MICROLEAKAGE
ALONG
TOOTH- RESTORATION INTERFACE

Definition
- “Clinically undetectable passage of bacteria and bacterial products, fluids, molecules or ions from the oral environment along the various gaps present in the cavity restoration interface”
- Acc. To Kidd FA “Movement of bacteria, Fluid, molecules or ions and even air between the prepared cavity wall and the subsequently applied restorative material”

Routes of Microleakage
1) Via Smear layer
2) Between smear layer and cavity varnish/cement
3) Between cavity varnish / cement and restoration

Clinical Implications
1) Post Operative Sensitivity- Pulpal pain
2) Secondary or recurrent caries- creates marginal gaps
3) Pulpal pathology- Inflammatory products
4) Marginal Discoloration – in esthetic materials (subsurface interfacial staining)
5) Dissolution of Luting cements – creates gap

Properties of Restorative Materials Contributing To Microleakage
- Microleakage is a useful indicator of the microscopic and anatomic aspects of bond between the restorative material and the tooth.
- The filling materials should be closely adapted to the cavity walls and should withstand thermal changes once placed in the oral environment
- Good marginal adaptation requires adequate physical and mechanical properties of the filling material and its careful manipulation

Coefficient of Thermal expansion (CTE)
- It is the change in length per unit length of a material per degree change in temperature.
- Both linear and volumetric coefficient of thermal expansion are important in restorative materials
- Percolation

<table>
<thead>
<tr>
<th>Material</th>
<th>C.T.E. (x 10^-6/°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth (crown enamel)</td>
<td>11.4</td>
</tr>
<tr>
<td>Dentin</td>
<td>8.3</td>
</tr>
<tr>
<td>Aluminous porcelain</td>
<td>6.6</td>
</tr>
<tr>
<td>Pure titanium</td>
<td>8.5</td>
</tr>
<tr>
<td>Type II glass ionomer</td>
<td>11.0</td>
</tr>
<tr>
<td>Pure gold</td>
<td>14.0</td>
</tr>
<tr>
<td>Dental amalgam</td>
<td>25.0</td>
</tr>
<tr>
<td>Composites</td>
<td>20.0-25.0</td>
</tr>
<tr>
<td>Denture resin</td>
<td>81.0</td>
</tr>
<tr>
<td>Pit &amp; fissure resin</td>
<td>85.0</td>
</tr>
<tr>
<td>Inlay wax</td>
<td>400.0</td>
</tr>
</tbody>
</table>
Polymerization Shrinkage (polymeric materials)
- Vol. & Density (Polymerization)
- Pulls away material from tooth intermediate adhesive present and contraction stresses high bond breaks (microleakage)

<table>
<thead>
<tr>
<th>Material</th>
<th>Shrinkage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic Heat cure</td>
<td>7%</td>
</tr>
<tr>
<td>Acrylic Cold cure</td>
<td>3.5%</td>
</tr>
<tr>
<td>Conventional composite</td>
<td>1.5 – 2.5%</td>
</tr>
<tr>
<td>Organic composite</td>
<td>2.5 – 3.5%</td>
</tr>
<tr>
<td>Microfilled composite</td>
<td>1.3 – 1.5</td>
</tr>
<tr>
<td>Hybrid composite</td>
<td>2.2 – 2.5</td>
</tr>
</tbody>
</table>

Adhesion- Attraction of the molecules of two different substances to each other, when they are brought in close contact
- Lack of adhesion ---microleakage
- Influenced by-
  - Wetting capabilities
  - Surface energy
  - Contact angle
  - Smear layer
  - Difference in composition of E and D

Role of Smear Layer in Microleakage
- “Natural deposits composed of microcrystalline cutting debris embedded within the denatured collagen .”
- Subsequent to instrumentation of the tooth, on the cut surface.
- Smear layer + Smear plug = 1 unit
- 2 schools of thought
  - Intact                    Remove
    (barrier)                  (porus-25- 30%)
    (Pashley-86%)        (less leakage as material adapt well)
  - Acid labile (destroyed)
  - Plaque
  - Proteolytic enzymes
  - Acid etching
  - Recently suggested to replace it with Sterile, inert and nontoxic synthetic smear layer.
  - Weak acids are used

Factors Controlling The Bacterial Penetration at tooth Restoration Gaps
1) Size and Nature of Gap
   - Size- Range (10-50 µm)
   - Nature- Self sealing ability of restorative material (deposition of mineral salts of low solubility in the space, accumulation of corrosion products, calcification of the plaque like debris around the margins and etc.)

2) Host defence
   - Sclerosis of Dentinal tubules
   - Reparative Dentine
   - The hydrostatic pressure of the pulp is higher compared to the outside pressure of the oral cavity. This pressure difference moves the dentinal fluid outwards which opposes the bacteria and their products moving inwards, though only to a negligible extent.
   - Some plasma proteins in the dentinal fluid may act as antibacterial substances and large molecular weight proteins like fibrinogen make dentin less permeable to bacteria.

3) Restorations
   - GIC, Composites, Compomers etc. release fluorides in gaps
Microleakage Around Amalgam Restorations

- When freshly mixed does not adapt to tooth leading to gap of 10-15µm around restoration.
- With time has property of **Self Sealing** by accumulating and forming corrosion products reducing microleakage. (Low Cu alloys)
- High Cu alloys confer greater resistance to corrosion- microleakage continue for longer time.
- Microleakage because of dimensional changes in Amalgam is minimal(.2%)
- Accepted dimensional change is 20µm for Amalgam (ADA Specif. No. 1)

The change in dimensions of the gap because of thermal changes is moderate

Prevention of Microleakage

1) **Use of Lathecut or admixed alloys instead of Spherical alloys.**
2) **Condensation**
   - Immediately after trituration
   - Small increments
   - Adequate pressure to adapt material to tooth
   - Centre to periphery
3) **Burnishing**
   - Enhance adaptability and homogeneity
   - Lathecut or admixed alloys better burnished
4) **Alloys with lesser creep values decrease leakage**
   - Acceptable rate is 3%
   - Low copper - .8-.8% (high)
   - High copper - .1-.1% should be used
5) **Sealing the cavity wall with varnish**
   - Prevents initial microleakage but does not offer benefit for longer period of time
   - Life is from 6 months to 1 year by that time corrosion products form.
   - Not useful under High Cu Amalgam Restorations.
6) **Sealed Amalgam Restoration**
   - Coating of Unfilled resin is placed over the restoration margins and the adjacent enamel after having etched.
   - Though it wears away but prevents initial microleakage.
7) **Bonded Amalgam**
   - Recent advancement – quite effective (All bond 2, Amalgambond, Scotchbond multipurpose plus)
   - Bond strength increases from 3-5 Mpa to 10-14 Mpa
8) **Gallium Alloys**
   - High wetting ability less microleakage

Microleakage around Glass Ionomer Cement

- Adheres to tooth structure by forming chemical bond b/w carboxyl gp of cement and Ca ions of tooth.
- Properties decreasing microleakage :
  - CTE similar
  - Fluoride releasing
  - Renew broken ionic bonds
  - Highly technique sensitive
  - First 30 min crucial to prevent microleakage
  - On exposure to water, the matrix forming ions are easily leached out during the initial set which could interfere at tooth restoration interface.
  - Excessive dehydration /dessication can result in chalky,cracked or crazed surface which if extends to margin result in microleakage.
  - Use of sharp instruments before the mat. sets, hampers marginal intergerity.
Prevention of microleakage
1) Proper manipulation and its placement after cleaning tooth surface
2) Use of rotary instruments over manual cutting for finishing margins.
3) Coating of Varnish or petroleum jelly should be applied to protect rest. From moisture contamination
4) Prior conditioning of tooth surface with weak acids.
5) Resin modified GIC (rapid initial setting) but show more leakage as shrink during polymerization as compared to chemically cured ones.

Microleakage around Composite Restoration
- Does not bond to tooth structure on its own.
- Development of internal stresses from polymerization shrinkage and thermal changes also has detrimental effect on bond leading to gap formation and microleakage.
- Acid etching, priming/conditioning and the use of enamel and dentin bonding agents necessary.
- Enamel – Better bonding if sufficient enamel thickness is present.
- Dentin – weaker bonding (vitality of the dentin, difference in physical and chemical composition of dentin compared to enamel, presence of dentinal fluid, smear layer and etc.)
- Other Reasons :
  1) Technique sensitive
  2) Polymerization shrinkage (range is 1.67-5.68%,)
     Tensile and/or shear stresses (interface.)
     (limits) (exceed)
     withstand separation at interface
     - bond with dentin (compromised)
     - bond with enamel (strong)
     - on root surface (V shape gap formation)
  3) Functional stresses by cyclic mastication (repeated plastic or elastic deformation of the restoration)
  4) Marked difference in CTE (22-55x10^-6 /° C)
  5) Absorb water from environment, causing restoration to expand but impairs its properties(high filler content – low water sorption)
  6) Incidences of marginal gaps are higher on the cervical margins of Class II restorations because:
     a) Placement difficult
     b) Air entrapment during placement
     c) Difficulty in condensation because of pull back of mat.
     d) Inadequate bonding to the gingival wall due to polymerization shrinkage.

Measures to reduce microleakage
1) Choice of material :
   - Microfilled composites (.01-.04µm) because
     a) Greater flexibility of mat. during poly. Shrinkage decreases contraction forces (Class V restorations)
     b) Larger water sorption capacity resulting in expansion to some extent.
  2) Cavity Design:
     - Placement of bevels, reduced depth and rounded internal angles
     - Bevels increase surface area for bonding thereby reducing microleakage.
     - Occlusal beveling(x)–load bearing areas
     - Bevel Cervical margins in class II (x)--- removal of enamel
       Facial and lingual margins of the proximal box(√)
     - Beveling gingival margin of class V preparations is not advocated as it usually increases microleakage (Owens et al, 1998).
  3) Acid etching and Bonding
    Purpose
    - Traditionally discouraged because etchants were thought to open and widen the dentinal tubules resulting in increased permeability and bacterial ingress to the underlying pulp.
    - Concept has now changed (hydrophilic resins). Many author now propose deliberate etching of dentin to create open tubules and a porous intertubular layer.(close adhesion)