



Adhesion to Enamel and Dentin

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Development of Dental Adhesives

1955

- Proposed dental application of adhesive technology

Mid
1960s

- Commercially available pit and fissure sealants and composite resins utilizing bonding

Late
1960s

- Proposed bonding of dentin

1980s

- Widespread acceptability of etch and rinse adhesives

1990s

- Acceptance of “hybrid layer” concept
- Availability of multi-step and single-step adhesives

Adhesion to Enamel and Dentin

1955 Buonocore

- Applied acid to teeth to be more receptive for adhesion.
- Led to major changes in dental practice.
- Traditional mechanical methods of retention replaced by-tooth-conserving adhesive methods.
- Expanded range of possibilities for esthetic restorative dentistry.

Adhesion to Enamel and Dentin

- The trend toward adhesive dentistry started in the mid-1960s with the first commercial restorative resin composites.
- Since then, there has been continuous progress in developing more refined and diversified restorative composites along with steady improvement in bonding agents.

Advantages of Adhesive Techniques

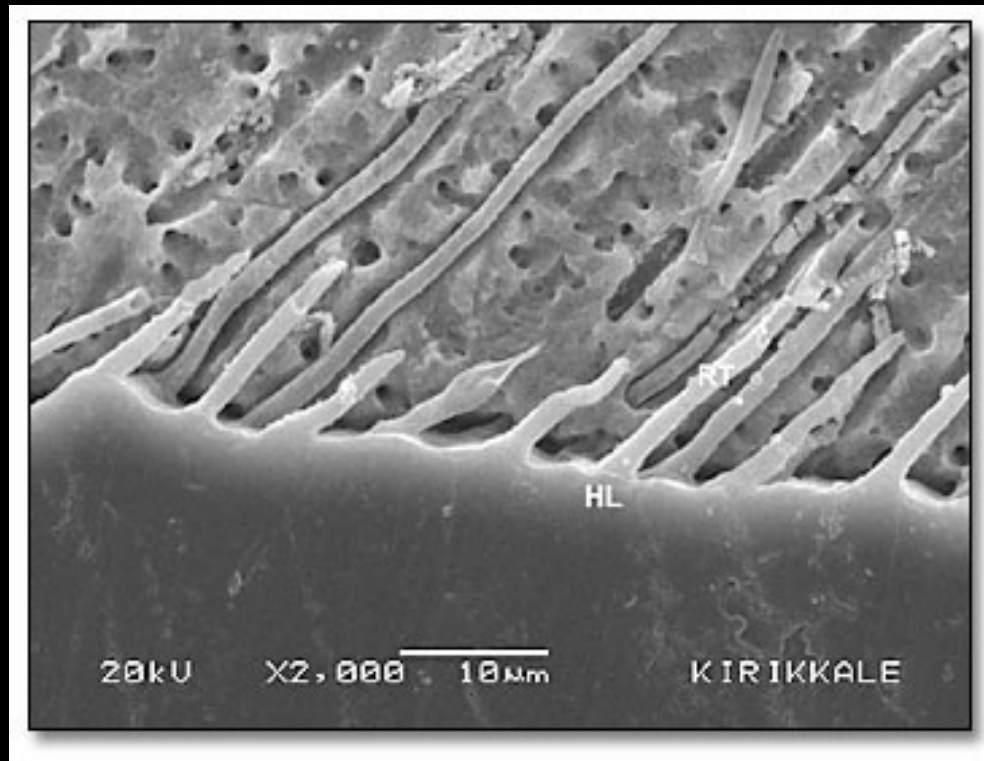
1. Conserves sound tooth structure
2. Reduces microleakage and clinical problems
 - Postoperative sensitivity
 - Marginal staining
 - 2° caries
3. Better transmits and distributes functional stresses across bonding interface.
4. Allows repair and replace restoration with minimal or no loss of tooth.

Indications for Adhesive Dentistry

1. Replace of carious and fractured tooth
2. Restore non-carious class V defects
3. Corrects unesthetic: shapes, positions, shades, or dimensions.
4. Restore post class I-II
5. Bond ceramic restorations; Veneers, inlays, onlays, and crowns
6. Bond silver amalgam
7. Bond orthodontic brackets
8. Treat dentinal hypersensitivity
9. Repair fractured amalgam, resin, and porcelain
10. Used with P&F sealants as part of preventive treatment
11. Used with core buildup foundations.

Ideal Bonding Agent

- High initial & permanent bond strength to E & D
- Biocompatible
- Low shrinkage
- Seal tooth surface & eliminate microleakage
- Prevent 2° caries & marginal staining
- Easy to use & minimally technique sensitive
- High shelf life
- Compatible with a wide range composite resins



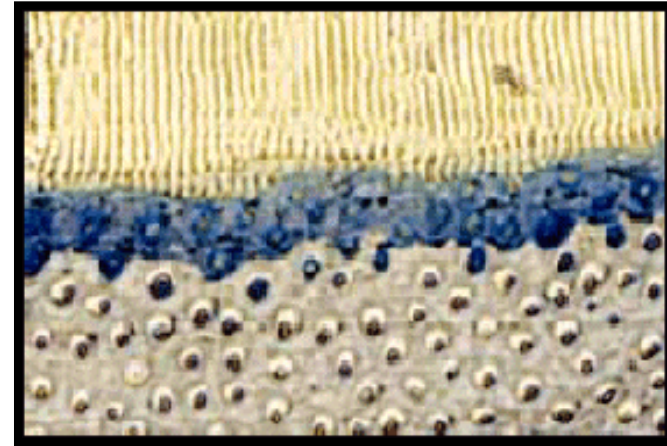
Adhesion to Enamel and Dentin

Fundamental Principles

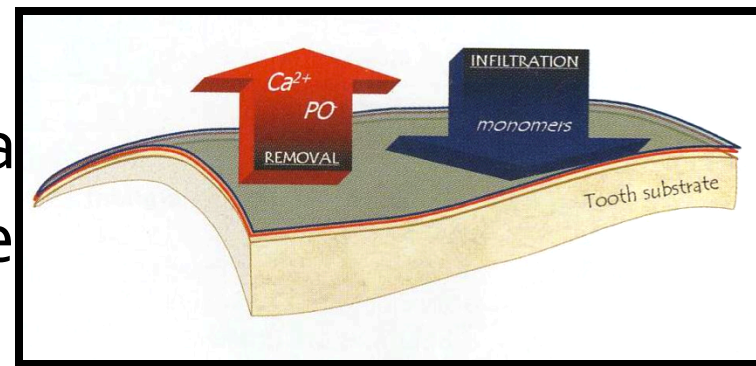
Fundamental Principles of Adhesion to tooth substrate:

This is done by 2 phases:

1. **Removal** of Calcium & phosphate, microporosities are exposed in both enamel and dentin.



2. **Hybridization** phase: infiltration and polymerization of resin in the microporosities.



Factors Affecting Adhesion to Dentin

1. Dentin composition
2. Dentin permeability
3. Changes in dentinal structure
4. Smear layer
5. Dentin wetness

1. Dentinal Composition

ENAMEL

- Inorganic HA 95-98% wt
- Water 4%
- Organic collagen 1-2%wt

DENTIN

- Inorganic HA 70%wt
- Water 12%
- Organic collagen 18%wt

Dentinal Tubules diameter size

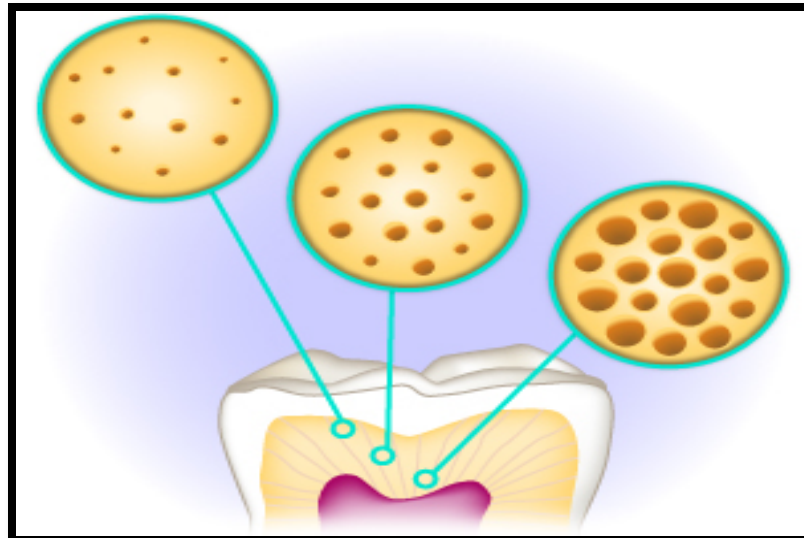
- 2.5 μm at pulp
- 0.8 μm at DEJ

Dentinal Tubules occupy

- 22% at pulp
- 1% near enamel

Dentinal Tubules Number/mm²

- 45,000?
- 20,000



2. Dentin Permeability?????

- Is the movement of material into or across dentin.
- Two types:
 - Transdentin: dentinal fluid moves across entire thickness
 - Intratubular : resin tag formation during bonding procedure
- Occlusal dentin permeability over pulp horn is more than at centre of occlusal surface
- Proximal D more permeable than occlusal D

3. Changes in Dentinal Structure

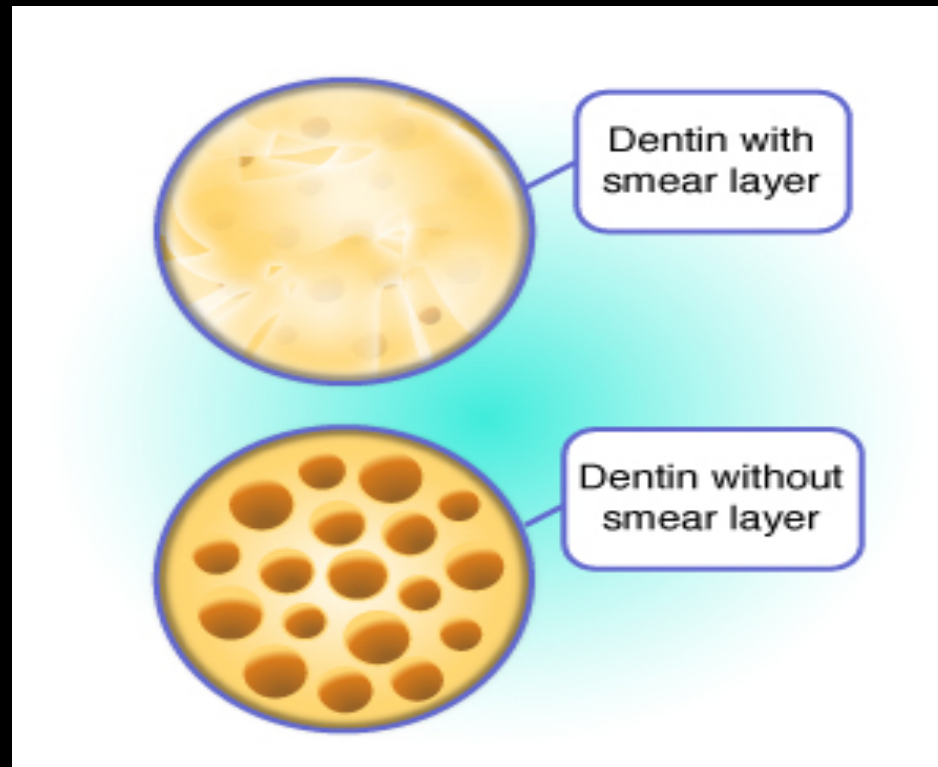
- Clinician should deal with:
 - a) Sclerotic dentin
 - b) Caries-affected dentin
 - c) Erosion-affected dentin
 - d) Abrasion-affected dentin
- All of these morphological and structural changes result in dentin that is less receptive to adhesive treatment than normal dentin.

a) Sclerotic Dentin

- Physiological: part of aging process
- Reactive : slow response to mild irritants, such as mechanical abrasion or chemical erosion
- Usually contains few patent DT and has low permeability
- Heavily sclerotic dentin difficult to be etched with acid needs more etching time.

b) Caries-Affected Dentin

- Hypermineralization
- Obstruction of DT caries crystal
- Apposition of 3 or reparative dentin in the pulp chamber at lesion site
- All these structural changes decrease dentinal permeability



4. Smear Layer

4. Smear Layer



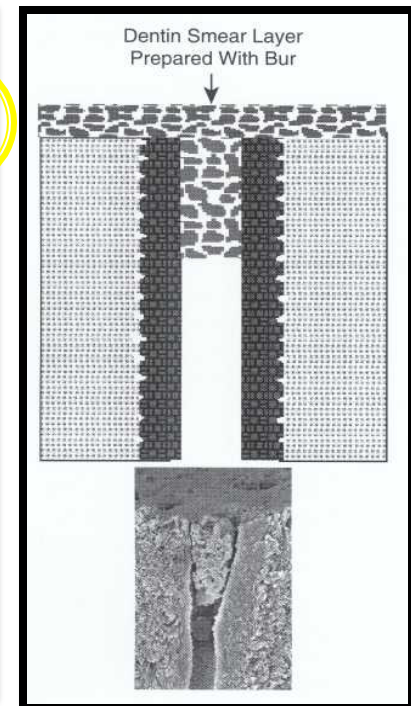
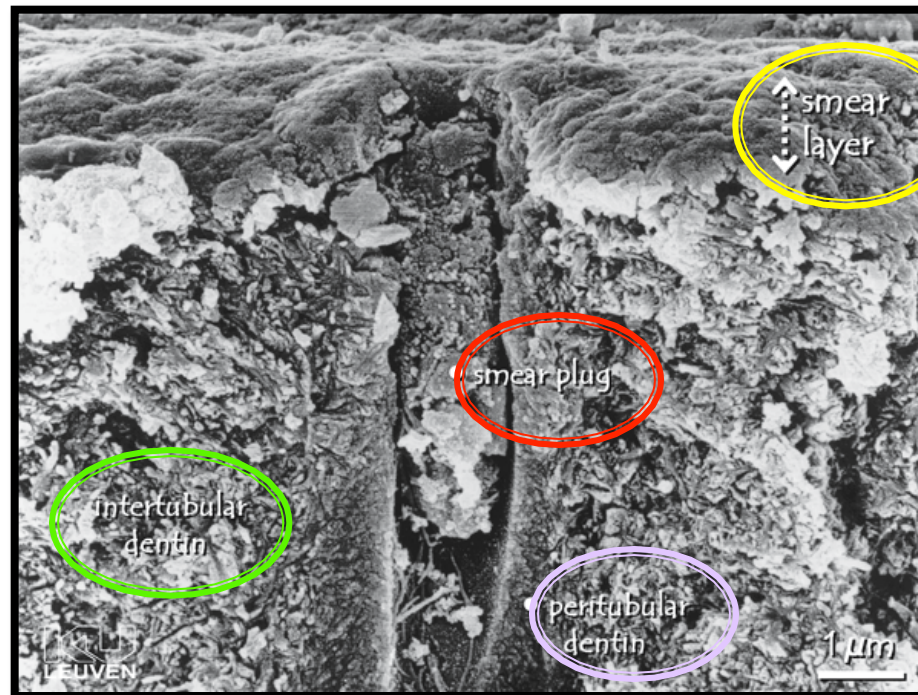
Whenever tooth structure is prepared with a bur or other instrument, residual organic and inorganic components form a “smear layer” of debris on E & D surfaces.

Composition of the smear layer is basically hydroxyapatite, altered denatured collagen, Saliva, bacteria and debris.

Thickness 0.5 to 5 μm .

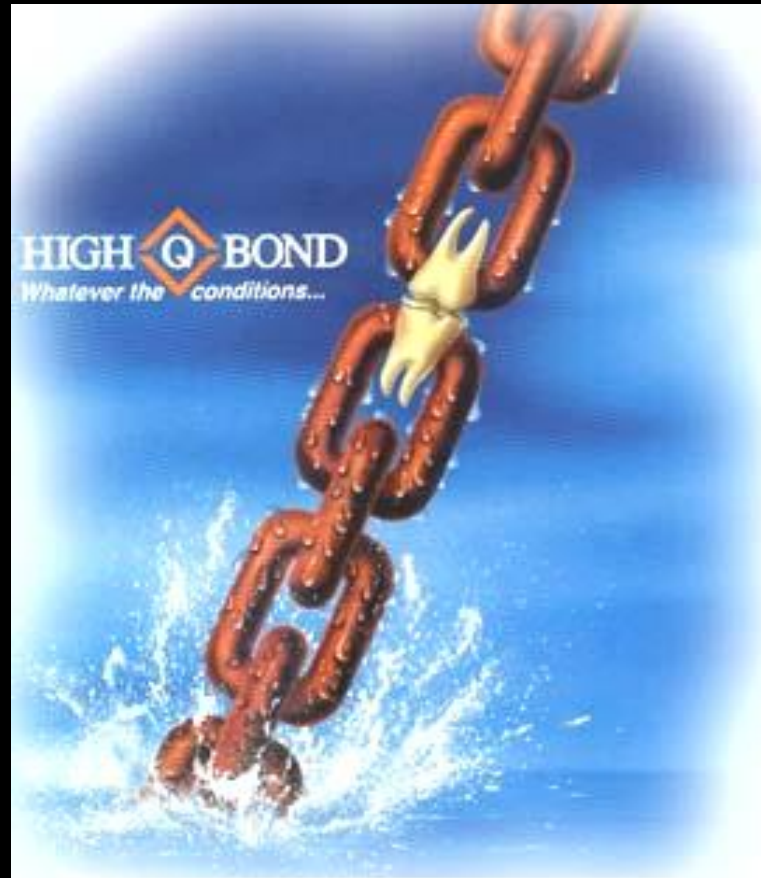
4. Smear Layer

- The smear layer fills the orifices of dentin tubules (forming **smear plugs**) and decreases dentin permeability by up to 86%
- Its a porous layer filled with dentinal fluids
- EDTA potent conditioner to remove SL and open DT



5. Dentin Wetness

- Water plays a very important role in dentin bonding:
 - dentinal fluid, oral humidity,
 - rinsing procedures, adhesive solution
- In the past water has been considered to be a contaminant which would interfere with resin bonding.
- **Early** dentin bonding agents were highly **hydrophobic**.
- Since water-free bonding procedure was impossible to achieve, dentin bonding agents were modified to be more **hydrophilic**.
- This resulted in higher bond strength to dentin.

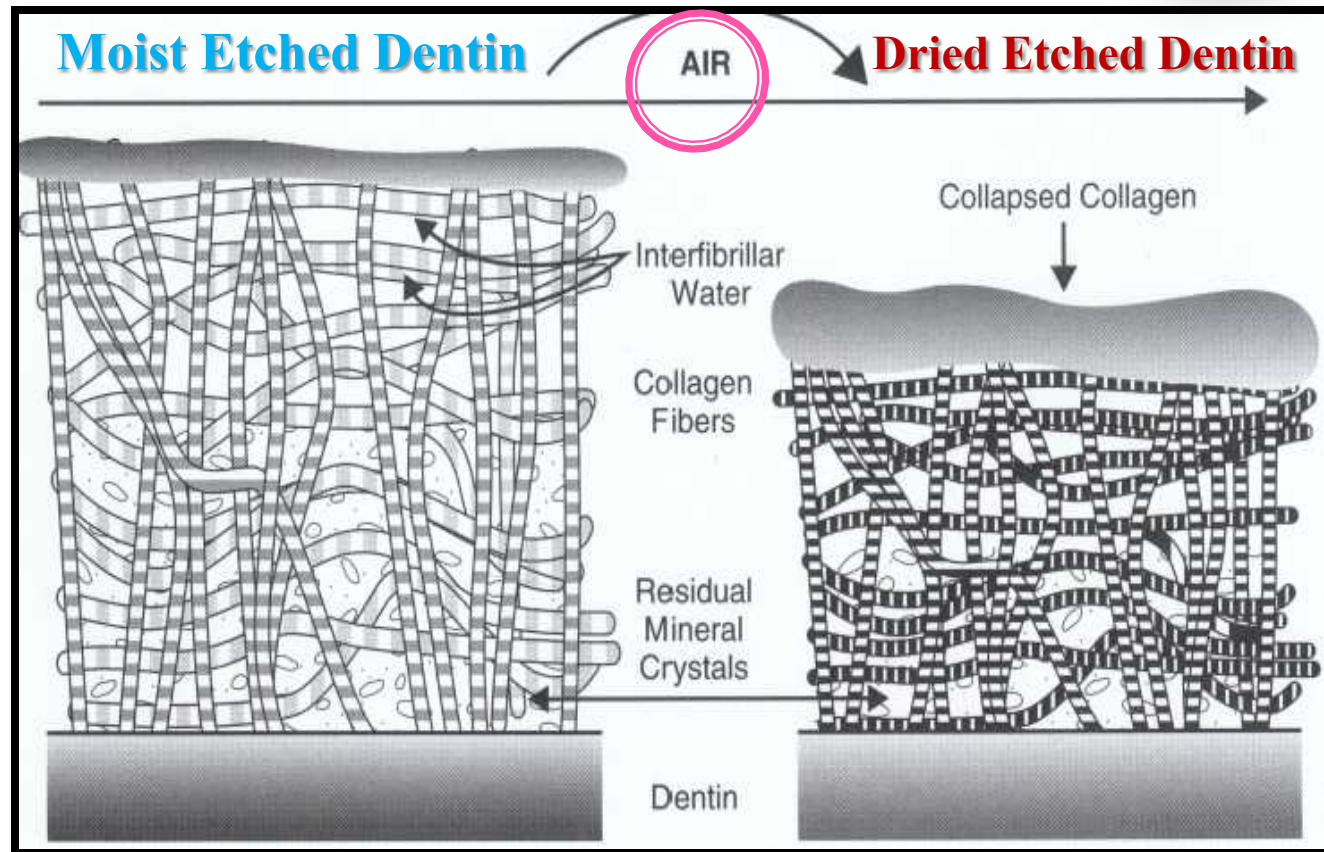


Dry vs. Wet Bonding

Dry vs. Wet Bonding

- “Surface moisture” is an important factor in optimal bonding
- On Enamel: dry condition is preferred.
- On Dentin: certain amount of moisture is needed to avoid collapse of the exposed collagen which leads to effective penetration of adhesive monomers
- It is DIFFICULT to achieve optimum conditions clinically for both E & D

Dry Bonding

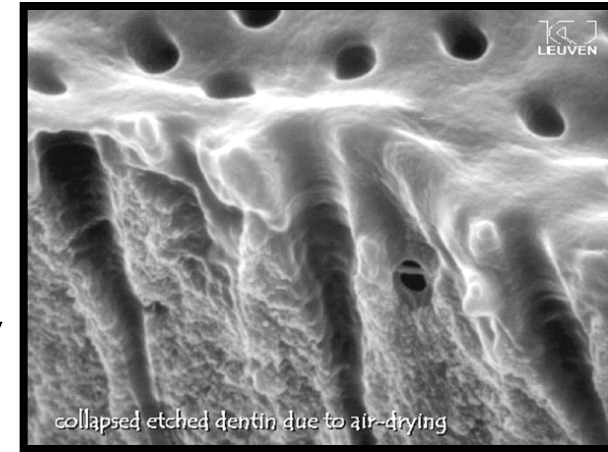


Collapse Of Etched Dentin By Air-drying

Dry Vs Wet Bonding

Two Ways:

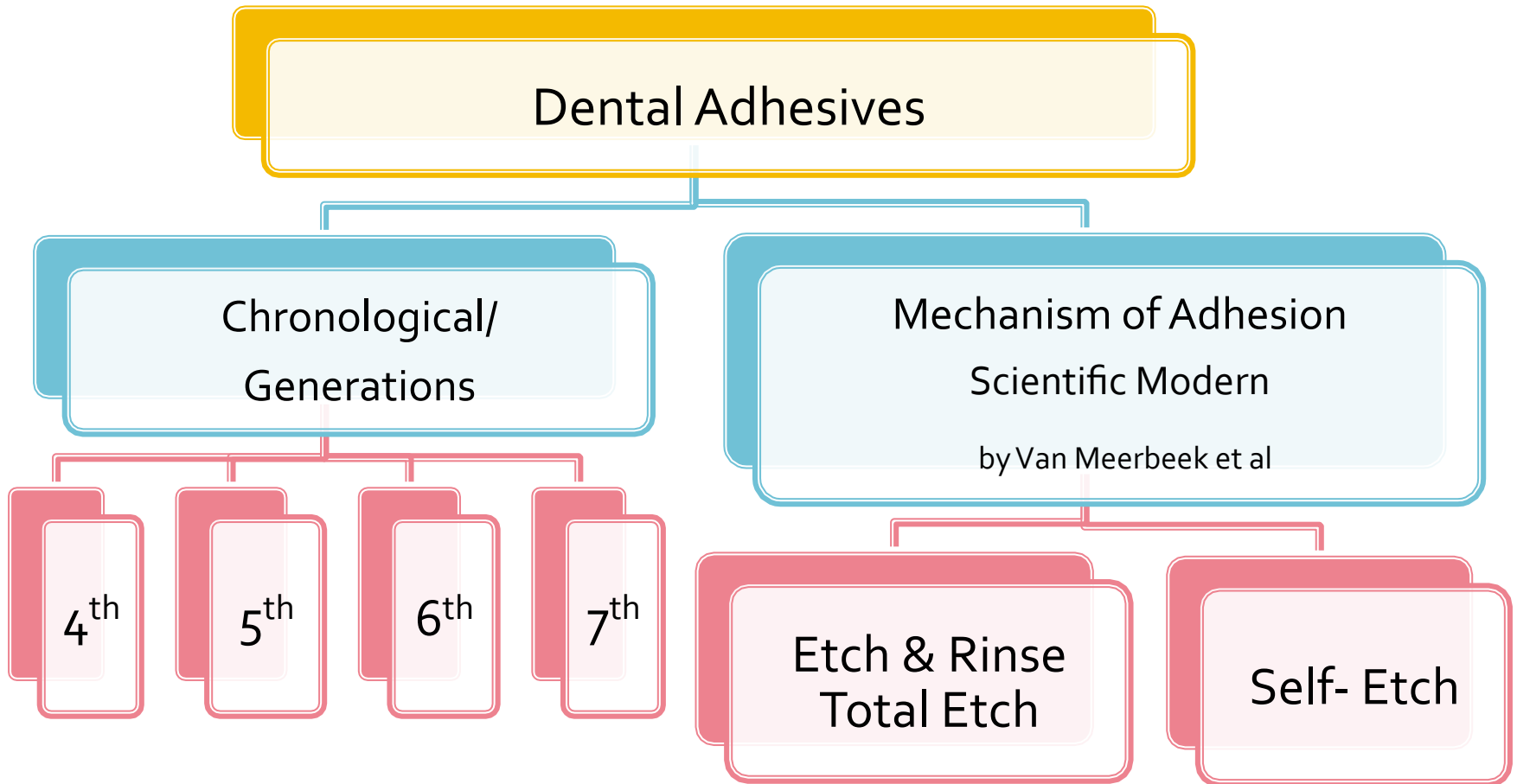
- Keep the acid-etched dentin wet and rely on water-chasing capacity of acetone-bases primers “**Wet Bonding**”
- Keep dry field & use adhesive systems with water-based primers to rehydrate the surface & re-expand the collagen fibers network “**Dry Bonding**”



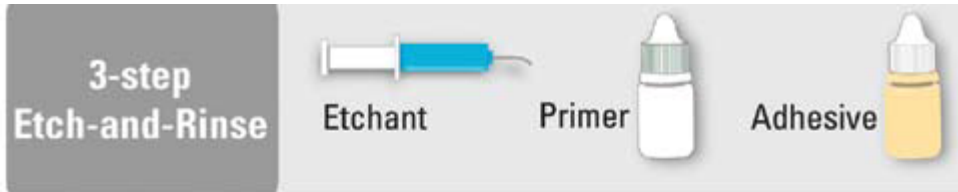


Classification of Dental Adhesives

Classification of Dental Adhesives



Classification of Dental Adhesives



4th Generation



5th Generation



6th Generation



7th Generation

Etch and Rinse Adhesives

3-step Etch-and-Rinse



Etchant

Primer



Adhesive



- (e.g. **All Bond 2**; OptiBond FL; Scotchbond Multi Purpose Plus)

2-step Etch-and-Rinse



Etchant

Single-bottle
primer/adhesive



- (e.g. **Excite**; OptiBond Solo; Adper Single Bond Plus; Prime&Bond NT; XP Bond)

Etch-and-Rinse Approach

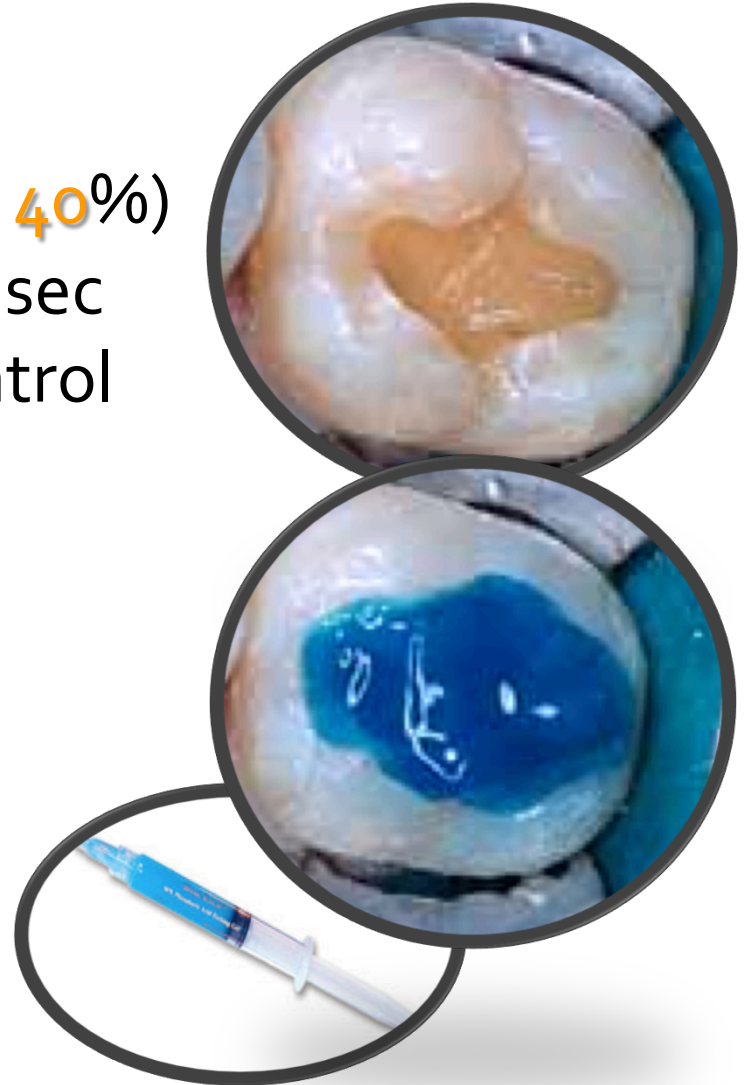
Effect of acid etching on E depends on several Parameters:

- Type of acid used
 - Acid concentration
 - Etching time
 - Form of the etchant (gel, semigel, or aqueous solution)
 - Rinsing time
 - Method of etching activation (rubbing, agitation, and/or repeated application of fresh acid)
-
- The chemical composition and condition of enamel
 - Whether enamel is instrumented before etching (cut)
 - Whether enamel is on primary or permanent teeth
 - Whether enamel is prism-structured or prismless
 - Whether enamel is Fluoridated, demineralized, or stained

Etch-and-Rinse Approach

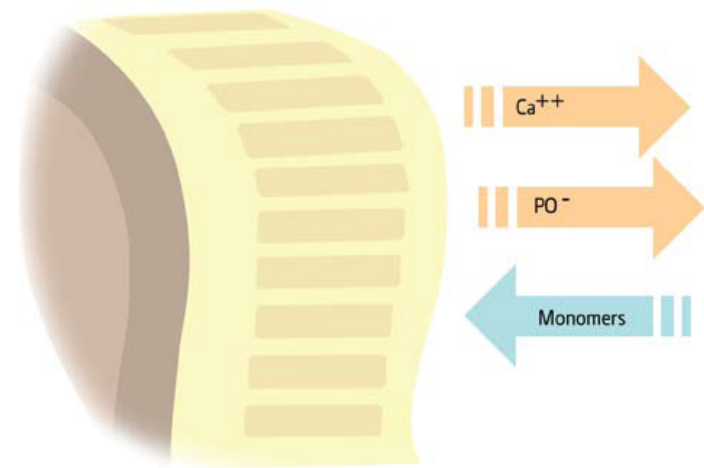
ACID ETCHING

- Use of *Phosphoric acid*
- Concentration between (30 - 40%)
- Etching time not less than 15 sec
- Gel is preferred for easier control



Etch-and-Rinse Approach

ACID ETCHING ENAMEL

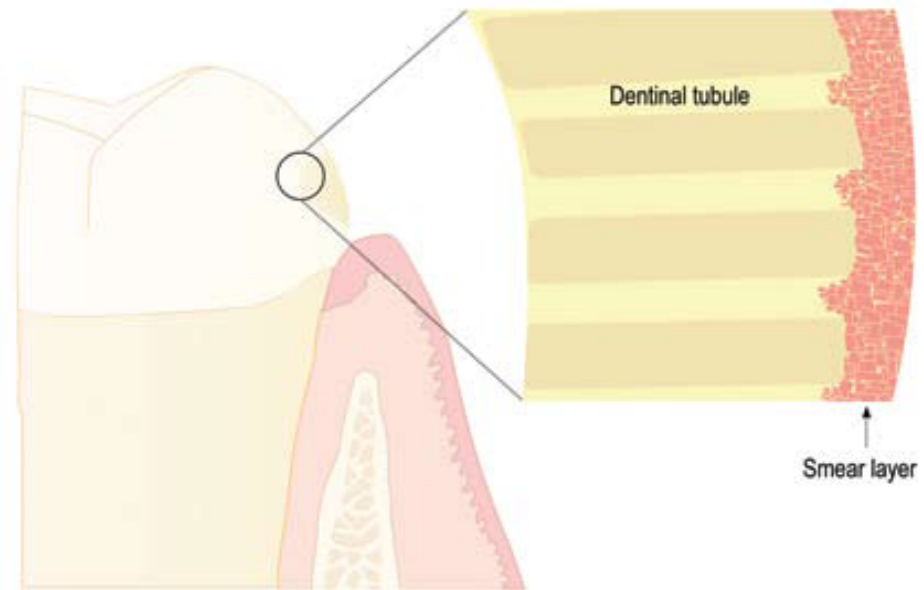


- Main **objective** is :
 - Removing the smear layer & rendering the E & D surfaces for bonding
 - Removes about 10µm of E surface to create a microporous layer of 5-50 µm
 - Penetration of the adhesive monomers into microscopic spaces created by the etchant
 - Curing of the adhesive monomers to form resin tags that microscopically provide a mechanical bond and seal to dentin and enamel
- Adequate rinsing (**5 -10**) sec.

Etch and Rinse Adhesives

ACID ETCHING DENTIN

- Demineralizes about 3 μ m to 5 μ m of the surface
- Removes the smear layer
- Exposure of microporous collagen fibrils → ↑ microporosity of intertubular D
- Failure to remove the smear layer reduces dentin permeability, preventing adhesion to the underlying intact tooth structure



Etch-and-Rinse Approach

PRIMERS

- Serve as the actual adhesion-promoting agents
- Contain *hydrophilic* monomers dissolved in organic solvents, such as **acetone** or **ethanol**
- Because of their **volatile** characteristics, these solvents can displace water from the dentinal surface and the moist collagen network, promoting the infiltration of *hydrophobic* monomers through the nanospaces of the exposed collagen network & copolymerize with adhesive resin.

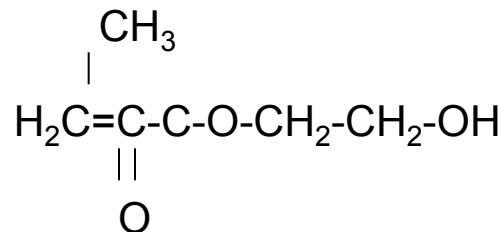


Etch-and-Rinse Approach

PRIMERS

Effective primers contain monomers with:

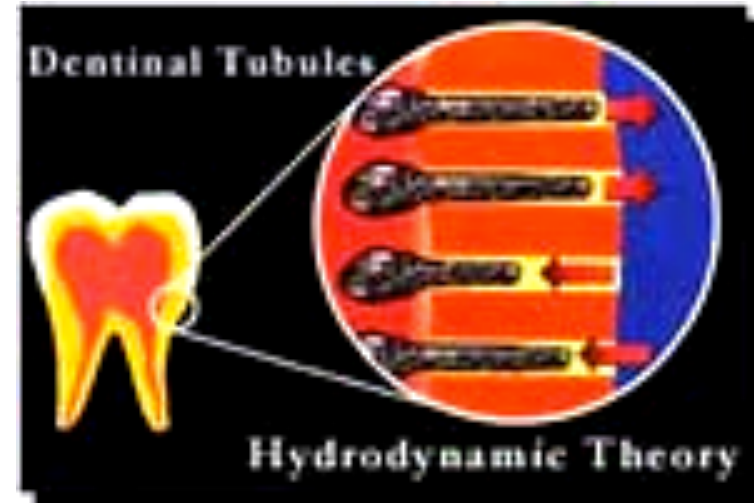
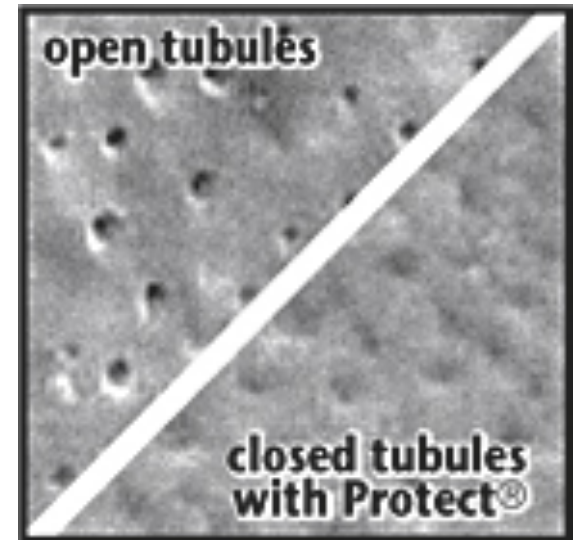
- **HYDROPHILIC** properties that have an affinity for the exposed collagen fibril arrangement
- **HYDROPHOBIC** properties for copolymerization with the adhesive resin



Etch-and-Rinse Approach

PRIMERS

- Primers have also been used to treat and prevent **Dentinal Hypersensitivity**:
is believed to be caused by pressure gradients of dentinal fluid within patent tubules that communicate with the oral environment



Etch-and-Rinse Approach

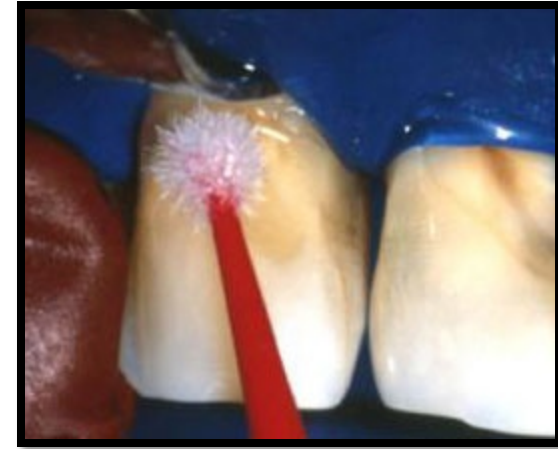
Adhesive Resin- Bonding Agent

- Low viscosity unfilled or minimally filled resin which penetrates demineralized collagen and co-polymerizes with primer resin encasing collagen and forming hybrid layer and resin tags.
- Consists of **Hydrophobic** monomers, such as **bis-GMA** and **UDMA** and
- **Hydrophilic** monomers **TEG-DMA** as a viscosity regulator and **HEMA** as a wetting agent.



Etch-and-Rinse Approach Adhesive Resin

- The main **role** of the adhesive resin is to stabilize the hybrid layer and to form resin extensions into the dentinal tubules, called “**resin tags**”
- Adhesive resins can be light curing and/or auto-cured



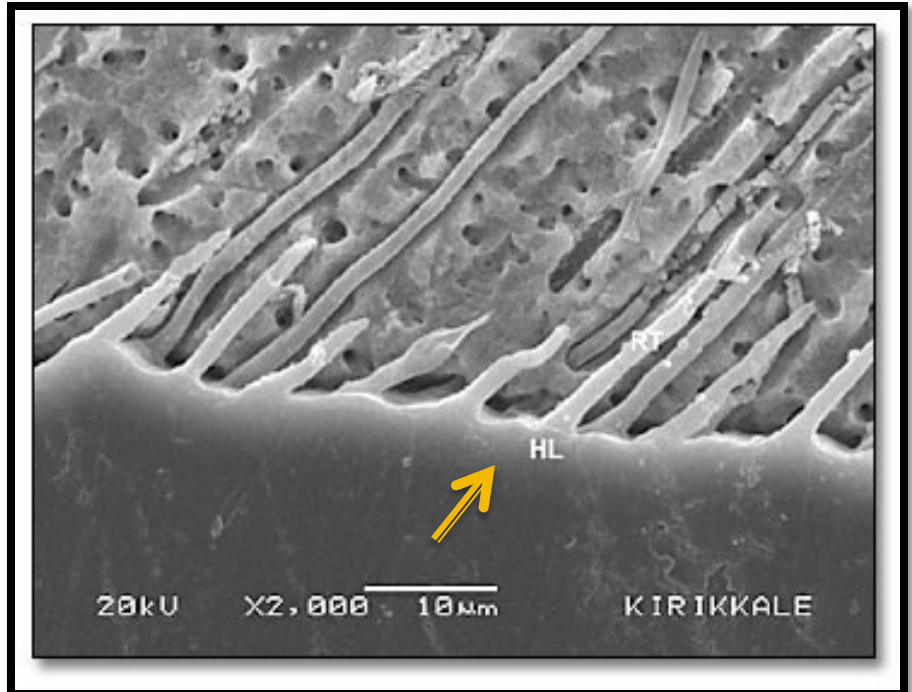
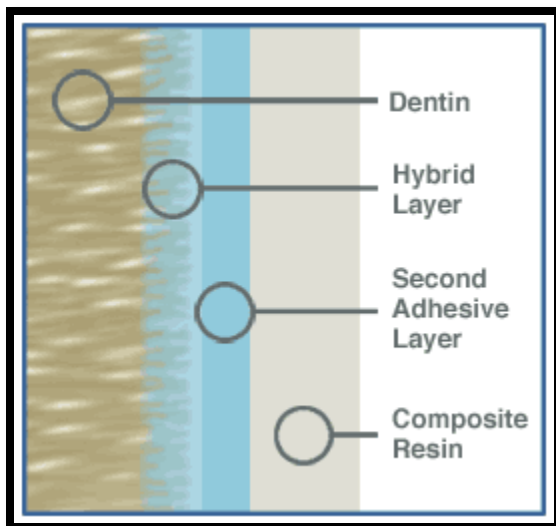
Etch-and-Rinse Approach

Adhesive Resin

- Because oxygen inhibits resin polymerization, An “**Oxygen-inhibited Layer**” of about **15** μm will always be formed on top of the adhesive resin, even after light curing.
- It offers sufficient double bonds for copolymerization of the adhesive resin with the restorative resin.

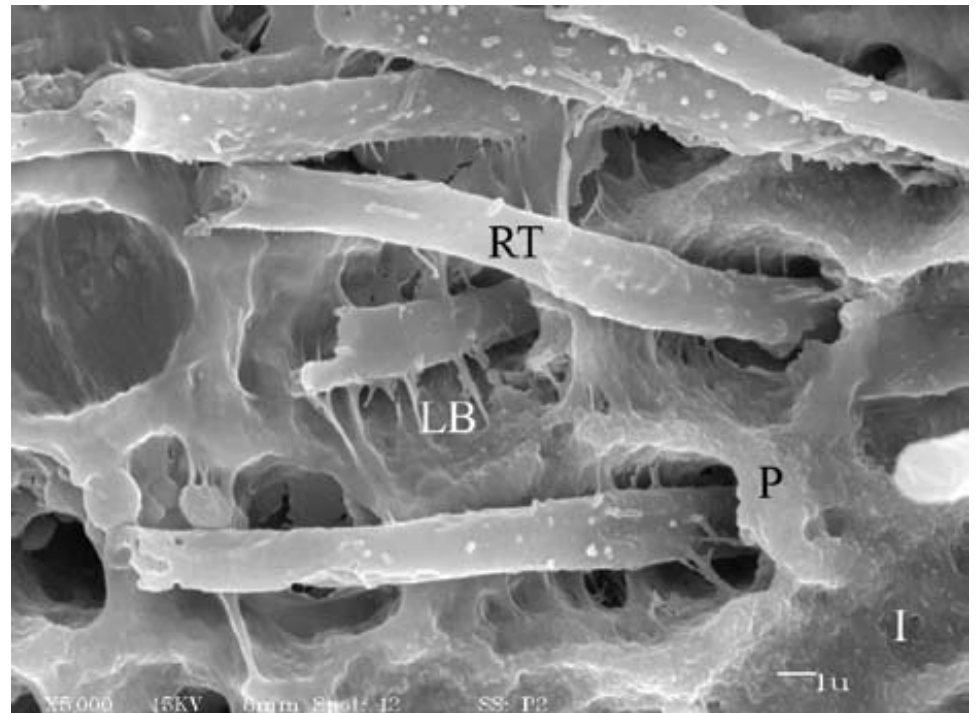
Etch-and-Rinse Approach Hybridization

Is the process of resin interlocking in the demineralized dentin surface, providing a micromechanical retention



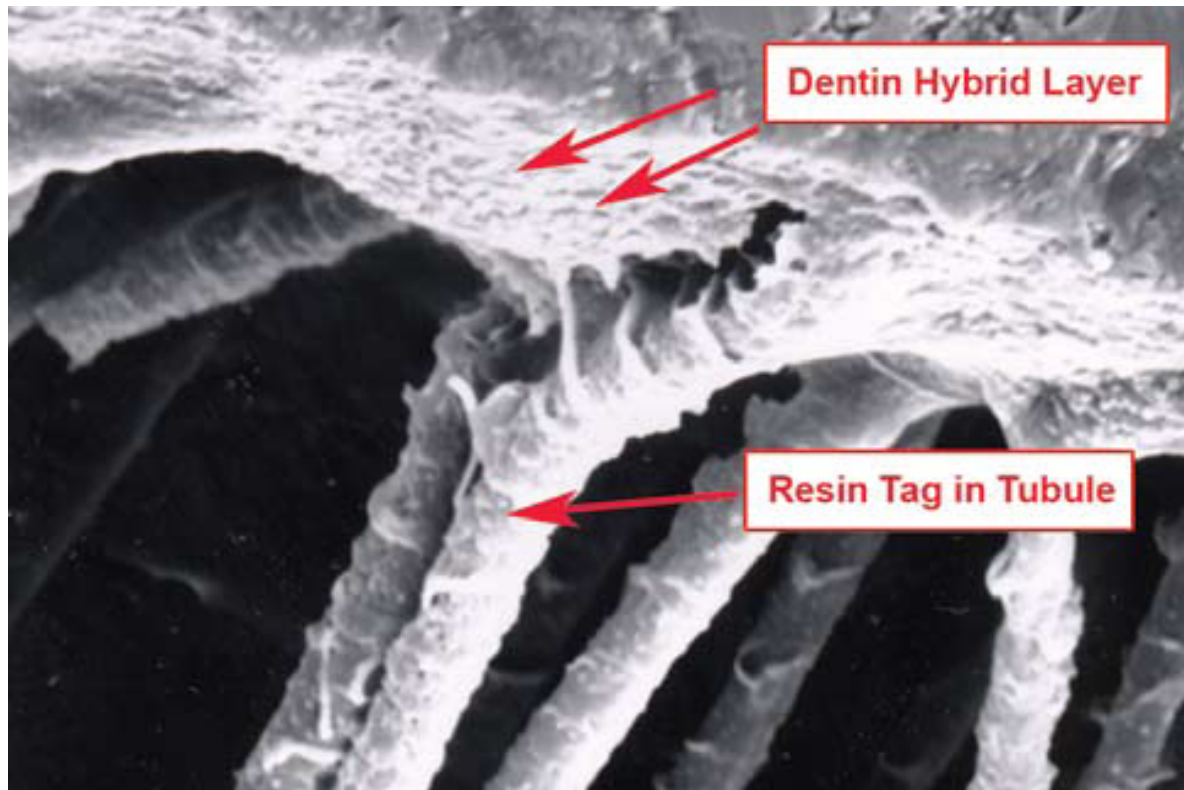
The Hybrid Layer

- The hybrid layer is observed in three distinct areas:
 - Within the dentinal tubules
 - Microscopic branches lateral to the tubules
 - Intertubular dentin



LB = Lateral Branches
RT = Resin tags within tubules
P = Peritubular Resin
I = Intertubular Resin

The Hybrid Layer



Techniques to Maximize Etch and Rinse System Performance

1. Etch enamel first (15 seconds) followed by etching the dentin (15 seconds)
2. Ensure dentin is slightly moist
3. Dispense the primer/primer-adhesive combination immediately before placement
4. Apply sufficient amount of adhesive
5. Thoroughly air-dry the adhesive
6. Ensure that the adhesive is thoroughly light-cured

Self Etch Adhesives

2-step Self-etching

Self-etching
primer



Adhesive



- (e.g. Xeno IV; iBond; Clearfil S3; Adper Easy Bond; G-Bond)

1-step Self-etching

Self-etching
primer/adhesive



- (e.g. AdheSE; Adper SE Bond; Clearfil SE Bond)

- Do not require a separate etching procedure
- More tolerant of moisture
- Etching process proceeds with adhesive penetration

Self Etch Adhesives

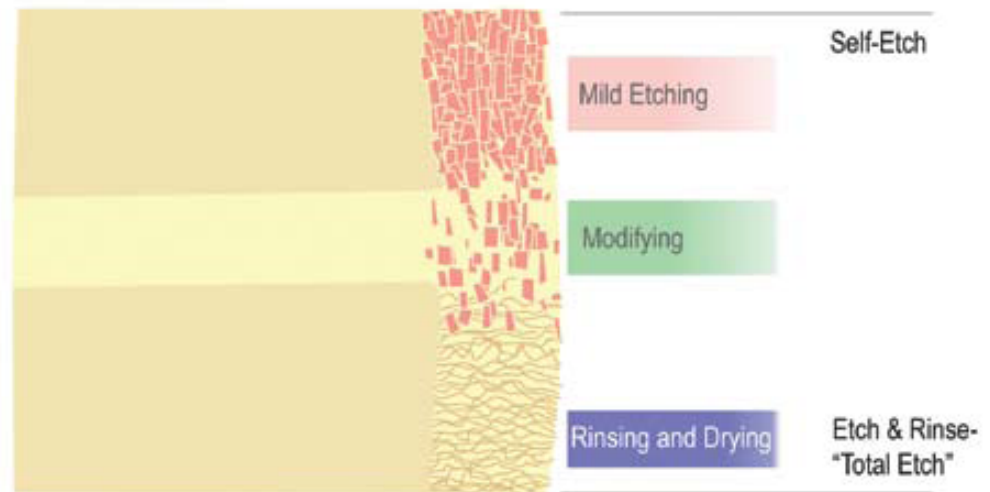
Mechanism of Action-Enamel & Dentin

- Have a range of acidity, low pH (<1) through mild pH (≥ 2) variants
- Combination of mechanical and or chemical retention
- Low pH self etch systems result in a hybrid layer with deep resin tags
- Mild pH self etch systems have shallower resin tags

Self Etch Adhesives

Mechanism of Action-Enamel & Dentin

- Contain water and monomers in their formulation
- Sufficient drying of adhesive is more critical
- Removal of smear layer is less complete, dentinal tubules not as open as in etch and rinse systems
- Thought to reduce post-operative sensitivity



Self Etch Adhesives

Mechanism of Action-Enamel & Dentin

- Disadvantages:
 - Enamel must be instrumented (beveled) to provide an effective etch
 - Don't provide as high an enamel bond compared to etch and rinse adhesives
- Better used when:
 - Area to be bonded to consists of mainly dentin
 - Proper isolation cannot be achieved

Techniques to Maximize Self Etch System Performance

1. Enamel should be present
2. The surfaces should be clean and debris free
3. In case of single bottle adhesive the desired amount should be applied immediately before use
4. Apply adhesive to enamel first followed by dentin
5. Don't use a separate etchant on dentin
6. Multiple applications to ensure adequate coating and penetration
7. Adequate light curing

Chronological Classification

Summary



Thank You..
Any Questions?

