OVERVIEW OF PULPAL PROTECTION:

A. Problem:

1. Metallic restorations (e.g., dental amalgam) not suitable as sole replacements for tooth structure.
2. Bonding systems provide sealing and retention but do not medicate pulp.

B. Objectives for PULPAL PROTECTION:

1. CHEMICAL Protection  
   | <----------Traditionally VARNISHES
2. PULPAL Medication  
   | <--------Traditionally CEMENT LINERS
3. THERMAL / ELECT Protection
4. MECHANICAL Protection  
   | <----Traditionally CEMENT BASES

* Always check to see the functions of the mtl to replace dentin

C. Terminology for Pulpal Protection: (terminology is used very inconsistently)

1. Solution Liner  
   -- Thin film (2-5 μm)  
   -- (Varnish)  
   -- (Bonding System)  
   -- (Dentin Sealer)
2. Suspension Liner  
   -- Relatively thin film (20-25 μm)
3. Cement Liner  
   -- Medium thickness (100-500 μm)
4. Cement Base  
   -- Thick film (500-1000 μm)
D. Pulpal Responses:

**PULPAL PROBLEMS:**
- Fluid Flow
- Microleakage

**DENTIN FUNCTIONS:**
- Chemical Protection
- Thermal / Electrical Protection
- Biological Protection (Medication)
- Mechanical Protection

![Diagram showing dentin layers and pulp exposure](image)

1º Dentin
2º Dentin, 3º Dentin
Ca(OH)₂
Eugenol
CHEMICAL PROTECTION:

A. Review of Pulpal Reactions:

1. Pulpal Stimuli:
   a. Physical: Thermal; Electrical
   b. Mechanical: Vibration from Cavity Preparation; Traumatic Occlusion
   c. Chemical: Fluid Flow (Osmotic, Dehydration); Acid from dental matl
   d. Biological: Microleakage (Endotoxins from Bacteria)

2. Pulpal Responses: (PAIN)
   a. Sensitivity (Acute) ------------ Control Fluid Flow
      Sensitivity (Chronic) ----------- Control Fluid Flow
   b. Inflammation (Acute) ----------- Medicate
      Inflammation (Chronic) ------- Control Microleakage / Use Bonding Systems

3. Pulpal Sensitivity Theories:
   a. Direct Stimulation ----- of nerves in tubules
   b. Indirect Stimulation --- of mechanoreceptors by fluid movements
      (1) Physics of Fluid Movement (David Pashley, Medical College of Georgia)

\[ FLOW\ RATE = J = \frac{(P)(r^4)}{(8)(\eta)(l)} = (\text{Hydrostatic Pressure})(\text{Tube Radius})^4 \]

(2) Fluid flow is directly proportional to fourth power of tube "r"
(3) Small reductions in "r" produce large reductions in "flow" and produce large reductions in "pain"

Goal is OCCLUDE tubule end or COVER tubule openings!

4. Anatomy and Physiology of Tubules:
   a. Cut Surfaces:
      (1) Enamel Smear Layer = layer of enamel debris
      (2) Dentin Smear Layer = layer of dentin debris (0.5-2.5 μm)
         Smear Plugs = dentin debris pushed into tubules (2.0 μm) and provide some occlusion of tubules although smear material is porous

   b. Debrided Surface:
      (1) Exposed Dentinal Tubules: (0.5-3.0 μm diameter)
         and represent about 15 v/o of dentin
B. Varnishes: thin layers to seal off tubules (but now substitute DBS or sealers)

1. Classification:
   a. Varnish (Solution Liner):
      (1) Organic solvent based; H₂O insoluble
      (2) 1-2 μm film; Used to line cavity up over cavosurface margins
      (3) Sets by physical reaction (drying)--just like finger nail polish
   b. Suspension Liner:
      (1) Water solvent based; H₂O soluble
      (2) 10-25 μm film; Used to line only the dentin
      (3) Sets by physical reaction (drying)

2. Commercial Examples:

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Film Formers</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Solution Liners:</td>
<td></td>
</tr>
<tr>
<td>Copalite = Mixture</td>
<td>Copal Resin</td>
</tr>
<tr>
<td>Hydroxyline = Mixture</td>
<td>PMMA Resin, CH</td>
</tr>
<tr>
<td>Chembar = Chloroform</td>
<td>PS Resin, CH, ZnO</td>
</tr>
<tr>
<td>Tubilitec = Chloroform</td>
<td>PS Resin, CH, ZnO, F, Dithymol-I2</td>
</tr>
<tr>
<td>b. Suspension Liners:</td>
<td></td>
</tr>
<tr>
<td>Pulpdent = Water</td>
<td>Methyl Cellulose, CH</td>
</tr>
<tr>
<td>Hypocal = Water</td>
<td>Ethyl Cellulose, CH</td>
</tr>
</tbody>
</table>

3. COPALITE:
   a. Composition:
      (1) 90 w/o Solvent (Chloroform, Acetone, Alcohol)
      (2) 10 w/o Resin (Copal)

   b. Indications:
      (1) For use with dental amalgam (except now substitute DBS or sealers)
      (2) Prevents post-op sensitivity from fluid flow
      (3) Prevents post-op sensitivity from galvanic shock or percolation
   c. Film Formation: dries like fingernail polish (not chemically adhesive)
      (1) Film forms by evaporation in 5 - 30 secs
      (2) Produces 1-5 μm film that brittle and poorly covers tubules
      (3) Always use second coat (due to poor wetting)
      (4) Use thin coats to promote drying
   d. Manipulation:
      (1) Apply film over cavity floor and walls and up over cavosurface
      (2) Use extra solvent that supplied to dissolve excesses at margins
           and to continually dilute Copal resin bottle after solvent loss
PULPAL MEDICATION:

A. Introduction:

1. Need depends on extent of cavity preparation
   a. Shallow  = 0.5 mm into dentin  \((\text{RDT} \geq 2 \text{ mm, Not necessary})\)
   b. Moderate = 1.0 mm into dentin  \((\text{RDT} = 0.5-2 \text{ mm, ???????})\)
   c. Deep < 0.5 mm from pulp  \((\text{RDT} \leq 0.5 \text{ mm, Yes})\)

2. Objectives for Pulp Medication:
   a. Eliminate acute inflammation (by de-enervating the nerves)
   b. Prevent chronic inflammation (stimulate secondary/reparative dentin)
   c. (Be anti-bacterial)

B. Management of Acute Inflammation:

1. EUGENOL:
   a. Palliative  = mitigates, alleviates, or eases pain
   b. Obtundent  = reduces violence or pungency by dulling senses

2. Delivery:
   a. Released from cement liner or cement base into dentinal tubules
   b. Short term effect

C. Management of Chronic Inflammation:

1. CALCIUM HYDROXIDE:  \((\text{HO})-(\text{Ca}^{++})-(\text{OH}^-)\)

2. Delivery:
   a. Released from susp liner, cement liner, comp liner, or cement base
   b. Very basic, dissolves in water, and diffuses to pulp
   c. Accelerates formation of reparative or secondary dentin
   d. Method of action unknown

3. Characteristics of Calcium Hydroxide, Ca(OH)\(_2\), Pastes:
   a. Generates very alkaline solutions, \(\text{pH} = 11.0\)
   b. Aqueous pastes are viscous and do not wet dry dentin well
   c. Apply without pressure only on concavely excavated dentin
   d. Apply thickness that creates uniform appearance
   e. Set materials are low strength, water soluble, and radiograph poorly
   f. CH diffuses to pulp to stimulate and above to neutralize acids

4. Commercial Examples:
   a. DYCAL (LD Caulk):
      Catalyst Paste= 51% CH, 39.7% Ethyl Toluene Sulfonamide, 9% ZnO, 0.3% Zn Stearate
      Base Paste= 39% Glycol Salicylate, 45% TiO\(_2\), 15% Ca Tungstate, 0.6% CH
      Reaction= Moisture allows Ca\(^{+2}\) ions to dissolve and chelate with salicylate

   b. LIFE (Kerr):
      Catalyst Paste = CH, ...
      Base = 83% Methyl Salicylate Oligomers, 15% Methyl Salicylate Polymer,...
      Reaction = Moisture dissolves CH and Ca\(^{+2}\) ions crosslink the oligomers

   c. Light Cured DYCAL:
THERMAL (and ELECTRICAL) PROTECTION:

A. Introduction:

1. Intraoral Heat Flow:
   a. Normal thermal transients = 30-60 secs and 5-60°C
   b. Normal thermal insulators = enamel + dentin
   c. Temperature Changes in Pulp:
      (1) Dependent on TIME, TEMPERATURE DIFFERENCE
      (2) Dependent on THICKNESS of insulation
   d. Amalgam Restoration Creates New Routes for Heat Flow
      (1) Amalgam (conductor), Dentin (reduced thickness)
      (2) Intraoral fluid leakage along margins (percolation)

2. Review of Physics of Heat Flow:
   a. Coefficient of Thermal Conductivity:
      (1) Heat transfer rate for constant mouth temperature
      and no change in pulp temperature
      (2) \( Q/\text{sec} = (k)(A/x)(\Delta T) \)

   b. Coefficient of Thermal Diffusivity:
      (1) Rate of temperature rise in pulp for constant
      mouth temperature with inadequate pulp cooling
      (2) \( h = (k)/(C)(\rho) \)

   c. Coefficient of Thermal Expansion and Contraction:
      (1) Marginal percolation between tooth and amalgam
      (2) \( \Delta l/l_0 = (\alpha)(\Delta T) \)

B. Thermal Protection Requirements:

1. To protect pulp need 1-2 mm (1000-2000 μm) for total insulation:
   (of dentin, RDT, and/or other insulating dental material)
   a. 5-25 μm --> No effective protection (e.g., varnishes, bonding agents)
   b. 200 μm --> Minimum to start to afford protection (e.g., liners)
   c. 2000 μm --> Excellent protection

2. To stop percolation need varnish, dentin sealer, DBS, ABs,
   and/or corrosion products.
MECHANICAL PROTECTION:

A. Introduction:

1. Problem: need adequate thickness of dentin for:
   a. **Resistance to flexion** (or breakage) during amalgam condensation
      (1) Liner or Base CS = 170-500 psi [1.2 – 3.5 MPa]
      (required by 6-7 minutes)
      (2) Most liner materials acceptable if not too thick
   b. **Pulpal bridging** -- prevents flexion and transfers stress in compression
      (1) Liner or Base CS = 12,000-15,000 psi [80-100 MPa]
      (to resist functional stresses)
      (2) Cement bases required to transfer stress to sound dentin

2. **BASE = 1.5 to 2.0 mm of pulpal protection against mechanical forces**
   a. Dentin is the best base:
      (1) Try to keep the restoration seated on sound dentin!
      (2) Use liner and/or cement base to augment remaining dentin
         (a) If 2 mm dentin, no liner or base
         (b) If 1-2 mm dentin, use liner to add to dentin
         (c) If <0.5 mm dentin, use liner and base to add to dentin
      (3) Do not cover floors and walls with unnecessary liner or base
   b. Alternative Terminologies for Bases (no longer used):
      (1) Intermediate Base = material between dentin and restoration
      (2) Primary Base = material next to dentin (liner)
      (3) Secondary Base = material next to restoration (above liner)

B. Dental Materials Bases:

1. Classification:

<table>
<thead>
<tr>
<th>Lining Cement</th>
<th>Basing Cement</th>
<th>Luting Cement</th>
<th>Filling Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Hydroxide</td>
<td>CH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc Oxide Eugenol</td>
<td>ZOE</td>
<td>xxx</td>
<td></td>
</tr>
<tr>
<td>ZOE, Reinforced</td>
<td>RZOE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZOE, EBA Modified</td>
<td>ZOE-EBA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc Phosphate</td>
<td>ZP</td>
<td>xxx</td>
<td></td>
</tr>
<tr>
<td>Zinc Silicophosphate</td>
<td>ZSP</td>
<td></td>
<td>xxx</td>
</tr>
<tr>
<td>Silicate</td>
<td>SC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polycarboxylate</td>
<td>PC</td>
<td>xxx</td>
<td>xxx</td>
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<tr>
<td>Glass Ionomer</td>
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<td>xxx</td>
<td>xxx</td>
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<tr>
<td>Resin Modified GI</td>
<td>RMGI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composite</td>
<td>COM</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Compositions:

<table>
<thead>
<tr>
<th>Cement</th>
<th>Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid:</td>
<td>Powder:</td>
</tr>
<tr>
<td>Reinforced ZOE</td>
<td>Zinc Oxide</td>
</tr>
<tr>
<td>Zinc Phosphate</td>
<td>Zinc Oxide</td>
</tr>
<tr>
<td>Polycarboxylate</td>
<td>Zinc Oxide</td>
</tr>
<tr>
<td>Glass Ionomer</td>
<td>Silicate Glass</td>
</tr>
<tr>
<td>RMGI</td>
<td>Silicate Glass</td>
</tr>
<tr>
<td>Composite</td>
<td>Silicate Glass</td>
</tr>
</tbody>
</table>
COMMERCIAL EXAMPLES OF VARNISHES, LINERS, AND BASES:

A. SOLUTION LINERS (Varnishes):

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer/Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copalite</td>
<td>(Harry J. Bosworth)</td>
</tr>
<tr>
<td>Caulk Varnish</td>
<td>(LD Caulk)</td>
</tr>
<tr>
<td>Varnall</td>
<td>(Cetylite Industries)</td>
</tr>
<tr>
<td>Handiliner</td>
<td>(Mizzy)</td>
</tr>
<tr>
<td>Hydroxyline</td>
<td>(George Taub Prod)</td>
</tr>
<tr>
<td>Chembar</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Cavaseal</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Tubilitec</td>
<td>(Buffalo Dental)</td>
</tr>
<tr>
<td>Repelac</td>
<td>(Caulk)</td>
</tr>
</tbody>
</table>

A2. SOLUTION LINERS (Dentin Sealers)

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer/Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gluma</td>
<td>(Hereaus-Kulzer)</td>
</tr>
<tr>
<td>Hurrisil</td>
<td>(Beutlich)</td>
</tr>
</tbody>
</table>

A3. SOLUTION LINERS (Bonding Systems)

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer/Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypo-Cal</td>
<td>(Ellman Dental)</td>
</tr>
<tr>
<td>Pulpdent</td>
<td>(Pulpdent Corp)</td>
</tr>
</tbody>
</table>

B. SUSPENSION LINERS:

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer/Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dycal</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Dycal Improved</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Light-Cured Dycal</td>
<td>(Kerr)</td>
</tr>
<tr>
<td>Life</td>
<td>(Kerr)</td>
</tr>
<tr>
<td>Ultrablast</td>
<td>(Ultradent)</td>
</tr>
<tr>
<td>Hydrex</td>
<td>(Kerr)</td>
</tr>
<tr>
<td>Cavitec</td>
<td>(Premier)</td>
</tr>
<tr>
<td>Pharmatec</td>
<td>(Kerr)</td>
</tr>
<tr>
<td>Pulpotex</td>
<td>(Kerr)</td>
</tr>
<tr>
<td>Z-O-E</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Temrex</td>
<td>(Caulk)</td>
</tr>
</tbody>
</table>

C. CEMENT LINERS:

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer/Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dycal</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Dycal Improved</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Life</td>
<td>(Kerr)</td>
</tr>
<tr>
<td>Dycal</td>
<td>(Caulk)</td>
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<tr>
<td>Light-Cured Dycal</td>
<td>(Kerr)</td>
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<tr>
<td>Life</td>
<td>(Kerr)</td>
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<tr>
<td>Ultrablast</td>
<td>(Ultradent)</td>
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<tr>
<td>Hydrex</td>
<td>(Kerr)</td>
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<tr>
<td>Cavitec</td>
<td>(Premier)</td>
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<td>Pharmatec</td>
<td>(Kerr)</td>
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<td>Pulpotex</td>
<td>(Kerr)</td>
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<td>Z-O-E</td>
<td>(Caulk)</td>
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<tr>
<td>Temrex</td>
<td>(Caulk)</td>
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</tbody>
</table>

D. CEMENT BASES:

<table>
<thead>
<tr>
<th>Product</th>
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</tr>
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<tbody>
<tr>
<td>Zinc Oxide Eugenol</td>
<td>(Caulk)</td>
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<tr>
<td>ZOE 2200</td>
<td>(J. Bird Moyer Co)</td>
</tr>
<tr>
<td>ZOE</td>
<td>(Caulk)</td>
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<tr>
<td>IRM</td>
<td>(Caulk)</td>
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<tr>
<td>Zinc Phosphate</td>
<td>(Mizzy)</td>
</tr>
<tr>
<td>Modern Tenacin</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>HyBond ZP Cement</td>
<td>(Shofu Dental Corp)</td>
</tr>
<tr>
<td>Zinc Cement Improved</td>
<td>(Mission White Dent)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Product</th>
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</tr>
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<tbody>
<tr>
<td>Polycarboxylate</td>
<td>(Caulk)</td>
</tr>
<tr>
<td>Tylok</td>
<td>(Premier)</td>
</tr>
<tr>
<td>Durelon</td>
<td>(Premier)</td>
</tr>
<tr>
<td>Hybond PC Cement</td>
<td>(Shofu Dental Corp)</td>
</tr>
<tr>
<td>Poly-F Plus</td>
<td>(Ash-USA)</td>
</tr>
<tr>
<td>Polybond</td>
<td>(Orthodont (Caulk))</td>
</tr>
<tr>
<td>Chemit</td>
<td>(Harry J. Bosworth)</td>
</tr>
<tr>
<td>Carboxyl (3M)</td>
<td>(Caulk)</td>
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</table>

Dentin Cement LC (GC Chemical)

<table>
<thead>
<tr>
<th>Product</th>
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</thead>
<tbody>
<tr>
<td>Glass Ionomer</td>
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<td>ASPA</td>
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<td>Chebond</td>
<td>(Caulk)</td>
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<tr>
<td>GC Lining Cement</td>
<td>(GC Chemical)</td>
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<tr>
<td>Fuji Lining LC</td>
<td>(Fuji)</td>
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<tr>
<td>Zionomer</td>
<td>(Demmat)</td>
</tr>
<tr>
<td>LC Zionomer</td>
<td>(Demmat)</td>
</tr>
<tr>
<td>Ketac-Bond</td>
<td>(ESPE)</td>
</tr>
<tr>
<td>Vitrebond</td>
<td>(3M)</td>
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<tr>
<td>Dentin Cement LC</td>
<td>(GC Chemical)</td>
</tr>
</tbody>
</table>

Resin Modified Glass Ionomers

<table>
<thead>
<tr>
<th>Product</th>
<th>Manufacturer/Supplier</th>
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<tbody>
<tr>
<td>Vitremer Cement</td>
<td>(3M)</td>
</tr>
<tr>
<td>Fuji Duet (Plus)</td>
<td>(GC)</td>
</tr>
</tbody>
</table>

SUMMARY OF "MEDICAMENT, LINER / BASE, VARNISH / SEALER / DBS" PROCEDURES

(Pulpal protection = pulpal medication, dentin sealing, thermal insulation, electrical insulation, and mechanical protection.)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Shallow Excavation (RDT &gt;=2 mm)</th>
<th>Moderately Deep (RDT = 0.5 - 2.0 mm)</th>
<th>Deep (RDT &lt; 0.5 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amalgam</td>
<td>[Medicament / Lining / Sealing]</td>
<td>[Medicament / Lining / Sealing]</td>
<td>[Medicament / Lining / Sealing]</td>
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<tr>
<td>Composite</td>
<td>[Medicament / Lining / Sealing]</td>
<td>[Medicament / Lining / Sealing]</td>
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</tr>
<tr>
<td>Gold Inlays, Onlays</td>
<td>[Medicament / Lining / Sealing]</td>
<td>[Medicament / Lining / Sealing]</td>
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<tr>
<td>Ceramic</td>
<td>[Medicament / Lining / Sealing]</td>
<td>[Medicament / Lining / Sealing]</td>
<td>[Medicament / Lining / Sealing]</td>
</tr>
</tbody>
</table>

Sealer = (originally Copalite Varnish and later dentin bonding agent but now sealers only) Gluma or Hurrisel

Liner = Dycal; Liner/Base = Vitremer or Durelon

DBS = ........

Luting Cement = Vitremer Cement; Luting Composite Cement = Dual Cure Cement
MULTIPLE CHOICE STUDY QUESTIONS: (Answers are bolded)

Which ONE of the following is NOT an objective for pulp protection?

a. Adhesion to amalgam  
b. Chemical protection  
c. Mechanical protection  
d. Thermal protection  
e. Pulpal medication

Pulpal SENSITIVITY is caused primarily by:

a. Vibration from cavity preparation  
b. Thermal trauma  
c. Electrical trauma  
d. Fluid flow in tubules  
e. Chemical irritation from bacteria

FLUID FLOW is detected by:

a. Mechanoreceptors on the edge of the pulp  
b. C-axis nerve fibers that penetrate into the tubules  
c. Odontoblast cells  
d. Odontoblastic processes  
e. Fibroblasts

CHRONIC INFLAMMATION is caused primarily by:

a. Mechanical inflammation  
b. Fluid flow in tubules  
c. Thermal trauma  
d. Microleakage of endotoxins  
e. Chemical irritation from dental materials

The DENTIN SMEAR LAYER increases:

a. Chemical adhesion for varnishes  
b. Mechanical adhesion for liners  
c. Thermal insulation for the pulp  
d. Coverage of tubule openings  
e. Formation of reparative dentin

Reduction in tooth SENSITIVITY with decreased fluid flow in tubules is related to the:

a. Number of tubules above a critical size  
b. Square of the tubule radius  
c. Cube of the tubule diameter  
d. Fourth power of the tubule radius  
e. Surface energy at the tubule opening

Copalite is CLASSIFIED as:

a. Solution liner  
b. Suspension liner  
c. Cement liner  
d. Cement base  
e. Cement filling material
Suspension liners [e.g., Ca(OH)$_2$ in H$_2$O] HARDEN intraorally by the:
   a. Physical reaction of drying
   b. Physical reaction of a sol-gel transformation
   c. Chemical reaction of acids and bases
   d. Chemical reaction involving polymerization
   e. Chemical reaction involving chelation

What is the typical THICKNESS range for varnishes?
   a. 2-5 μm (0.002-0.005 mm)
   b. 10-50 μm (0.010-0.050 mm)
   c. 50-100 μm (0.050-0.100 mm)
   d. 100-200 μm (0.100-0.200 mm)
   e. 200-1000 μm (0.200-1.000 mm)

What is the THICKNESS of thermal insulation required for pulpal protection?
   a. 2-5 μm (0.002-0.005 mm)
   b. 10-50 μm (0.010-0.050 mm)
   c. 50-200 μm (0.050-0.100 mm)
   d. 200-1000 μm (0.200-0.500 mm)
   e. 1000-2000 μm (1.000-2.000 mm)

Varnishes should be applied in:
   a. 1 thin coat
   b. 1 thick coat
   c. 2 thin coats
   d. 2 thick coats
   e. 1 thin and 1 thick coat

How much tubule coverage is produced by 1 thin coating of varnish?
   a. 25%
   b. 50%
   c. 75%
   d. 90%
   e. 100%

The chemical composition of COPALITE includes all of the following, EXCEPT:
   a. Organic resin
   b. Chloroform solvent
   c. Acetone solvent
   d. Alcohol solvent
   e. Calcium hydroxide

What is the average LIFETIME for the integrity of a varnish film?
   a. 1 hour
   b. 1 day
   c. 1 month
   d. 1 year
   e. 10 years

DYCAL is classified as a:
   a. Solution liner
   b. Suspension liner
   c. Cement liner
   d. Cement base
   e. Cement filling material
Dental materials that are designed as PULPAL MEDICAMENTS contain:

a. Calcium hydroxide or Eugenol
b. Calcium phosphate or Eugenol
c. Calcium hydroxide or Methyl Salicylate
d. Zinc oxide or Eugenol
e. Calcium hydroxide or Zinc Oxide

The pH of concentrated CALCIUM HYDROXIDE solutions is:

a. pH = 1-3
b. pH = 3-5
c. pH = 5-7
d. pH = 7-9
e. pH = 9-11

Which intraoral component is required to start the setting of DYCAL?

a. Ca ions from tooth structure
b. Higher temperatures of the intraoral tissues
c. Denatured proteins in the smear layer
d. Monovalent ions from saliva
e. Moisture for calcium hydroxide dissociation

What is the key IONIC species for the setting of DYCAL and LIFE?

a. Zn++
b. Ca++
c. Sn++
d. K+
e. Na+

Which factor is LEAST IMPORTANT to thermal protection of the pulp?

a. Thickness of the insulating material
b. Temperature gradient from the mouth to the pulp
c. Time period of thermal imbalance
d. Coefficient of thermal conductivity
e. Copper content in the overlying dental amalgam

THERMAL TRANSIENTS in the mouth are typically:

a. 5-10s in the range of 37-95°C
b. 5-10s in the range of 5-95°C
c. 30-60s in the range of 5-60°C
d. 60-90s in the range of 0-100°C
e. 60-90s in the range of 10-45°C

The rate of change of temperature in the pulp depends on:

a. Thermal conductivity of overlying materials
b. Thermal diffusivity of overlying materials
c. Thermal contraction of overlying materials
d. Thermal expansion of overlying materials
e. Electrical conductivity of overlying materials

Which ONE of the following is FALSE about a cement liner?

a. The setting reaction is accelerated by moisture
b. The liner should be placed in relatively thin layers
c. It has sufficient strength in 6-7 mins to support amalgam condensation
d. It releases constituents for pulpal medication
e. It provides adequate mechanical strength to replace existing dentin
Dental materials to be used at BASES should have COMpressive STRENGTHS of:

a. 1000-5000 psi [7-35 MPa]
b. 5000-12000 psi [35-80 MPa]
c. 12000-15000 psi [80-100 MPa]
d. 15000-30000 psi [100-200 MPa]
e. 30000-60000 psi [200-400 MPa]

Which ONE of the following statements is FALSE about bases?

a. An intermediate base is between the restoration and dentin
b. A primary base is adjacent to the dentin
c. A secondary base is next to the restoration
d. A dental cement base is used to transfer stresses to sound dentin
e. A dental cement base is mixed at low powder-to-liquid ratios.

What STRESSES must be supported during amalgam CONDENSATION?

a. 50-170 psi [0.3-1.2 MPa]
b. 170-500 psi [1.2-3.5 MPa]
c. 500-1000 psi [3.5-7 MPa]
d. 1000-5000 psi [7-35 MPa]
e. 5000-7000 psi [35-70 MPa]

Which ONE of the following cements are typically used as bases?

a. SPC, ZP, ZOE
b. ZP, PC, GI, RMGI
c. ZOE-EBA, ZP, GI
d. CH, ZP, PC
e. ZP, PC, COM

Which ONE(s) of the following materials is advertised simply as a "dentin sealer"?

a. HurriSeal, Gluma
b. ZP, PC, GI, RMGI
c. Dentin Bonding Systems
d. Dycal or Visible-Light Cured Dycal
e. Copalite

Which of the following sequences would be correct for pulpal protection prior to AMALGAM insertion into a cavity excavation that included RDT >= 2 mm?

a. Vitremer, Dycal, and Dentin Bonding System
b. HurriSeal or Gluma
c. Gluma, Vitremer
d. Dycal, Vitremer, Gluma
e. Vitremer, Gluma

Which of the following sequences would be correct for pulpal protection prior to COMPOSITE insertion into a cavity excavation that included RDT = 1 mm?

a. Vitremer, Dycal, and Dentin Bonding System
b. Dentin Bonding System
c. Gluma, Vitremer
d. Dycal, Vitremer, Gluma
e. Vitremer, Dentin Bonding System
Which of the following sequences would be correct for pulpal protection prior to COMPOSITE insertion into a cavity excavation that included RDT <= 0.5 mm?

a. Dycal, Dentin Bonding System
b. HurriSeal, Vitremer
c. Vitremer, Dentin Bonding System
d. Dycal, Vitremer, Dentin Bonding System
e. Vitremer, Gluma

Which of the following sequences would be correct for pulpal protection prior to AMALGAM insertion into a cavity excavation that included RDT <= 0.5 mm?

a. Dycal, Dentin Bonding System
b. HurriSeal, Vitremer
c. Vitremer, Dentin Bonding System
d. Dycal, Vitremer, HurriSeal
e. Dycal, Vitremer

Which of the following materials would not be considered a solution liner?

a. Dentin Bonding System
b. Vitremer
c. Gluma
d. HurriSeal
e. Copalite

DISCUSSION QUESTIONS:

• In a relatively shallow dental amalgam cavity preparation, what would be the result of not using cavity varnish, bonding agent, or dentin sealer before amalgam placement?

• Why shouldn't the smear layer be removed from the dental amalgam cavity preparation in order to produce more intimate adaptation of the amalgam and the supporting enamel and dentin structures?

• In a moderately deep cavity preparation with one portion of the floor that is close to a pulp horn, what is the best selection of varnishes, liners, and bases to use, and what is the order and coverage of application?

• What is the reason that calcium hydroxide is included in compositions if the odontoblasts will produce reparative or secondary dentin on their own without stimulation in 5-to-7 more days?

• Explain the special requirements for cavity preparation for a carious lesion that has penetrated within 0.5 mm of the pulp.