Silver Diamine Fluoride:  
Back to the Future  
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Course Objectives

- Explain the history of silver nitrate and silver diamine fluoride (SDF)
- Describe what SDF is and how it works
- Discuss the safety and indications for use of SDF
- Present protocols for SDF application, available products, and follow-up recommendations
- Review CDT codes and recent legislation

History of Silver Nitrate

- Silver Fluoride (AgF)
  - Used in Japan for approximately 900 years
  - Intended for cosmetic blackening
  - Unintended effect was caries prevention
- Silver Nitrate
  - Caries arrest protocols documented in the 1800s
  - 1891: 87 of 142 treated lesions were arrested
Early 1900’s in the U.S.

- G.V. Black
  - Father of Modern Dentistry
  - In 1908, Black documented protocols for silver nitrate
  - Used to treat troops deployed in World War I
  - Side effect was that the silver nitrate made teeth brittle (loss of Calcium)
  - In 1909, Black traveled to Colorado Springs to learn about “Colorado brown stain”, which later proved to be the result of fluoride and led to a reduction in caries

- Percy Howe
  - First research director at Forsythe Institute in Boston and ADA President 1928-1929
  - Became well known for his successful treatment of caries with silver nitrate, that other dental professionals began calling it “Howe’s Solution”
  - Advertised in JADA

Water Fluoridation

- In the 1950’s, water fluoridation became the focus of prevention and interest in silver faded

Silver Diamine Fluoride

- Silver Diamine Fluoride (SDF) Development in Japan
  - Built upon AgF success
  - Added remineralization properties of fluoride to antimicrobial properties of silver
  - NH₃⁺ added to silver fluoride for stabilization
  - Mizuho Nishino researched SDF for PhD from 1965-1969
  - Her research was published in the Journal of Osaka University Dental Society in 1969
  - SDF product by the name Saforide was released
  - Over 2 million bottles sold. Zero adverse outcomes documented.

Recent Developments in the U.S.

- FDA Approval in U.S.
  - 2014: FDA approval for dental sensitivity
  - 2015: Elevare Oral Care releases Advantage Arrest (SDF)
  - 2016: Breakthrough Therapy Designation by FDA
  - 2018: SDI North America releases Riva Star (SDF+K)

- Publicity and Popularity
  - PBS - January 2018
    - https://www.pbs.org/newshour/show/this-new-treatment-could-make-your-next-trip-to-the-dentist-more-bearable
  - JADA - August 2016
    - https://jada.ada.org/article/S0002-8177(16)30232-0/abstract
  - Washington Post - September 2016
  - Written by Colorado dental hygienist, Jennifer Geiselhofer
    - https://wapo.st/2FJSckn
Science Behind SDF

- **Formulation**
  - 25% silver (antimicrobial)
  - 8% ammonia (solvent)
  - 5% fluoride (remineralization)

  - Twice the concentration of fluoride is used, but less than half the volume compared to fluoride varnish, so overall fluoride exposure is less.
  - The rest of the solution is made up of water. In the Elevate Advantage Arrest, there is also <1% blue dye which dissipates as the solution dries.

- Silver nitrate alone can make teeth brittle.
- Formulations with fluoride help strengthen enamel and are optimal for long term outcomes.

- **Multiple Benefits**
  - Arrests caries
  - Prevents caries
  - Decreases dentinal sensitivity

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Caries Arrest

- **Silver ions**
  - Bactericidal
  - Prevents bacterial growth
  - Deactivates proteins

  ![How Silver Ions Work](https://www.sciencemag.org/news/2015/05/silver-turns-bacteria-deadly-zombies)

  - Silver ions kill active bacteria by deactivating proteins necessary for bacterial growth.

- **Caries Prevention**
  - **Direct**
    - Remineralizes dentin lesions
    - Increases lesion hardness
    - Prevents demineralization

  - **Indirect**
    - Can inhibit plaque bacteria
    - *Zombie Effect*
      - Silver-killed bacteria kill active bacteria

  ![Caries Prevention](https://youtu.be/w3QlqlX9s_k)

  - SDF penetrates dentin up to 150 microns.
Efficacy

- **Caries arrest**
  - ~90% arrest with 2/year application.
  - 40-80% arrest with 1/year application.

- **Caries prevention**
  - SDF inhibits the metabolic activity (acid production) of S.mutans more than NaF.
  - Meta analysis shows new caries decreased by 77% in children.

- **Caries prevention**
  - SDF prevents 61% of caries lesions. [all studies, weighted average]

1. Prevention of Dental Caries by Silver Diamine Fluoride, Compendium 2019, Horst & Heima
2. Journal of Dentistry, Ishiguro et.al.
3. The Effect of Silver Diamine Fluoride in Preventing Caries in Primary Dentition: A Systematic Review and Meta-Analysis, Oliveira et.al.

Indications for Use (and limitations)

- **Indications**
  - Extreme caries risk (xerostomia, severe ECC)
  - Behavior or medical management challenges
  - More lesions than treatable at 1 visit
  - Difficult to treat lesions
  - Patients without access to care
  - Patients looking for minimally invasive treatment options
  - Reduce gingival inflammation/gingivitis
  - Caries Prevention
  - Possible use as indirect pulp cap
  - Reduce aerosol generating procedures

- **Contraindications and limitations**
  - Possible concern with silver allergy
    - Though some research says this is not a concern because it contains silver ions
    - Do not use if there is exposed pulp in lesion
    - Can cause sensitivity and "zinging" feeling
  - No adverse reports in over 80 years in Japan

SDF For Gingival Inflammation

Texas A&M College of Dentistry, Dallas, TX, USA
Differences in gingival index (GI) and plaque index (PI) between SDF and control (S) groups at each time point

<table>
<thead>
<tr>
<th>Time</th>
<th>SDF group</th>
<th>Control group</th>
<th>P-value</th>
<th>SDF group</th>
<th>Control group</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>1.89±0.39</td>
<td>1.35±0.15</td>
<td>0.000</td>
<td>1.89±0.44</td>
<td>1.14±0.25</td>
<td>0.000</td>
</tr>
<tr>
<td>W3</td>
<td>0.97±0.53</td>
<td>1.22±0.18</td>
<td>0.156</td>
<td>0.66±0.53</td>
<td>1.11±0.37</td>
<td>0.031</td>
</tr>
<tr>
<td>W5</td>
<td>0.70±0.46</td>
<td>1.28±0.20</td>
<td>0.001</td>
<td>0.65±0.40</td>
<td>1.24±0.44</td>
<td>0.002</td>
</tr>
<tr>
<td>W7</td>
<td>0.61±0.34</td>
<td>1.33±0.19</td>
<td>0.000</td>
<td>0.78±0.37</td>
<td>1.17±0.35</td>
<td>0.014</td>
</tr>
</tbody>
</table>

BL: Baseline, W: Week, SDF: Silver diamine fluoride, S: Saline, M: Mean, SD: Standard deviation

Source: Wedad Alshehri*, Amal Noureldin, Helena Tapias, Peggy Timothe, Jacqueline Plemons, Lisa Mallonee, Kathy Svoboda. Texas A&M College of Dentistry, Dallas, TX, USA

COVID-19 and Minimally Invasive Options

- CDC recommends that minimally invasive and non-aerosol procedures be prioritized during this time (and that it is also stated in the PHO)
- During this time:
  - SDF can be applied without aerosols
  - ITR can be placed without a handpiece, or other aerosols
- Optimize schedules (for dentist OR hygienist) by:
  - Scheduling more patients for less time
  - Addressing treatment that was left undone for the past 3 months and buy time for treatment plans
  - Minimize aerosols in the office
  - Consider remote/community based options for SDF/ITR to keep patients from needing to come in the office so many times, or for so long of appointments

*Video of non-aerosol application of SDF: [https://www.youtube.com/watch?v=7aiyiRnXhQE](https://www.youtube.com/watch?v=7aiyiRnXhQE)

Safety

- Silver
  - No known serious side effects of ingesting silver
  - Average: 0.1 mg of silver
  - EPA lifetime exposure = 1 gram
  - Highest applied dose for 3 permanent teeth = 2.37 mg
  - ~1,266 treatments to reach lifetime maximum exposure

- Toxicity
  - Max dose of 1 drop per 10kg (22lbs) body weight with weekly intervals
  - The lethal subcutaneous dose (LD50) is 380mg/kg and gives a five-hundredfold safety margin (UCSF Protocol)

- SDF Side Effects
  - Possible local silver induced lesions - will disappear in 48 hours
  - In 1 out of 11 cases, lesions develop (caused by the silver precipitating out of the solution)

- Silver
  - No research to show safety of SDF in pregnancy or breastfeeding. However, research is available to show that Ag, F, and KI are all safe during pregnancy and breastfeeding in low doses.
Getting Started

- Informed Consent
  - Separate consent is not REQUIRED, but since the products and procedure are "new" to most people, a consent is helpful for patients/parents to fully understand
  - An extra measure to ensure treatment option discussion has covered all the important points
  - Should include color photos so that patients/parents can not claim later that they were not aware of the staining/color change that would happen
  - Sample consent form: www.cosda.org/legal

- Basic Setup

Protocols

1. Prepare setup with proper isolation and PPE
   - Plastic-lined tray cover, cotton roll(s), gauze, dry angles, microbrush, plastic dappen dish, 1-2 drops of SDF, fluoride varnish, Superfloss (if needed), air/water syringe, basic kit with mirror
2. Isolate lesion(s) using cotton roll, dry angle, and/or bite block.
3. Dry with air/water syringe
4. Dip microbrush in SDF (from dappen dish) and apply a small amount for 60 seconds.
   - Do not need to excavate caries prior to application
   - Do not dry with air/water syringe or solution will spread to other areas.
   - Do not light cure!
5. Apply fluoride varnish
   - Helps mask taste of SDF and "seals" over application site so that it does not wash away with saliva or contact mucosa
   - You can wipe with gauze if fluoride varnish is not desired

*Note: SDF will stain everything it touches (counter tops, clothes, etc.). Be careful to isolate well and only apply to lesions. Additional wipes with alcohol post-treatment will help remove stain. Staining of mucosa will resolve in approximately 48 hours.*
## Product Comparison

<table>
<thead>
<tr>
<th>Advantage Arrest (Elevate Oral Care)</th>
<th>Ring Star (OCS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td></td>
</tr>
<tr>
<td>Unit Dose = $4 (2 drops, can treat 10+ lesions)</td>
<td>$8 per dose</td>
</tr>
<tr>
<td>Bottle = $162/250 drops = $0.64 per drop</td>
<td></td>
</tr>
<tr>
<td><strong>Storage &amp; Shelf Life</strong></td>
<td></td>
</tr>
<tr>
<td>Room Temperature 3 years</td>
<td>Refrigerated 2 years</td>
</tr>
<tr>
<td><strong>Distribution</strong></td>
<td></td>
</tr>
<tr>
<td>Direct Ship (international shipping)</td>
<td>Dental Distributors Only (Dentsply, Patterson, Benco, etc.)</td>
</tr>
<tr>
<td><strong>Stains Teeth</strong></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Application Technique</strong></td>
<td></td>
</tr>
<tr>
<td>One-Step</td>
<td>Two-Step (SDF + KI)</td>
</tr>
<tr>
<td><strong>Special Features</strong></td>
<td></td>
</tr>
<tr>
<td>Tinted blue so that clinicians can see area where solution was applied</td>
<td>Additional step of applying potassium iodide can decrease staining</td>
</tr>
<tr>
<td><strong>Other Considerations</strong></td>
<td></td>
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Photos from Dr. Jeanette Maclean
Follow-Up

- Schedule patient for follow up visit 2-4 weeks after initial application
- Ensure that lesion is hard and dark black, if not, reapply
- Place restoration at this visit, if applicable.
- Best results if SDF is reapplied at least twice per year for at least 2 years
- Unless restoration is placed over application site
- SDF treatment can be the definitive treatment, or part of a larger treatment plan, depending on patient’s needs and desires

- Additional treatment options:
  - Can be used to treat interproximal lesions using Superfloss
  - Can be used in combination with other restorations, ideally glass ionomer
  - SMART technique
  - Can be placed same day or at future appointment
  - Can be used for primary crowns (Hall Crowns)
CDT Procedure Codes and Billing

- D1254 - Interim Caries Arresting Medicament Application - per tooth
  - When SDF is used primarily to arrest caries, either prior to a restoration placement, or as a way to "buy time" due to cooperation limitations of patients, or because of medical, behavioral, and physical, or financial limitations.

- D1255 - Caries preventive medicament application - per tooth
  - When SDF is used site specifically to offer prevention to high risk caries sites

- D9910
  - When SDF is used to treat dentinal hypersensitivity
Colorado Laws and Rules Regarding SDF

- HB 18-1045
  - Signed into law March 2018
  - Full text: [https://leg.colorado.gov/bills/hb18-1045](https://leg.colorado.gov/bills/hb18-1045)

- Rule XXVI
  - Approved by Colorado Dental Board in June 2018
  - Effective August 14, 2018 (Revised July 2019)

Requirements for dental hygienists to use SDF in Colorado

- Successfully complete course
  - A minimum of 1 hour, “live and interactive”
  - Approved by AGD/PACE, ADA/CERP, CODA accredited institution, and/or others
  - Carry professional liability insurance, as specified in 12-35-141
  - If using under indirect or telehealth supervision, have a written collaborative agreement with the supervising dentist

Supervision required

- Direct
- Indirect
- Telehealth

SDF section of Practice Act is going through Sunset Review process and will be revised in 2021 legislative session.

Resources

- Dr. Jeanette Maclean DDS
  - [www.kidsandbraces.com](http://www.kidsandbraces.com)
  - Anterior application of SDF - [https://www.youtube.com/watch?v=zxlvbhUx3QE&t=47s](https://www.youtube.com/watch?v=zxlvbhUx3QE&t=47s)
  - SDF application without aerosols - [https://www.youtube.com/watch?v=7aiyiRnXhQE](https://www.youtube.com/watch?v=7aiyiRnXhQE)
  - Interproximal application of SDF - [https://www.youtube.com/watch?v=nPyYpZYfrHQ](https://www.youtube.com/watch?v=nPyYpZYfrHQ)
  - More videos - [https://www.youtube.com/channel/UCuJ6qgHP6JxaIqmSe3HSLmQ](https://www.youtube.com/channel/UCuJ6qgHP6JxaIqmSe3HSLmQ)

- Additional CE
Resources (cont.)

- Research on Caries Arrest:
  - "Silver Diamine Fluoride: a caries silver-fluoride bullet" - [Link]
  - "Effectiveness of silver diamine fluoride and sodium fluoride varnish in arresting dental caries in Chinese preschool children" - [Link]
  - "Caries arrest: add buccal appearance using two different silver fluoride therapies on primary teeth with and without panicaria in 13-week results" - [Link]
  - "Silver Diamine Fluoride Significantly Decreased Gingivitis in Geriatric Patients in Three Weeks" - [Link]
  - California Dental Association Journal Issue on SDF - [Link]

- Research on Caries Prevention:
  - Folder with many studies - [Link]

- ADA Articles:
  - "Controlling Caries in Exposed Root Surfaces With Silver Diamine Fluoride: A Systematic Review With Meta-analysis" - [Link]
  - "Systematic Review of SDF Effectiveness and Application in Older Adults" - [Link]
  - More JADA publications - [Link]

- Colorado Laws and Regulations:
  - Sample Consents and Collaborative Agreements - [Link]
  - Current Practice Act and Rules and Regulations - [Link]
  - Updates on 2021 legislation regarding SDF - [Link]

- Tray Set Up and Procedure (video) - [Link]

Contacts

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- Elevate Oral Care (Advantage Arrest)
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- SDI (Diva Star)
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  720.635.3400