Neither I nor my immediate family have any financial interests that would create a conflict of interest or restrict my independent judgment with regard to the content of this course.

Caries Management Challenges

- Very young children
- Elderly
- Medically compromised
- Uncooperative patients
  - Age
  - Cognitive status
Managing Early Childhood Caries

- No recognized standard of care.
- Surgical approaches often involve costly restorative treatment with sedation or GA.


Microbial Response to Dental Restorations

- Numerous reports show extensive restorative treatment lowers the oral burden of microbes.
- Mutans streptococci readily colonize restored surfaces and materials.
- Microbial reduction appears to be transitory.

Oral Microbial Response to Restorative Treatment

![Graph showing microbial response to restorative treatment.](attachment:graph.png)


Antimicrobial Approaches to Manage Caries

- Chlorhexidine
- Povidone Iodine
- Silver Diamine Fluoride
- Silver Nitrate

Antimicrobial Properties of Silver

- Three Ag salt products are currently available in the USA for caries management.
  - Silver Nitrate solution (25%)
  - Silver Diamine Fluoride Solution (38%)
Silver Salts

• The silver ion has strong antimicrobial activity.

Products with Silver

• Consequently silver is used in products from water lines management to home cleaning clothes.

Products with Silver

Sliver ions bind sulfhydryl groups on enzymes.

Silver Nitrate

• AgNO₃
• Least expensive salt of silver
• Commercially available in a variety of concentrations
• Has been used for over 1000 years in various medical applications
Silver Nitrate Uses

- Nongenital warts and verrucas, granulation tissue
- Wound healing, stoma maintenance
- Umbilical stumps
- Cautery anterior epistaxis
- Pain relief for aphthous stomatitis
- Eye drops in newborns (mostly replaced with erythromycin antibiotic eye drops)

Silver Nitrate Uses in Dentistry
Silver nitrate used by dentists for years to treat caries and under fillings to kill bacteria - "Howe's solution,"

Percy R. Howe, D.D.S., the Forsyth Institute's research director.

Silver Nitrate Caries Trials

Gao et al., Int J Environ Res Pub Health 2018

Steve Duffin AgNO3 and 5% NaF Varnish Protocol

Gao et al., Int J Environ Res Pub Health 2018

Silver Compounds

Table 1 – Use of silver compounds for caries management in dentistry.

<table>
<thead>
<tr>
<th>Period</th>
<th>Advances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1900</td>
<td>AgNO3 used in caries management</td>
</tr>
<tr>
<td>1960</td>
<td>Howe's solution (AgNO3) invented and used up to 1950s</td>
</tr>
<tr>
<td>1970s–1980s</td>
<td>AgF used alone and combined with SnF2 in clinical studies in Western Australia</td>
</tr>
<tr>
<td>1970s</td>
<td>Development of SDF in Japan supported by Central Pharmaceutical Council of the Ministry of Health and Welfare</td>
</tr>
<tr>
<td>1990s</td>
<td>SDF was recommended for young children in Brazil</td>
</tr>
<tr>
<td>2000s</td>
<td>Randomized controlled clinical trials on SDF and other preventive treatments</td>
</tr>
<tr>
<td>2000s</td>
<td>Addition of silver particle into restorative materials</td>
</tr>
</tbody>
</table>

Peng et al., 2012
Silver Diamine Fluoride

38% Silver Diamine Fluoride (Ag(NH₃)₂F) –
- Blue solution
- pH ~8 to 10
- Metallic taste

SDF Solution and FDA

- Became commercially in United States - March 2015
- FDA clearance - Class II medical device tooth hypersensitivity
- Not recommended for use in people under the age of 21

Silver Diamine Fluoride

Ammonia and AgF combined - form a diamine silver ion complex
- More stable than AgF
- When in contact with dentin: Ag₃PO₄ Black, hard layer

Ca₉₀[PO₄]₆(OH)₂ + Ag[NH₃]₂F → CaF₂ + Ag₃PO₄ + NH₂OH
Alkaline environment

Safety Data Sheet
Advantage Arrest
Silver Diamine Fluoride 38%
(Ag(NH₃)₂F)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver (Ag)</td>
<td>24 - 27</td>
</tr>
<tr>
<td>Ammonia (NH₃)</td>
<td>7.5 - 11</td>
</tr>
<tr>
<td>Fluoride (F)</td>
<td>5-6</td>
</tr>
<tr>
<td>Deionized Water</td>
<td>&lt;= 62.5</td>
</tr>
</tbody>
</table>

Action of SDF Components

Rosenblatt et al., 2009
**Ag Reactions:**
- Silver phosphate
- Silver chloride
- Silver oxide
- May incorporate Ag into apatite
- Inhibits dentin collagenase

**F Reactions**
- React with crystallites
- Calcium fluoride
- Inhibits dentin collagenase

**SDF + KI Treatment**
- Developed to reduce staining effect of Ag on carious dentin for immediate restoration placement.
- Mechanism – KI placement immediately after SDF forms AgI which is yellow not black

**SDF – KI Antimicrobial Effect**

**SDF Caries Management**
- Outcomes:
  - Caries arrest – stops and arrests active lesions
  - Primary caries prevention

**Dr. Scott Eidson**

Application of KI after SDF may improve initial restoration esthetics but does not result in long term difference in staining.
Diagnosis of Arrested Caries

- Appearance of lesion –
  - Location
  - Color
  - Margin
  - Hardness
  - Microbiology

Diagnosis of Arrested Caries

- Appearance of lesion –
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Caries Research

Nyvad criteria for Caries Lesion Activity and Severity Assessment: A Validated Approach for Clinical Management and Research

Management of Carious Lesions

Diagnose and Assess Risk

Remineralize

Continuous Patient Evaluation

Repair

No Carious Lesion

Incipient Lesion

Non-Active Lesion

Cavitated Active Lesion

Table 1. Descriptions of the new caries diagnostic criteria

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<thead>
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<tr>
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<td>Surface of enamel is visibly and/or palpably softened with loss of luster. Feels rough when the tip of the probe is moved gently across the surface. No clinically discernible loss of substance. Smooth surface. Caries lesion typically located close to gingival margin.</td>
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Before and After Tx with Ag

SDF Effect on Microbiome

- In vitro studies – biofilm and specific microbes


SDF Kills Cariogenic Organisms

- SDF, AgF, AgNO3, NH4F, NH4Cl, NaCl, NaF
- Strep Mutans, Lactobacillus acidophilus, Actinomyces naeslundii
- SDF, AgF, AgNO3, NH4F antibacterial effect (NH4F only at high concentrations)
- Conclusion – Ag ion primary antibacterial action

SDF Pulp Study: Wistar Rat

- Pulp not histologically altered after 38% SDF placement in cavity preparation

Acta Odontol Latinoam 2017

SDF and Pulpal Health

- Indirect pulp cap 0.25-.5 mm (Class V prep)
- No inflammation/necrosis
- Good tertiary dentin
- Recommended as IPT material for deep caries management

Korwar et al. Contemp Clin Dent. 2015
SDF Safety/Toxicity

US EPA Lowest Observed Adverse Effect Level (LOAEL)
Oral Dose: 0.014mg/kg/day – outcome is chronic - Agyria

Silver Compound Safety
- If consumed excessively will cause agyria
- Will stain skin black

Short Term SDF serum Pharmacokinetics
- Mean DSF solution applied to the 3 teeth was 7.57 mg (6.04 μL)
- 4 hour observation period,
- Mean max serum concentrations: F = 1.86 μmol/L; Ag = 206 nmol/L
- F and Ag EPA oral reference dose - cumulative daily exposure over a lifetime

SDF Caries Management
- Case selection
- Application technique
- Post SDF treatment protocol
- Restoring SDF treated teeth

Silver Diamine Fluoride Possible Advantages
- Control of pain (it's noninvasive)
- Control of infection (inherent in the material)
- Ease of use
- Affordability of material (it costs just pennies per application)
- Minimal time for application
Case Selection is Critical

- Caries control approach: enamel – dentin caries that is not encroaching on pulp or associated with spontaneous pain.

Goals of Treatment

- Arrest caries process.
- Prevent surgical treatment with sedation or with GA.
- Stop caries progression and pulpal demise.
- Subsequent restoration - consider need to replace form, function, esthetics.

Clinical Application of Silver Diamine Fluoride

- Wear gloves - avoid tissue tattoos from SDF.
- Paper tray cover to protect counter surfaces before dispensing one drop of SDF solution.

Patient Preparation

- Eye protection
- Lip protection
- Napkin
- Clean lesion debris
Silver Diamine Fluoride Protocol

- Isolate the tooth with cotton rolls or other means
- Moisten carious lesion with smallest amount of SDF solution possible with a microbrush
- Be careful not to touch intra or extraoral soft tissues with microbrush or solution

https://www.youtube.com/watch?v=zxlvbhUx3QE

Silver Diamine Fluoride Protocol

- Moisten carious lesion with SDF solution for 2-3 minutes
- Recommendation to not treat more than 5 lesions
- Place 5% NaF varnish over all teeth

Post SDF Treatment Protocol

- Return to office for recare visit 2-6 weeks
- Evaluate lesions for arrest at regular visits
- Reapply SDF to lesions not arrested

Follow Up Treatment Alternatives

- Leave teeth unrestored until child is older
- Consider restoration
- GI restoration or Atraumatic Restoration Technique
- Resin strip crown with minimal removal or black areas of caries
- Minimal reduction on posterior with SSC (modified Hall technique)
Effect of SDF on Bonding

- Multiple studies on bond strength of SDF and SDF/KI
- Etch rinse - OK


2017-18 Reference Manual Components
Oral Health Policies,
Best Practices
Clinical Practice Guidelines

Use of Silver Diamine Fluoride for Dental Caries Management in Children and Adolescents, Including Those with Special Health Care Needs

Recommendations
The SDF panel supports the use of 38 percent SDF for the arrest of cavitated caries lesions in primary teeth as part of a comprehensive caries management program. (Conditional recommendation, low-quality evidence)
Silver Diamine Fluoride Has Efficacy in Controlling Caries Progression in Primary Teeth: A Systematic Review and Meta-Analysis

Ana Claudia Chibnikb, Leticia Maria Warnerb, Juliana Feltrinb, Alessandro Dourado Loguanoc, Denise Studier Wambaib, Alessandra Renib.

*Department of Dentistry, State University of Paraiba Gomes, Paraiba Gomos, *Department of Pediatric Dentistry, Federal University of Pernambuco, Recife, Brazil.

Table 2

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>SDF events total</th>
<th>Other material events total</th>
<th>Weight</th>
<th>Risk ratio</th>
<th>95% CI</th>
<th>Risk ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>L11 SD vs control</td>
<td>209 102 71 156</td>
<td>209 102 71 156</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>L12 SD vs placebo</td>
<td>34 63 17 47</td>
<td>34 63 17 47</td>
<td>0.98</td>
<td>1.00</td>
<td>0.92</td>
<td>1.00</td>
<td>0.92</td>
</tr>
</tbody>
</table>

SDF Cost of Application

ADA CDT Code 1354
Interim caries arresting medicament application – per tooth
NC Medicaid reimburses $5 per tooth up to 5 teeth
NC covers children under 5 years of age
Adopting Disease Management Approach - D1354?

- Many NC Medicaid enrolled children ages 0-8 receive dental services under GA
- ~ 10,300 cases in SFY 2015 roughly 1.5% of the total enrolled children ages 0-8
- NC SFY 2015 Medicaid expenditures for GA cases approximately $40 million

<table>
<thead>
<tr>
<th>Authors (Year)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chu et al. (2002)</td>
<td>SDF arrests lesions better than FV and nothing (1/year: PF ~ 30-84%); better than FV ~46-83%</td>
</tr>
<tr>
<td>38% SDF better then lower concentrations</td>
<td></td>
</tr>
<tr>
<td>Tuo et al. (2006)</td>
<td>No advantage to excavating caries</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>DoSantos et al. (2012)</td>
<td>SDF was more effective than interim restoration with GI for arresting caries in primary teeth (86% vs. 80%)</td>
</tr>
<tr>
<td>Repeated application increases benefit</td>
<td></td>
</tr>
<tr>
<td>Braga et al. (2009)</td>
<td>1X SDF not an effective method to prevent dentinal (D3) caries lesions if brushing with F toothpaste.</td>
</tr>
<tr>
<td>Liu et al. (2012)</td>
<td>ART sealants significantly reduced the onset of caries over a period of 18 months.</td>
</tr>
<tr>
<td>Monse et al. (2012)</td>
<td>38% SDF better than lower concentrations</td>
</tr>
<tr>
<td>Evidence is not complete, some good quality studies</td>
<td></td>
</tr>
<tr>
<td>Optimal protocol for application</td>
<td></td>
</tr>
<tr>
<td>Reapplication rate</td>
<td></td>
</tr>
<tr>
<td>Is curing light OK</td>
<td></td>
</tr>
<tr>
<td>Secondary caries prevention</td>
<td></td>
</tr>
<tr>
<td>Long term affect on microbiome</td>
<td></td>
</tr>
<tr>
<td>Cost savings</td>
<td></td>
</tr>
</tbody>
</table>

Take Home Messages

- Various restorative approaches OK after SDF
- SDF is part of comprehensive caries management program but—there is no silver bullet!
Non-Surgical Caries Management

Historically dental caries has been synonymous with presence of cavitation.
- Emphasis on caries measurement and management.
- New approaches in caries detection, assessment, and management.

The American Dental Association Caries Classification System for Clinical Practice
JADA 146(2) February 2015
http://jada.ada.org

Caries Management Strategies

- Diagnosis
  - Lesion location
  - Non-cavitated vs Cavitated
- Secondary Prevention
- Non-surgical approaches
- Surgical Approaches

Caries Management Considerations in Children

- Dental condition
- Caries risk – progression
- Preventive program compliance
- Cooperation of child
- Parent’s desires - cost, esthetics, delivery method
Restorative Care in Children

- Surgical based treatment can be difficult to deliver due to patient’s ability to cooperate.
  - In office
  - Sedation
  - General anesthesia

Managing Early Childhood Caries

- No recognized standard of care.
- Surgical approaches often involve costly restorative treatment with sedation or GA.

Baby Dies Under Anesthesia as Dentist Fixed Cavities
Inside Edition
August 30, 2016

Oral Microbial Response to Restorative Treatment


Clinical Review: Bacteria-Intervening in Evers" levels for restored cavities treated, by region and year

Mean = 16.4 restored surfaces
Caries Management Considerations in Children

- Extent and character of dental conditions
- Caries risk - progression
- Ability/desire to follow preventive program
- Age - cooperation of child
- Desire of parents: cost, esthetics, treatment approach, delivery method

Evidence Based Dentistry

- Lesions are arrested by placement and retention of pit and fissure sealants.

- Non-cavitated carious lesions are arrested by placement and retention of pit and fissure sealants.

- The belief that caries under sealants is arrested has been disproven. It is now known that aerobic organisms become anaerobic when they do not have oxygen, and that lesions remain active.

- Fissurotomy or opening the fissures surgically.

- Described as being useful when not sure if area is carious or not.
Suspicious Occlusal Carious Lesions

National Dental Practice Based Research Network

- 1593 non-cavitated questionable lesions
- 40% treated surgically
- 50% of these did not reach dentin

Incipient Proximal Lesions

Resin Infiltration of Incipient Enamel Lesions

- Randomized split-mouth controlled clinical trial
- 39 patients with 3 proximal lesions
- Group A – ICON Resin perfusion
- Group B – Prime Bond T Dentsply resin perfusion
- Group C – Control – placebo microbrush only


Resin Perfusion Proximal Sealing 3 year Trial

- 3 year follow up – N=37


Mirco-invasive interventions for managing proximal caries

- 8 trials – 365 participants – split mouth design – non-cavitated, dentin outer 1/3
- 1-3 years follow up
- Outcome – radiographic lesion progression
- Significantly less progression than F varnish or hygiene instructions and flossing
Atraumatic Restorative Technique (ART)

- Similar Approaches
- Alternative Restorative Therapy (ART)
- Interim Therapeutic Restoration (IRT) – caries control approach and not definitive
- Protective Restoration – indirect pulp cap coverage and not definitive

Caries Control With Glass Ionomer

ART – Atraumatic Restorative Treatment

- Traditionally involves removing caries with hand instruments only.
- Restore cavity and adjacent fissures, usually with glass ionomer.

High Viscosity GIC vs Amalgam

- 20 trials accepted for review
- Systematic Review shows that failure rate of GIC/ART was similar to amalgam after periods longer than 6 years

ART Restoration Survival Rates

- Clinical studies indicate that small ART restorations have high short term success rates (2-3 yr Class 1 ~ 90%)
- Success rates markedly lower for larger Class I and for Class II restorations.
Hypomineralized first permanent molars (MIH)

- Prevalence ~ 2-30% depending on country
- Hypersensitivity
- Difficult to restore

Severe Enamel Hypomineralization of Multiple 6 yr Molars

10 year old with solicited pain

CC: Rotten Teeth – Doesn’t like needles
Hyperactive - Adderall

10 yr 2 Month Patient

12/20/01 – Excavate #3 and 14 with no anesthesia. Restore with Fuji IX. Patient gags easily

A role for Silver Diamine Fluoride???
- Desensitizing agent
- Remineralizes caries
- Is there added benefit???
Pulpal Implications with ART

- High success rate of indirect pulp capping
- Stepwise caries excavation

SMART Technique

- Silver Diamine Fluoride and Atraumatic Restorative Technique
- Treat lesion with SDF
- Restore with GIC or RMGI

AAPD Policy 2016

- Supports Interim Therapeutic Restoration
- Beneficial provisional technique
  - Use when traditional restoration not possible in uncooperative or special needs patients
  - Caries control
  - Stepwise excavation

ART and Early Childhood Caries Management

- Excavate bulk of caries?
- Glass ionomer, compomer or resin restoration to seal the lesion and surface
- Control caries completely or maintain dentition until patient is cooperative

Primary Tooth Posterior Stainless Steel Crowns: Excellent restoration for multi-surface treatment in young children.
stainless steel crowns ... good performance as restoratives for posterior primary teeth.

Hall technique was shown to have validity ... technique appears to be gaining ground in usage among clinicians; however, it remains controversial.

The Hall Technique is a method for managing carious primary molars where decay is sealed under preformed metal crowns (PMCs) without local anaesthesia, tooth preparation or any caries removal.

Hall Technique ... represents a gross distortion of science and medicine and is antithetic to the service that pediatric dentists, and other dentists who treat children, are providing for their patients. ... appears to be a quick and expedient attempt to treat a significant disease process, regardless of an inferior treatment result.

The Hall Technique is highly controversial in the US.

There is evidence from retrospective studies showing greater longevity of preformed metal crown restorations compared to amalgam restorations.
Hall SSC Technique

Hall Crown Case Selection

- Non-inflamed pulp
  - No unsolicited pain and preferably no solicited pain (try and delineate food impaction from pulpal pain).
- No parental desire for esthetic crown

Making Proximal Spacing

For the 91 patients with 48-month minimum follow-up, 84 of the 91 teeth (92%) in the Hall Technique arm and 47 of the 91 teeth (52%) in the control arm were ascribed as ‘Successful’ (Table 1), i.e., not experiencing a ‘Major’ or ‘Minor’ failure.
Preformed metal crowns are likely to reduce risk of major failure or pain compared to fillings.

Hall Technique may reduce discomfort at time of treatment.

Pros and Cons Hall vs. Conventional Stainless Steel Crowns

- **Hall Crown – Pros**
  - Minimal discomfort
  - Less traumatic to pulp
  - Less chair time
  - Cost
  - No risk of damaging adjacent teeth
  - Child, parent, provider preference
  - Useful for teeth with developmental defects

Current Pulp Biology Principals

- Seal caries and the process stops
- Pulp tissue has tremendous ability to heal
- Indirect pulp capping is highly successful

Pros and Cons Hall vs. Conventional Stainless Steel Crowns

- **Hall Crown - Cons**
  - Limited to SSC in posterior – excludes zirconium
  - Tight contacts require separator placement
  - No surgical diagnosis of caries relation to pulp

No direct comparison of Hall vs conventional prep SSC
3 Year Old Patient
Restorative Treatment

Stainless Steel Crown Cementation

- Many cements work very well
- Glass ionomer cements

Figure 12: Patient, clinician, and dentist preference for Rill Technique or conventional restorations in a split-mouth study for 122 children. 62% want Rill. Data from same study discussed above.
Indications for Stainless Steel Crowns in Young Permanent Teeth

- Caries
- Endodontics
- Developmental Defects

Molar Incisor Hypomineralization

- Prevalence varies around the world (~2-40% of children)
- Severity is highly variable

Criterion for Material Selection and Surgical vs Non-Surgical Restorative Approach

- Extent of decay
- Risk of future decay
- Integrity of pulp
- Expected longevity of tooth
- Isolation of tooth
- Patient Cooperation
- Cost

Non-Surgical or Surgical: How to Decide?

- What is the child’s future disease risk?
- Is the caries progressing?
- What is the likelihood that arrested caries will become active?
- Will a primary tooth exfoliate prior to becoming clinically symptomatic?

Diverse Armamentarium

- What are all the alternatives?
- What are the benefits?
- What are the risks?
- What are the financial implications?

Discussion