PRINCIPLES OF ADHESION

DR ZURYATI AB GHANI

BDS (WALES), Grad Dip Clin Dent (Adelaide), Doctor in Clinical Dentistry (Prosthodontics), Adelaide, FRACDS (Australia).

22.10.07
Lecture Content

PRINCIPLES OF ADHESION
- Types of adhesion
- Development of adhesion in dentistry
- Advantages of adhesive in dentistry

ADHESION TO ENAMEL AND DENTINE
- Adhesion to enamel
- Adhesion to dentine
Adhesion

- Adhesion / bonding - The joining together of two objects using glue or cement.
- All dental materials must function in a wet, hostile environment.
- The oral environment limit the types of adhesives used in dentistry.
ADHEREND
Enamel, dentine, Alloy, ceramic

ADHESIVE
Adhesive resin, Silane primer, tin plating

ADHERENT
Resin Composite, Ceramic, Acrylic

Dr T. Berekally
Types of adhesion/bonding

- **Macro-mechanical**: The glue or cement flows into surface irregularities. The set cement is locked into the surface irregularities of the objects being joined.

- **Micro-mechanical**: The glue or cement flows into surface irregularities. The set cement is locked into the surface irregularities of the objects being joined.

- **Interfacial/Chemical Adhesion**

- **True adhesion**
Macro-mechanical

- Bonding using surface irregularities where surface roughness can be seen or felt.
- Screws, nuts, bolts, glues join two pieces of woods.
- In dentistry- cementation of crown or bridges to teeth with ‘non adhesive cement’
- Disadvantage- stress is concentrated in the vicinity of the fastener.
Macro-Mechanical Adhesion

- Visible interlocking between dissimilar materials
- Acrylic facings on alloy subframes for bridges
- Removable partial dentures
- Overlay dentures
- Implant-supported prostheses

Dr T. Berekally
Micro-mechanical adhesion

- Bonding using surface irregularities smaller than can be seen with naked eye or felt with the dental explorer.
- Increased number of surface irregularities are used thus forces are distributed evenly.
- Stronger than macro-mechanical adhesion.
Micromechanical Adhesion

- Microscopic mechanical interlocking between dissimilar materials
- Resin composite
- Amalgam bonding
- Resin-bonded ceramics

Dr T. Berekally
Surface Coatings Enhancing Adhesion

- Sandblasting with alumina oxide (Micro-Etcher Danville Engineering)
- Silica oxide coating (Silicoater: Kulzer; Rocatec® ESPE)
- Porous metal coatings (INZOMA P990)
- Tin plating (Kura Ace, EX Oxisor, Micro Tin*)
Surface Preparation of Indirect Resins for Cementation: Rocatec®

Dr T. Berekally

Al₂O₃

High temperature fuses SiO₂ to resin surface
Interfacial/Chemical Adhesion

- ENAMEL
- CERAMIC
- Silane layer
- Resin Cement

Berekally
True/chemical adhesion

- Involves chemical bonds between the materials being joined
- Bonding of GIC to tooth structure
Advantages of adhesive in dentistry

- Retention of restoration
  No need to use undercut or mechanical lock
- Conservation of tooth structure
- Reduction in microleakage- ↓post operative sensitivity, ↓stain
- Reduction in recurrent caries
- Reinforcement of tooth structure
- Repair of restorations
Development of adhesive materials

- 1950’s Michael Buonocore introduced acid etching to create micromechanical retention for pit and fissure sealants
- 1960’s composite restoration was developed
- 1970’s-1980’s- many other composite materials developed with acid etching technique:
  - ortho brackets
  - Etch the metal part of bridge and bond it to tooth.
  - Plastic/composite/porcelain veneers bonded to labial tooth surface of tooth to hide discolouration/ close space
  - Periodontal splint

ACID ETCHING COMPOSITE IS ‘GOLD STANDARD’ OF ADHESIVE DENTISTRY.
Chemical adhesion

- 1970’s- Polycarboxylate cement was introduced
- GIC introduced by Wilson, Cusp and McLean
- BUT- lack aesthetic and mechanical toughness of compared to composite
Factors affecting bonding to tooth structure

- **Surface factors**
  - Clean surface
  - Compatible surface for increased surface wetting

- **Biofilms**
  - Enamel pellicle decreased bonding
  - The need to use rubber dam
B = Material has superior wetting, a desirable property
Adhesive Failure

ADHEREND

ADHERENT

Adhesive Resin

Berekally
Resin Fracture in Maryland Bridge Pontic

OR = Opaquer Resin
RB = Metal Beads for resin retention

Berekally
Cohesive Failure

Failure within material

Failure in adhesive layer

Berekally
ADHESION TO ENAMEL AND DENTINE
Enamel Composition

- 95-98% by weight inorganic component (hydroxyapatite)
- Crystalline structure is fairly constant at different levels
- Minor organic components
- Water (very low percentage)
Adhesion to Enamel

- Etching of enamel with 37% orthophosphoric acid for 15-30 secs produce micropores.
- 30 – 40% phosphoric acid removes about 10mm of the enamel surface
- A low viscosity liquid polymer (bonding resin) applied and flows into microscopic irregularities and set, producing RESIN TAGS
- Then layers of restorative materials bond to this bonding resin
- Bond strength → 20-25 mPa
- Simple and strong adhesion
- Initially used in fissure sealant
Enamel: Etching Pattern

Type 1

Type 2

Type 3

Summit et al, 2001
Factors Influencing Type of Etched Surface

- Type of etchant (organic/ inorganic acid)
- Etchant concentration
- Etching time
- Gel versus liquid etchant
- Enamel instrumentation after etching
- Tooth type (deciduous/ adult)
- Prismless enamel
- Presence of contaminants
- Status of the enamel (fluorosis, hypoplasia, staining, amelogenesis imperfecta)
Adhesion to Dentine

- A typical cavity preparation has more dentine available for bonding than enamel

<table>
<thead>
<tr>
<th>Dentine content</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic</td>
<td>72%</td>
</tr>
<tr>
<td>Organic</td>
<td>18%</td>
</tr>
<tr>
<td>Water</td>
<td>10%</td>
</tr>
</tbody>
</table>
Problems in Dentine Bonding

- Dentine structure is more complex and variable than enamel
- Odontoblastic processes are mostly water
- $1^\circ, 2^\circ$, reparative, sclerotic dentine and dead tracts
- Smear layer-extend to dentinal tubules
Dentine Tubule Distribution

- Reparative Dentine
- Erosion
- Multizoned Carious Lesion
- Outer Occlusal dentine
- Inner Occlusal Dentine

Reactive Dentine (erosion, abrasion)
Physiologic Dentine (aging, wear)
Many Occluded Tubules

PULP
Dentine Bonding System

- Bond to both enamel and dentine
- Historically- enamel etched, washed, dried. Then dentine conditioned with chelating agent or EDTA to remove smear layer. Primer applied, followed by adhesive, then composite.
- Now- 3 steps, 2 steps or 1 step
3 Steps Dentine Bonding

1. **Etch enamel and dentine** with 37% orthophosphoric acid.

   (Etched dentine- smear layer removed, surface disinfected, decrease fluid oozing from odontoblast, decalcify dentine a few micron thick)

   - Rinse with water
   - Slightly dry with gentle air stream or blot dry
2. Apply primer,

- Primer is a wetting agent that aids adhesive in flowing into dentinal tubules around collagen.
- Contains volatile solvents such as acetone.
- Hydrophilic

3. Apply adhesive, light cure.

Place composite
Hybrid Layer in Dentine Bonding

- Adhesive
- Hybrid layer
- Lateral canal
- Intertubular dentine
- Peritubular dentine
- Resin tag

Summit et al, 2001
Dentine Bonding

- Resin tags in dentinal tubules- Micromechanical
- Hybrid layer
  - Adhesive resin interlocks with the dentinal collagen (micromechanical)
  - There are a small number of amino acids which are available for chemical reactions (eg; dicarboxylic acids, arginine, lysine)
  - Attempts to measure the chemical bond strengths have been up to now been unsuccessful
2 steps

i) – Etch (smear layer removed)
   - Primer + Adhesive

ii) - Etching primer (smear layer altered)
    - Adhesive

1 step

Etch, primer, adhesive in one bottle
Smear layer altered
Smear layer

• A layer of dentine, enamel shavings, organic matter, bacteria, blood products crevicular fluid and saliva which is formed during cavity preparation

• Bond strength to tooth structure ~ 2-3 MPa
• Can be altered or removed because it is not a very stable adhesion interface
Dry vs wet bonding

Dry

Wet

Summit et al, 2001
Summary

- There are macromechanical, micromechanical, and chemical adhesion/bonding.
- Adhesion used in all aspects of dentistry—retention of restoration, fixed and removable prosthetics, orthodontics and aesthetic dentistry.
- Bonding to enamel is simple, but not dentine.
- Therefore dentine bonding system was introduced. The system either by removing or altering smear layer.
REFERENCES