
• It is a progressive infection unless preventive actions are taken.
• Sharing bacteria is implicated in the transmission process.
• Bacteria cause demineralization of teeth progressing to outright cavitation.
• Fluoride hardens enamel, silver causes bactericidal effects and reacts with dentin to form a protective layer. It also prevents metabolic processes of bacteria and replication.
Mechanism of action

• Interaction of SDF effects bacterial killing and inhibits biofilm development.

In Vitro studies show that SDF penetrates enamel to a depth of 25 microns, 2-3 times more fluoride is retained than that delivered by NaF-PO$_4$, NaF or SnF$_2$

SDF may be effective in controlling caries and preventing caries in both primary and permanent teeth. Rosenblatt J Dent Res 88(2) 2009
Cysteine contributes to collagen degradation in the caries process. AgF(CH₃)₂ has an inhibitory effect on Cysteine cathepsins enzymes (B&K) with Silver greater than Fluoride.


Cathepsin activity, in carious dentin, increases with increased depth. Salivary Cathepsins are stable in slightly acidic environments and mostly unstable at neutral pH.
Mei et al (con’t)

- The addition of Ag+ may inactivate the Cathepsins or block the site of degradation.
What effect does SDF and KI have on bond strength to dentin? Using Human mid coronal dentin sections:

The aim of this study was to determine whether Riva Star influenced bond strengths to an etch-and-rinse (Optibond FL; Kerr, USA), 2-step self-etching (Clearfil Liner Bond F; Kuraray Noritake Dental, Japan) and all-in-one (Optibond Versa; Kerr) resin-based adhesives and a resin-modified GIC adhesive (Riva Bond LC; SDI Australia).

Conclusion: Riva Star should not be used as a ‘whole cavity’ ‘disinfecting’ agent but may be used for spot application where a cavity floor approximates the pulp where caries-affected dentine may still exist, otherwise adhesion may be compromised.

<table>
<thead>
<tr>
<th></th>
<th>Optibond FL</th>
<th>Optibond Versa</th>
<th>Clearfil Liner Bond F</th>
<th>Riva Bond LC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>32.1a(1.2)</td>
<td>35.0a(3.9)</td>
<td>28.4a(8.4)</td>
<td>18.4b(5.6)</td>
</tr>
<tr>
<td>Riva Star</td>
<td>21.4c(9.4)</td>
<td>9.6d(2.0)</td>
<td>10.8d(2.1)</td>
<td>14.5cd(5.2)</td>
</tr>
</tbody>
</table>

Mean(SD); Identical lower case letters indicate values that are not significantly different (Sidak’s multiple comparisons; \( p>0.05 \).
Effect of SDF and KI on bond strength

Fig. 3. SEM images of the dentine and restorative materials interface before testing. Control (first column) and treated Riva Star (second column).
Effect of SDF and KI on Residual Bacteria in dentinal tubules.

Hamama HH, Burrow MF. Effect of silver diamine and potassium iodide on residual bacteria in dentinal tubules. Aust Dental J 60 (2015) 80-87

Forty-five dentine discs prepared from caries-free maxillary premolars were randomly divided into nine groups. Group 1 (negative control) contained non-infected sound dentine discs. The remaining discs were infected with *Streptococcus mutans* suspension and received dentine treatments as follows: Group 2 (positive control), discs were left untreated; Group 3 SDF/KI (Riva Star); Group 4 chlorhexidine (CHX); Group 5 CHX + SDF/KI; Group 6 Carisolv; Group 7 Carisolv + SDF/KI; Group 8 Papacarie, and Group 9 Papacarie + SDF/KI. The discs were then fractured into two halves, stained with fluorescent LIVE/DEAD stain and observed using confocal laser scanning microscopy.

Results: **SDF/KI exhibited a potent antibacterial effect, as represented by a significantly higher percentage of dead bacteria**

- Strep Mutans, Strep sobrinus, Lactobacillus rhamnopsis and acidophilus and Actinomycetes naeslundii Biofilm
- 1. Inhibition of cariogenic Biofilm Formation (fewer colonies)
- 2. Repeat SDF applications after one week enhances the effect in caries arrest. (greater Ca and Phosphorus in Dentin outer 50 micro mm)

Ag interferes with biofilm formation by inactivating and interfering with the bacterial synthesis of cellular polysaccharides through inactivation of glycotransferase enzymes responsible for the synthesis of soluble and insoluble glycan. SDF increases microhardness of dentin by precipitation that forms a protective layer over dentin that decreases Ca and Phosphorus loss from carious lesions.
Trials

- Chu et al., 2002-Application to primary teeth: 375 (308 finished) kindergarten children SDF applied yearly for 2.5 years, soft dentin removed for group 1, grp 2-SDF no soft dentin rem., grp 3 soft dentin rem. NaF applied, ev 3 mos., grp 4-no caries rem. Varnish app. Ev 3 mos. grp 5 H2O only. Results: More arrested caries than other groups. Prior caries removal had no effect on ability to arrest caries.

- Llodra et al 2005-Both Primary and Permanent teeth:
  - 452 < 6 y/o Cuban Children received 38% SDF ev 6 mos.
  - Results: SDF caries reduction in primary and permanent teeth and more inactive caries.
Indications

• Patients with several lesions but not amenable to immediate treatment. Potential OR cases.

• Carious lesions in high risk patients, fragile asthmatic children, ADHD patients on medications that dry the mouth.

• Difficult lesions to treat, e.g. partially erupted molars with obvious caries.

• Behaviorally or medically challenged circumstances
SMART Technique

• https://youtu.be/0kiqG0z66qs
Application

• SDF packaged in 8 ml plastic drop-dispensing bottle, one drop is dispensed in a dappen dish and applied to 4-5 teeth using a micro brush.

• Apply for 1 minute, then rinse.

Color Stain can be mitigated by the use of Potassium Iodide (KI) - avoid in pregnant/lactating women.
Arrest Studies

Horst 2016

Santos et al., 2014
322 5- to 6-year-olds
3.8 lesions at start

Yee et al., 2009
624 3- to 9-year-olds
6.8 lesions at start
Arrest Studies

Chu et al., 2002
308 3- to 5-year-olds
6 lesions at start

Zhang et al., 2013
227 60- to 89-year-olds
0.91 lesions at start
Prevention Studies

1. Chu et al., 2002
   - 308 3- to 5-year-olds
   - control: 1.6 new lesions
   - (only applied to lesions)

2. Tan et al., 2010
   - 203 79-year-olds
   - control: 2.5 new lesions

3. Zhang et al., 2013
   - 227 60- to 89-year-olds
   - control: 1.3 new lesions

4. Monroe et al., 2012
   - 708 6- to 8-year-olds
   - control: 0.44 new lesions
Prevention Studies

- **Llocred et al., 2005**
  - 373 6-year-olds
  - Control: 2.5 new lesions (only applied to lesions)

- **Liu et al., 2012**
  - 482 9.1-year-olds
  - Control: 4.6 new lesions

- **Chu et al., 2002**
  - 308 3- to 5-year-olds
  - Control: 1.6 new lesions (only applied to lesions)
Gotjamanos T  Aust Dent j 1996;41:328-34
AgF treated tooth and resultant tertiary dentine after 6 weeks
Isolation
Application of vaseline
STAIN
Use of Dental Dam
2 yr 5 m/o
2 yr 5 mo. Female
Blackening
Blackening
One year old 2nd application
SDF After Application
SDF Discoloration
Case  3 yrs-6 mos
Case 3yr-6 mos
3 yrs-6 mos
3 yrs 6 mos
Final 3 y 6 mos
Consents

San Francisco Department of Public Health Dental Services

INFORMED CONSENT FOR SILVER DIAMINE FLUORIDE

Facts for consideration:
- Silver diamine fluoride (SDF) is a liquid that helps stop tooth decay. SDF is applied every 3.6 or 12 months.
- A small amount of SDF is applied to the decayed tooth area.
- After SDF application no eating or drinking for 60 minutes and no tooth brushing until the following morning.
- The decayed area will stain black permanently. Healthy tooth structure will not stain.
- I should not be treated with SDF if: 1) I am allergic to silver,
  2) There are painful sore or raw areas on my gums or anywhere in my mouth.

Benefits of receiving SDF:
- Helps stop tooth decay.
- Fast.
- Do not need to numb teeth.
- Does not hurt.

Risks of receiving SDF:
- The affected area will stain black permanently. This means SDF is working.
- Tooth-colored fillings and crowns may discolor if SDF is applied to them.
- After SDF treatment, a filling or crown might still be needed.
- If accidentally applied to the skin or gums, a brown or white stain may appear that causes no harm, cannot be washed off and will disappear in one to three weeks.
- Permanent dark spots if spilled on clothing.
- Allergic reactions.
- Risk that the procedure will not stop the decay.
- Not every cavity can be treated with SDF.

Alternatives to SDF, not limited to the following:
- No treatment, which may lead to continued breakdown of the tooth. Symptoms may get worse.
- Placement of fillings or crowns; extractions or referral to a specialist.

I have read this form, I understand the treatment and have had the chance to ask questions. I have seen the photo of how teeth may look after SDF discolors the cavities. I understand that I may refuse treatment with SDF. I understand that I can decide to have no treatment or I can have fillings, crowns, or extractions done at this or another dental office.

I consent and authorize SDF Dhonal Dental Services to use Silver Diamine Fluoride to help stop tooth decay.

Signature of patient/parent/guardian ____________________________ Date _______

Signature of witness ____________________________ Date _______
Consents

**Silver Diamine Fluoride Treatment Consent**

**Patient Name:** __________________________ **Date of Birth:** ____________

**Parent/Legal Guardian (print):** __________________________

The permission of a parent or legal guardian is necessary for dental treatment of a minor before any treatment can be started or completed by our office. While signing this form gives consent for us to treat your child, we encourage you to speak to any of our staff members, especially Dr. Coffman, if you have any questions regarding your child’s specific needs or treatment being provided.

Silver Diamine Fluoride is a medication that is applied to an active area of decay (cavity) to kill the bacteria causing the cavity, prevent the formation of a plaque layer on the treated surface, and strengthen the tooth.

It is very important that you are made aware that treating cavities with this medicine will cause color changes to the lesions (cavity). The areas of the tooth with active dental decay will turn dark black as the medicine is working. The healthy areas of the tooth will not be effected and will remain your child’s natural tooth color. The black color indicates that the treatment is successful.

It is also important that you are aware that this medicine will treat the bacteria causing tooth destruction, but will not restore the tooth structure that has already been effected by the disease process. Your child will still require restoration of the teeth (fillings, crowns and possibly nerve treatment) if there is any loss of tooth structure. Dr. _____ and our team will discuss the recommended timing of this treatment, and will discuss the best way to provide this treatment to ensure that your child receives treatment in the least invasive, most predictable and least traumatic way possible. You will sign a separate treatment plan for the actual restoration (filling, crown and/or nerve treatment) of your child’s teeth.

As a parent or legal guardian of the above patient, I grant Dr. _____ permission to provide my child’s dental treatment as discussed. I also understand that this treatment may not be covered by my insurance (if applicable) and any estimates of insurance coverage discussed by any staff member at DCPD was provided to me as courtesy. It is my responsibility to contact my child’s dental insurance company (including any insurance provided to my child by the state) to discuss and understand my child’s policy.

I agree to inform Dr. _____ and the staff of DCPD of any changes in the patient’s medical history. This authorization is valid until revoked by me in writing.

**Parent/Legal Guardian Signature** ______________________________________ **Relationship to Child** ______________________________________ **Date** ____________

Sample pictures of teeth treated by Silver Diamine Fluoride
CONSENT FOR SILVER DIAMINE FLUORIDE TREATMENT

Child’s Name: ___________________________ Date: ___________________________

Parent’s or Caregiver’s Name: _______________________________________________

I understand that my child is having the following treatment performed:

Silver Diamine Fluoride treatment to stop cavities from progressing or treat hypersensitivity

I may refuse this treatment. Other treatment options may include: fluoride varnish, fillings, tooth removal, or advanced procedures.

My dentist will: Dry the tooth. Put a small amount of Silver Diamine Fluoride on the cavity. This will help to stop the cavity.

This may need to be done again at future appointments. I understand that treated teeth may still need other treatments, such as fillings, crowns, or tooth removal.

I will tell my dentist if I might have a silver allergy.
I will tell my dentist if I have had ulcerative gingivitis or stomatitis in the past.

Side effects:

1. The cavity will change color to brown or black. This means the treatment is stopping the cavity. The dark stain is like a scar. Healthy tooth enamel will not stain.
2. Fillings and crowns may also change color if Silver Diamine Fluoride gets on them.
3. If Silver Diamine Fluoride touches the skin or gums, they may turn brown. The stain will not harm my child. The stain will not wash off. It will go away in 1-3 weeks.
4. These side effects may not include all of the possible situations reported by the manufacturer. I will let my dentist know if I notice any other side effects.

After the Silver Diamine Fluoride treatment, I will avoid food and drink for one hour. This will help the treatment to work better.

I AGREE THAT: I HAVE READ AND UNDERSTOOD THIS FORM. MY DENTIST EXPLAINED AND ANSWERED MY QUESTIONS ABOUT THE TREATMENT: BENEFITS, SIDE EFFECTS, AND RISKS. MY DENTIST TOLD ME ABOUT OTHER OPTIONS AND THEIR RISKS AND BENEFITS. I HAVE HAD THE CHANCE TO ASK QUESTIONS. I CONSENT TO THIS TREATMENT.

Date ______ Signature ________________________________

__________________________
Relationship to patient

Witness: ________________________________
Cases

- Application Process - isolation
- Use of KI
- Blackening of teeth - consents.
- Patients that would not be good candidates
- Amounts of SDF used - 1 drop
- Vasoline on gingiva - application
- Use under crowns?
- Use under fillings?
- Use with indirect pulp caps?
Summary

• Careful Use
• Consent provided by caretaker
• Avoid in resistant children unless sedated or guided by behavioral techniques
• Avoid spills, staining
• Excavation appears somewhat helpful if done carefully
• Be aware of recent studies
Questions
References


3. Jeremy A. Horst, DDS, PhD; Hellene Ellenikiotis, DDS; and Peter M. Milgrom, DDS UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications and Consent.. Jour Calif Dental Assoc. CDA JOURNAL,2016 VOL 44 , Nº 1


References