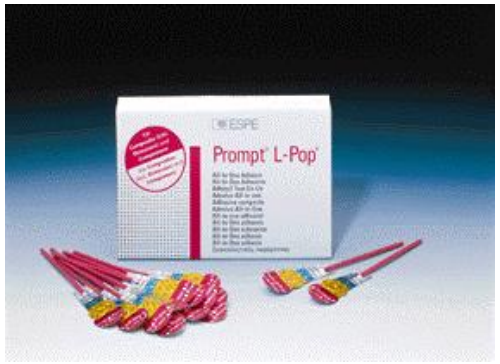
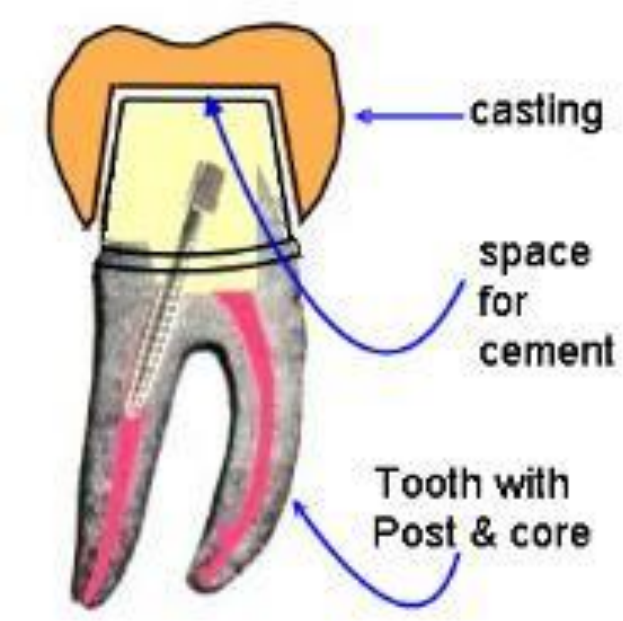



# ADHESION IN RESTORATIVE DENTISTRY

# ADHESION

- **<u>Definition</u>**
  - Adhesion is the bonding of dissimilar materials by the attraction of atoms or molecules.



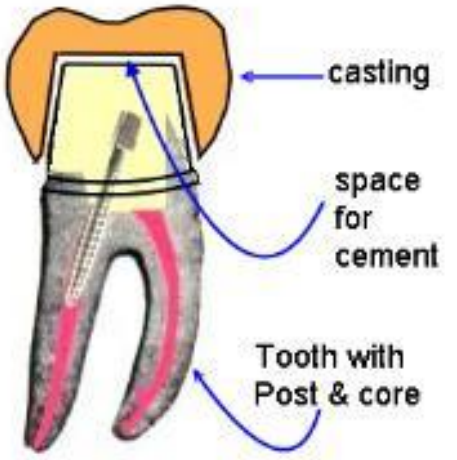
# Introduction

- Every dental restoration requires retention by some system of connection or attachment.
- The scientific beginnings of dental adhesion originated in the early 1950s with studies of bonding to enamel and dentin.
- Now the bonding agents are used routinely in restorative and preventive dentistry.

# INDICATIONS AND ADVANTAGES OF ADHESION

# Indications for Adhesion

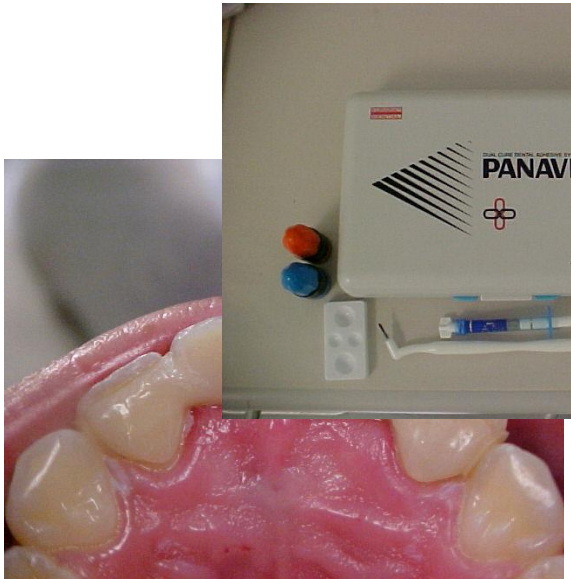
- Direct resin composite restorations
  - caries, fractures, reshaping, masking
- Bond all-ceramic restorations
  - veneers, inlays, onlays, crowns
- Bond amalgam
- Resin-retained fixed-partial dentures
- Pit and fissure sealants
- Orthodontic brackets
- Treat dentinal hypersensitivity
- Core build-ups
- Repair fractured porcelain and composite

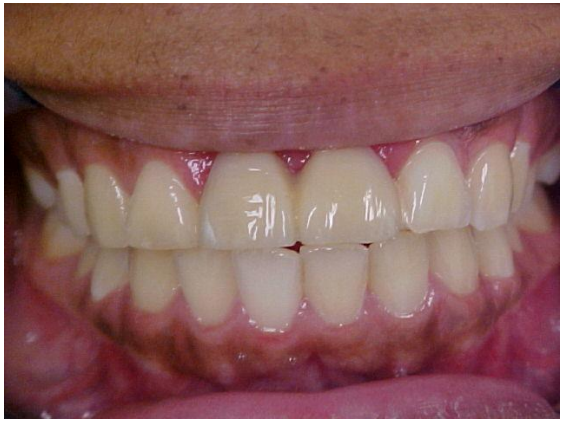


# Bonding Direct Restorations

# Bond Indirect Restorations

# Bond resin retained fixed partial dentures



# Advantages Of Adhesion

- Help offset polymerization shrinkage
  - reduce marginal leakage
    - staining
    - sensitivity
    - caries
- Adhesion
  - conservation of tooth structure
  - internal splinting
- Esthetic restorations

# MECHANISM OF ADHESION

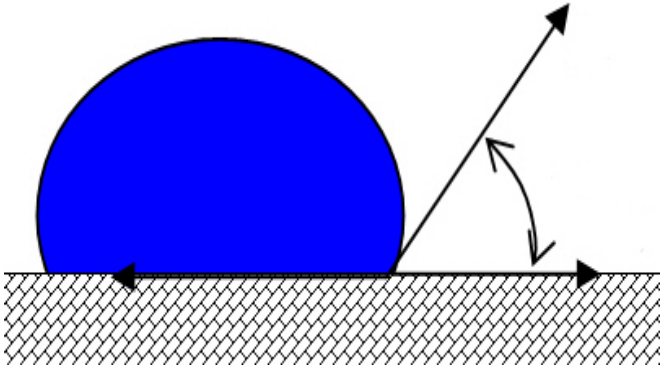
# Mechanisms of adhesion

- ***Two mechanisms***
- **Chemical adhesion**
  - Involves bonding at the atomic or molecular level (replacement of minerals from hard tissue by resin monomers)

- **Mechanical adhesion**
  - is based on retention by the interlocking or the penetration of one phase into the surface of the other (retentive interlocking).
  - micromechanically interlocked
- In many cases chemical and mechanical adhesion occur together

# Requirements For Optimal Adhesive Bonding

- Clean surface of the substrate
- Good wetting of the substrate by adhesive, have a low contact angle, and spread onto the surface
- Adaptation to the substrate produces intimate approximation of the materials without entrapped air or other intervening materials
- The interface include the sufficient physical, chemical and /or mechanical strength to resist intraoral forces of debonding; and
- Good curing of the adhesive as recommended for use.



# Bonding agents

# COMPOSITION OF BONDING AGENTS

# Composition of Bonding Agents

- Etchants
- Primers
- Adhesives
- Initiators and accelerators
- Fillers.
- Other ingredients
  - fluoride or antimicrobial ingredients
  - glutaraldehyde as a desensitizer

# Composition contd

- ***Etchants***
  - Most commonly used are the phosphoric acid solutions and gels(37%, 35%, 10%) are the most reliable etchants used. These are also called conditioners because they are relatively strong acids (pH = 1.0).
- ***Primers***
  - Primers are hydrophilic monomers usually carried in a solvent. Acidic primers containing carboxylic acid groups are used in self etching bonding agents. The solvents used in primers are acetone, ethanol-water; or primarily water.
- ***Adhesives***
  - Adhesives are generally hydrophobic, dimethacrylate oligomers that are compatible with monomers used in the primer and composite.

# Composition contd

- ***Initiators and accelerators***
  - Light cured bonding agents contain an activator – camphoroquinone and an organic amine. Dual cured bonding agents include a catalyst to promote self-curing
- ***Fillers***
  - Most bonding agents are unfilled, but some contain inorganic filler ranging from 0.5% to 40% by weight.
- ***Other ingredients***
  - Bonding agents may contain fluoride or antimicrobial ingredients
  - glutaraldehyde as a desensitizer

# BONDING TO ENAMEL AND DENTINE

# Variations in Tooth Structure

- Enamel
  - more predictable bonding
    - more homogeneous structure
    - higher inorganic content
    - higher surface energy
- Dentin
  - less predictable bonding
    - higher variability
    - higher organic content

# Enamel Bonding

- Developed by Buonocore-1955
- Etching
  - various acids
    - traditionally phosphoric acid


  - creates micropores (acidic solution will dissolve (etch) away some of enamel mineral content. The net result of this etching process is that at a microscopic level the surface of the tooth enamel will have become very roughened).
    - 5 – 50 microns deep
  - increases surface energy
  - increases wettability

# Enamel Bonding Process

- Untreated enamel surface is either smooth (not retentive) or covered by plaque
- Steps for bonding enamel
  - ***Roughen the enamel surfaces-*** to expose prism rods in a perpendicular, longitudinal, or tangential way.
  - ***Condition*** the enamel surface

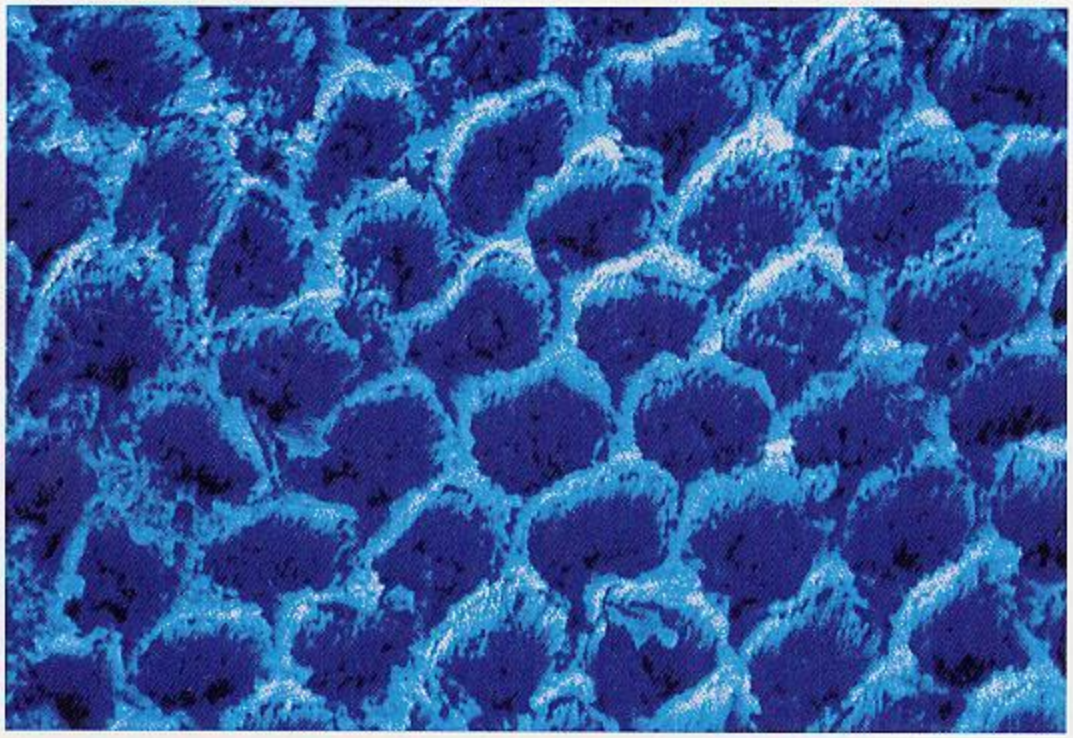
***Apply ecthant:*** Application of 30% to 40% phosphoric acid removes about 10 μm of the superficial enamel, resulting in a rough surface with partly dissolved enamel rods down to a depth of 10 to 20 μm for 30 -60s

  - ***Remove ecthant*** using water, the blow/blot dry the enamel surface
  - ***Apply bonding agent***
  - ***Blow off the excess bonding agent***
  - ***Cure***

# Etched enamel surface

- Acid etching of enamel results in a rough and enlarged surface with high surface energy.
- Such a surface promotes wettability and improved micromechanical retention and meets the requirements for effective adhesion
- However, the high energy of the acid-etched enamel is also attractive to other liquids like water, saliva, blood, or sulcus fluid.
- Contact of any liquid to the conditioned enamel will decrease the surface energy, resulting in a reduced wettability of the hydrophobic adhesive.
- Therefore, isolation by rubber dam is preferred over isolation with cotton rolls.

# Etched enamel



Etching pattern of enamel after treatment with 37% phosphoric acid for 60 seconds (SEM 4,000x).

# Enamel Bonding

- Low-viscosity monomers
  - examples
    - Bis-GMA
    - UDMA
    - TEGDMA
    - HEMA
- Predictably high bond strengths
  - > 20 MPa

# Conditioner

- Chemical alteration of surface
  - acids
    - phosphoric, citric, maleic, nitric


- Removes dentinal smear layer
    - exposes collagen fibrils
- Simultaneous enamel etch
- Rinse
  - keep moist

# Primer

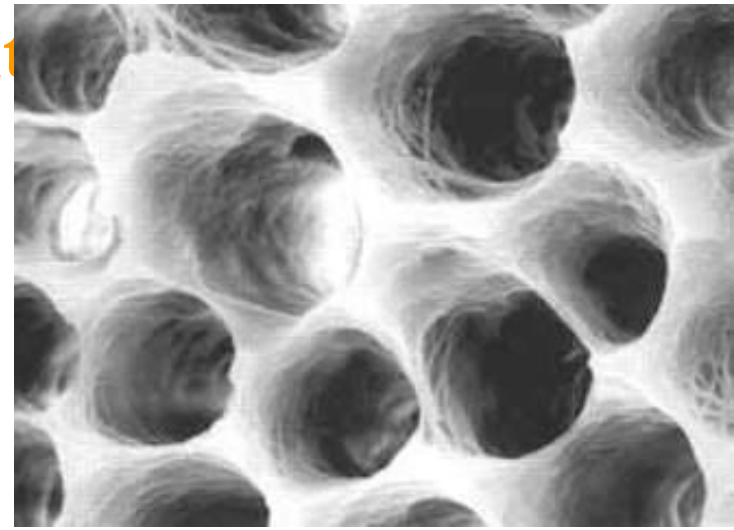
- Hydrophilic monomers
  - dissolved in acetone, alcohol, or water
- Displaces water
- Promotes infiltration into collagen
- Lightly air dry
  - drive off solvents, water
- Transforms hydrophilic to hydrophobic

# Bonding to dentine

# Dentine Structure

## Problems In Bonding To Dent

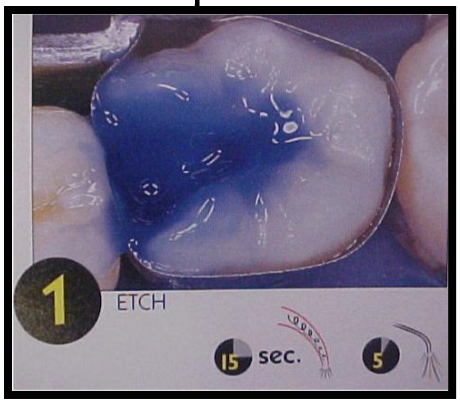
- Dentine composition
- Dentinal tubules
- Changes in dentin structure
- Smear layer
- Dentinal wetness.



# Features of clinically successful Dentine Bonding- 5 steps

## STEP 1

Cavity margins placed in enamel wherever possible ; use of a bevel is preferred when clinically appropriate; acid conditioning must be adequate - a minimum of **15 to 30s**



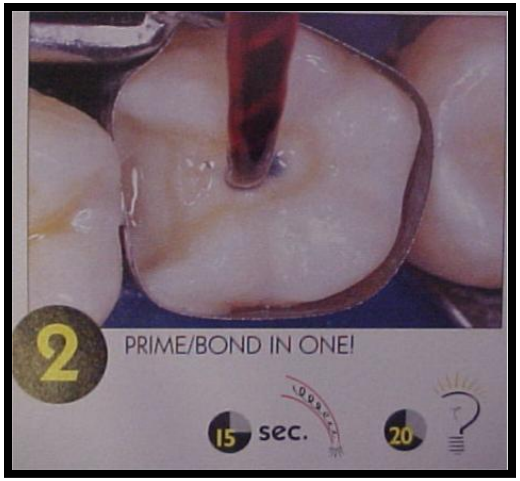

## STEP 2

Dentine conditioning should be brief - a maximum of **15s-** to remove the smear layer

- **STEP 3**

Conditioned dentine should be kept **moist as the enamel is being dried by placing a moist cotton pellet**

- **STEP 4**: Apply primer-Multiple primer coats will ensure optimal dentinal priming

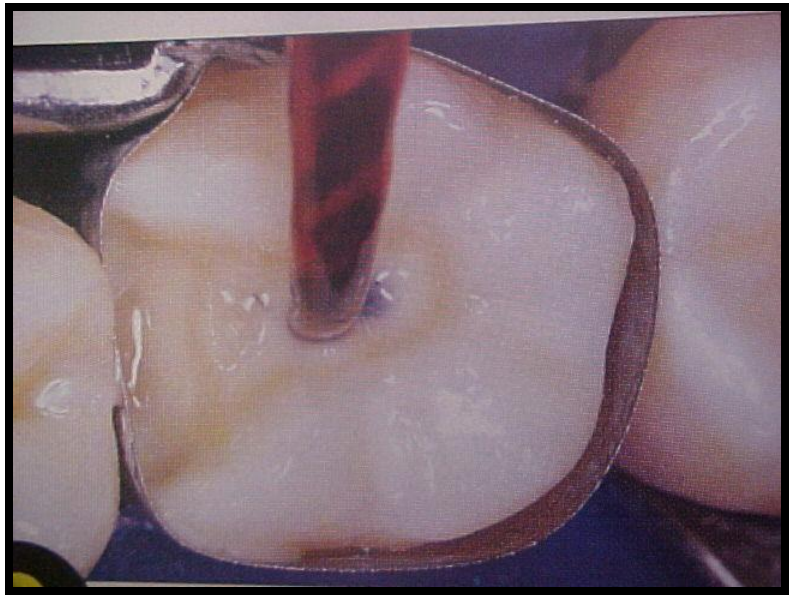


- **STEP 4**

Adhesive bonding resin provides a valuable elastic intermediate layer for stress absorption: it should be uniform and **not air thinned**

- **STEP 5**

Insertion of resin composite in **diagonal increments** will reduce stresses of **polymerization shrinkage** at the bonded interface: each increment should be thoroughly cured



# CLASSIFICATION OF DENTIN BONDING AGENTS

# DENTINE BONDING SYSTEMS

- CONDITIONER/ ETCHANT
- PRIMER
- ADHESIVE

# Enamel and dentin bonding agents

- Development
  - seven generations
  - Chronologic order
- First Generation ⟶ Seventh generation

# First Generation
## (1950-1970's)


- Hydrophobic monomers
- Very low bond strengths
  - 2 to 3 MPa
- First commercial dentinal adhesive
    - *Cervident* - SS White (1965)
      - claimed chemical bond to calcium
  - retention only 50% at 6 months
    - Class 5

# Second Generation
## (late 70's to mid 80's)

- Early 1970s - introduced acid-etching of enamel; and enamel bonding agents of self cured nature
- Phosphorous-ester monomers
  - enhanced surface wetting
  - claimed chemical bond to calcium
  - smear layer predominately intact
    - fear of etching dentin
- Low bond strengths
  - 5 to 6 MPa
- Retention 70% at 1 year
  - Class 5

# Third Generation
## (mid-80's)

- Developed hydrophobic enamel bonding agents. hydrophilic dentin bonding agents, and light cured components
- Mechanism of action
  - mildly acidic hydrophilic monomer
  - modified/altered smear layer
- Moderate bond strengths
- Improved short / long term success

# Fourth Generation

(early 1990's)


- Mid to late 1980s developed for removal of dentin smear layer; acidic monomers and acidic pretreatments; reduction of steps in bonding technique; multiuse bonding agents
- Multi-step
  - condition dentin
    - remove smear layer
  - primer
  - adhesive
- High bond strengths
  - Retention 98 to 100 % at 3 yrs
    - Class 5

# Fifth Generation

(late 1990's)

- Early 1990s developed etching to achieve hybrid layer in dentin; hydrophilic agents for both enamel and dentin; bonding to moist tooth structure; single-bottle primer-adhesive
- Attempt to simplify by reducing the number of bottles
    - combined primer and adhesive
- High bond strengths

# Sixth Generation
## (late 1990's)


- Mid to late 1990s developed self-etching primers and primer-adhesive; light-and dual-cured options
- Combined conditioner and primer
  - moderate bond strengths
- Combined conditioner, primer and adhesive
  - lower bond strengths

# Seventh Generation

(most recent)


- In future hope that the development will take place to make low-shrinkage- self-adhesive restorative materials.
- "All-in-one" adhesives
  - combined conditioner, primer and adhesive
  - one-step
- No mixing
- Low bond strengths

# Currently Available Generations

- Fourth Generation - Three-step Etch & rinse
- Fifth Generation -Two-step Etch & rinse
- Sixth Generation
  - Two-step Self-etch
  - One-step Self-etch
  - mix
- Seventh Generation
  - One-step Self-etch
  - no mix

# Adhesive Categories

- Etch & Rinse
  - Three-Step
    - conditioner, primer, adhesive
  - Two-Step
    - conditioner, (primer & adhesive)
- Self-Etch
  - Two-Step
    - (conditioner & primer), adhesive
  - One-Step
    - (conditioner & primer & adhesive)
- Glass Ionomer
  - Two-Step
    - conditioner, resin-modified glass-ionomer mixture

# Etch & Rinse (Three-Step)

- Conditioner
- Primer
- Adhesive resin


- Examples
  - Scotchbond Multi-Purpose
  - Optibond FL

# Conclusions

- Trend toward simplified application
  - reduced number of steps
  - not necessarily better