Silver Diamine Fluoride
UCSF Caries Arrest Committee
disclosures

We have no financial interests in any silver diamine fluoride product.
1.5 year outcome – 5 year old with special needs
95 year old: “hurts when I brush”
SDF - what is it?

Colorless liquid
25% **silver**: antimicrobial
8% **ammonia**: solvent
5% **fluoride**: remineralization
SDF - what does it do?

- Arrests dental caries
- Prevents dental caries
  - directly & indirectly
- Decreases dentin hypersensitivity
Where did this come from?

- **Silver Nitrate** used globally for >1000 years.
  - Caries arrest case series & protocols in 1800s.
  - 1891: 87 of 142 treated lesions were arrested.
  - Founding fathers of dentistry had protocols.

- **AgF** used in Japan for ~900 years.
  - Cosmetic blackening of teeth
  - Known to prevent caries.

- **NH₃⁺** added >80 years ago = SDF.
  - Approved & monitored by Japan.

- Available in Australia, Brazil, Argentina, Cuba, China since 1980s or before...

*J Dent Res 81:767*
SDF is now available in the U.S.

- $100/bottle = ~250 drops
- 31¢/drop
- CDT code for caries arrest approved for 2016: D1354.

FDA clearance = hypersensitivity.

Off label use = caries treatment.

This is the same as fluoride varnish.
Caries arrest

Llodra et al., 2005
373 6 year olds
3.2 lesions at start

Zhi et al., 2012
181 3-4 year olds
3.4 surfaces at start

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

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

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

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

Llodra et al., 2005
373 6 year olds
color: 2.5 new lesions
(only applied to lesions)

Liu et al., 2012
482 9.1 year olds
color: 4.6 new lesions

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

Tan et al., 2010
203 79 year olds
color: 2.5 new lesions

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

Monse et al., 2012
708 6-8 year olds
color: 0.44 new lesions
How well does it work?

- 9 RCTs with 1,493 patients.
- 6 on caries arrest.
  - ~90% arrest with 2/year application.
  - 40-80% arrest with 1/year application.
  - more effective in young children.
- 6 on caries prevention (3 overlap).
  - 25-70% prevention, outperforms everything by far.
  - 70-80% prevention in kids by application only to lesions.
Silver: how does it work?

How Silver Ions Work
They inhibit the reproduction of the microbe by:

1. Silver ions breaking through the cell wall
2. Silver ions disrupting the respiration of the microbe
3. Silver ions attaching to the DNA of the microbe to stop cell replication
Fluoride: how does it work?

- promotes remineralization
- inhibits demineralization
- can inhibit plaque bacteria
SDF: how does it work?

- Bactericidal
- Prevents bacterial growth
- Deactivates proteins
- Remineralizes dentin lesions
- Increases lesion hardness
- Prevents demineralization
- Occludes dentinal tubules
- Penetrates far into dentin
SDF: sustained antimicrobial effects

Prevents bacterial growth
– Treated dentin resists biofilm formation.
– Treated demineralized dentin resists more.
– Zombie Effect
  • Silver-killed bugs kill active bugs.
  • Ideal substantivity.
SDF: resists acid attack

- Increases mineral density and hardness
- Decreases lesion depth
- Products:
  - Fluoroapatite
  - Silver-protein conjugates
  - Silver chloride
  - Metallic silver

silver diamine fluoride
control
Ag and F ions penetrate:
- enamel: ~25 microns
- dentin: 200-300 microns

SDF arrested lesions:
- ~150 microns thick

Figure 1: Depth of penetration of silver phosphate crystals

Shah, JAOR 2014 1:25
When would you use it?

**UCSF Indications:**
1. Extreme caries risk (Xerostomia, S-ECC)
2. Behavior or Medical management challenges.
3. More lesions than treatable at 1 visit.
4. Difficult to treat lesions.
5. Patients without access to care.
How much do you use?

- microliters per lesion.
- 1 drop (20μL) can treat 5+ lesions.
How much *can* you use?

- FDA rat & mouse LD50 studies:
  - Oral LD50 = 520 mg/kg
  - Subcutaneous LD50 = 380 mg/kg

- 100% absorption of 20uL drop in 10kg child
  - ~15 month old = 0.76 mg/kg
    - 500-fold LD50 safety margin.

- NOAEL level for 14 days of daily exposure = 1.3 mg/kg
  - Higher levels resulted in mild gastric inflammation.

**UCSF limit:** 1 drop per 10kg per visit.
How do you use it?

UCSF Protocol:

1) PPE, plastic-lined covers.
2) Cotton isolation, air dry.
3) Light vaseline to gingiva. (Optional)
4) Apply to lesions with microsponge.
5) 1 minute dry time.
6) *Potassium Iodide until no precipitates.
7) Rinse with water.
8) Dispose in brown plastic bags.
How do you use it?

1. Accessible cavity.
2. Isolate with cotton, apply with microbrush.
3. Arrested cavities after 1 year
How often should you apply it?

- It needs to be re-applied.
- Twice per year, or more often.
- **Where?** To carious lesions, without excavation.
- **How long?** For at least the first 2 years...
SDF, how safe is it?

- No adverse reports in >80 years of use in Japan.

- **Contraindication**
  - Silver allergy.

- **Relative contraindication:**
  - Significant desquamative processes e.g. ulcerative gingivitis, stomatitis
    → Protect by petroleum jelly

- **Side effects:**
  - Small, white mucosal lesions
    • disappear in 48 hours.
  - It will stain the lesion black.
  - 14 days: mild gastric inflammation.
• Fluoride
  – ~50,000 ppm (5%) fluoride = highest available.
  – No known significant risk for this level of acute exposure.

• Silver
  – ~25% silver.
  – No known medical risks of ingesting silver.
  – Argyria: bluing of the skin
    • EPA lifetime exposure: 1 gram.
    • Highest applied dose for 3 permanent teeth: 2.37mg
    • = ~1,266 lifetime treatments.
SDF staining

time 0 1 day 1 week
Person and Clinic Protection

• Permanent dark staining of clinic surfaces and clothes.
  – Does not come out after setting (exceptions).
  – Clean immediately with copious water, ethanol, or high pH solvents such as ammonia.

• Temporary staining of skin
  – Rinse.
  – Will go away in days.
  – No harm.
Restoration Effects

- Effects on bonding:
  - SDF/1 minute wait/Rinse/Standard etching for composites.
  - Rinse SDF prior to GIC and Amalgam.
  - Resin cement: excavate SDF-treated superficial dentin before final impression.
Resin bond unaffected

Quock et al., Op Dent, 2012
GIC bond – better?

- etch / condition
- rinse
- SDF
- rinse
- GIC

Yamaga, Dent Mater J, 1993

Knight, Aust Dent J, 2006

photo courtesy of John Frachella
Combination with GIC sealants: SM-ARTs

- Glass Ionomer Cements (GICs) add the benefit of sustained fluoride release and a seal!
- Protocol: SDF, then standard GIC protocol.

(they darken over time)

Courtesy of Dr. John Frachella
GIC stain by SDF

- **SDF + GIC**
  - Fuji 9
  - 1 month

- **SDF + GIC**
  - Shofu FX-II
  - 1 month

- **3x SDF; no-prep GIC**
  - Shofu FX-II
  - 2 weeks

Courtesy of Dr. John Frachella
SDF take-homes

1. SDF arrests >90% caries when used 2/year.

2. Powerful indirect prevention.

3. Dry before use.

4. SDF stains the crap out of everything.
Summary

• Another tool for our tool box.
• Safe, effective, painless, inexpensive.
• Implications: - improving quality of care,  
  - improving access to care.
Bonus round!

• Fluoride toothpaste
• Xylitol for Moms
• Betadine
• Vitamin D
Fluoride toothpaste

% prevention DMFS

1000-1250 F toothpaste (ppm) 2400-2800 F toothpaste (ppm)

54 studies 4 studies

Walsh et al., Cochrane Reviews, 2010
Toothpaste by Mail!

- **Graph 1:** Bar chart showing the percentage of patients with tooth extractions across SocioEconomic quartiles.
  - 1st Qtr (Least deprived): 10%, 15%
  - 2nd Qtr: 15%, 20%
  - 3rd Qtr: 17%, 20%
  - 4th Qtr (Most deprived): 18%, 20%

- **Graph 2:** Line graph comparing fluoride levels in toothpaste:
  - 440 ppm F
  - 1450 ppm F

**Legend:**
- □ none sent
- ■ 440 ppm
- □ 1450 ppm
- △ Comparison

Walsh et al., Cochrane Reviews, 2010
xylitol gum for new Moms!

less need for treatment by treating mothers

accessed Jan 5th 2015
Caries prevention with Betadine (under F varnish)

<table>
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<th>Product</th>
<th>Frequency</th>
<th>Effect</th>
<th>Source</th>
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<tbody>
<tr>
<td>Betadine foam (10%)</td>
<td>once</td>
<td>no Δ</td>
<td>Zhan et al., 2006</td>
</tr>
<tr>
<td>Betadine (10%)</td>
<td>once</td>
<td>no Δ</td>
<td>Berkowitz et al., 2011</td>
</tr>
<tr>
<td>Betadine foam (10%)</td>
<td>once</td>
<td>no Δ</td>
<td>Xu et al., 2009</td>
</tr>
<tr>
<td>Betadine (10%)</td>
<td>q3mon</td>
<td>11%</td>
<td>Tut &amp; Milgrom, 2010</td>
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<tr>
<td>Betadine (10%)</td>
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<td>24%</td>
<td>Milgrom et al., 2011</td>
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<td>Simratvir et al., 2010</td>
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<tr>
<td>Betadine (10%)</td>
<td>q2mon</td>
<td>80%</td>
<td>Lopez et al., 2002</td>
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</table>

:. 10% Betadine start by 12 months of age q2-3months
Vitamin D prevents caries