

Enamel and Dentin Bonding (Agents and Techniques)

Definition The bonding agents (dental adhesives) are resinous materials used to enable the restorative material to bond and adhere to dental tooth structures (enamel and dentin).

Requirements of dentin Bonding Agents

1. Provide high bond strength to enamel.
2. Provide bond strength to dentin similar to that to enamel.
3. Show good biocompatibility to dental tissue, including the pulp.
4. Minimize microleakage at the margins of restorations.
5. Prevent recurrent caries and marginal staining.
6. Be easy to use.
7. Possess a good shelf life.
8. Be compatible with a wide range of resins.

Indications

1. To aids in bonding composite and even amalgam restorations to tooth structure.
2. To treat dentinal hypersensitivity.
3. For the repair of fractured porcelain, amalgam and resin restorations.
4. For pit and fissure sealants.
5. To lute crowns.
6. To bond orthodontic brackets.

Enamel Bonding

Bonding to enamel requires two clinical steps;

- 1) Acid etching, followed by
- 2) The application of the adhesive resin to the etched surface.

Usually 37% phosphoric acid is used for 15 to 30 seconds.

The goals of enamel etching are 1) to clean enamel surface from debris, 2) to increase the enamel surface area available for bonding, and 3) to partially dissolve the mineral crystallites to create retentive microporosities into which the resinous bonding agent can infiltrate and form retentive resin tags (micromechanical retention). 4) In addition, acid etching increases the surface energy and lowers the contact angle of resins to enamel.

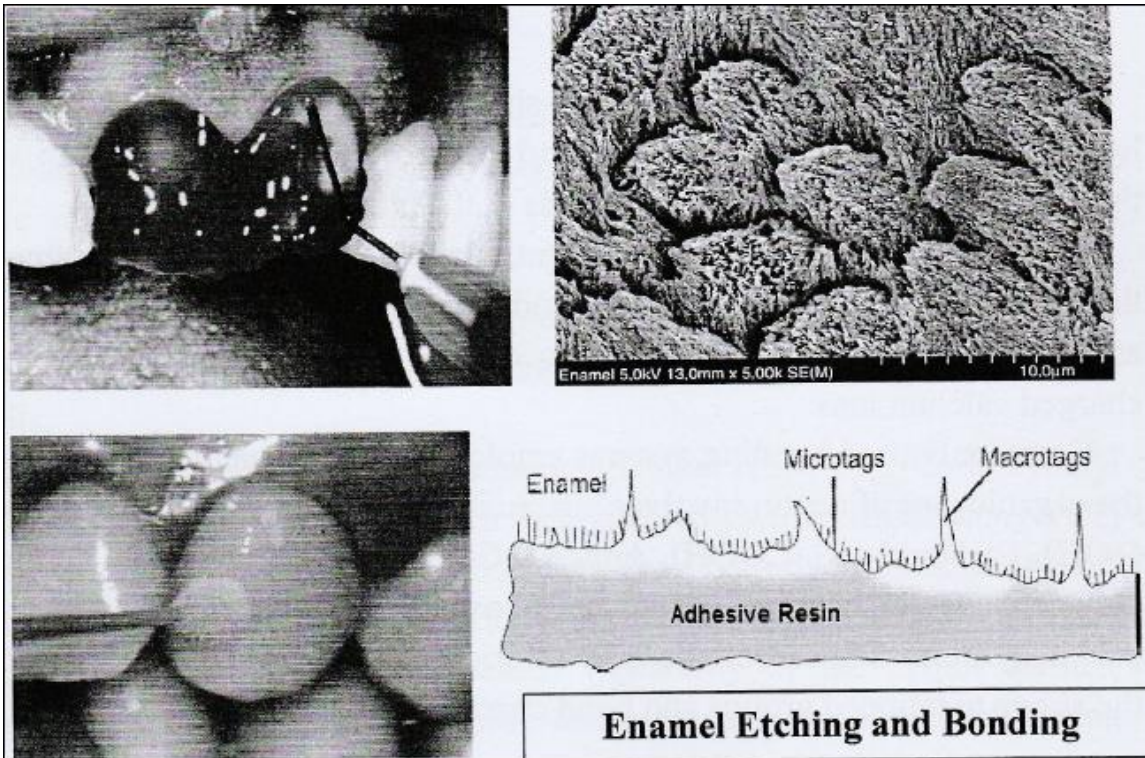
It has been shown that optimal enamel-resin bonds could be achieved as long as the etched enamel surface was clean and free from any contamination.

- ❖ If phosphoric acid concentration is greater than 50%, then monocalcium phosphate monohydrate will get precipitated.
- ❖ If concentration is lower than 30%, dicalcium phosphate monohydrate is precipitated which interferes with adhesion.
- ❖ Deciduous teeth require longer time for etching than permanent teeth because of the presence of aprismatic enamel in deciduous teeth.

Procedure

Apply acid etchant in the form of liquid or gel for 15 to 30 seconds.

- ❖ Wash the etchant continuously with water for 10 to 15 seconds.
- ❖ Note the appearance of a properly etched surface. It should give a frosty white appearance on drying.
- ❖ If any sort of contamination occurs, repeat the procedure.
- ❖ Now apply bonding agent and low viscosity monomers over the etched enamel surface. Generally, enamel bonding agents contain Bis-GMA or UDMA with TEGDMA added to lower the viscosity of the bonding agent. The bonding agents due to their low viscosity rapidly wet and penetrate the clean, dried, conditioned enamel into the microspaces forming resin tags. The resin tags which form between enamel prisms are known as Macrotags
- ❖ Finer network of numerous small tags is formed across the end of each rod where individual hydroxyapatite crystals were dissolved and are known as microtags. These microtags are more important due to their larger number and greater surface area of contact. Micro and macrotags within the enamel surface constitute the fundamental mechanism of enamel-resin adhesion.



Dentin Bonding

Bonding to dentin has been proven more difficult and less reliable and predictable than enamel. This is because of morphologic, histologic and compositional differences between them.

Problems Encountered During Dentin Bonding

1. Dentin contains more water than does enamel.
2. Hydroxyapatite crystals have a regular pattern in enamel whereas in dentin, hydroxyapatite crystals are randomly arranged in an organic matrix.
3. Presence of smear layer makes wetting of the dentin by the adhesive more difficult.
4. Dentin contains dentinal tubules which contain vital processes of the pulp, odontoblasts. This makes the dentin a sensitive structure.
5. Dentin is a dynamic tissue which shows changes due to aging, caries or operative procedures.
6. Fluid present in dentinal tubules constantly flows outwards which reduces the adhesion of the composite resin.

Ideally a dentin bonding agent should have both hydrophilic and hydrophobic ends. The hydrophilic end displaces the dentinal fluid to wet the surface. The hydrophobic end bonds to the composite resin.

Bonding to the inorganic part of dentin involves ionic interaction among the negatively charged group of the bonding agent (for example, phosphates, amino acids and amino alcohols, or dicarboxylates) and the positively charged calcium ions.

Commonly used bonding systems employ use of phosphates. Bonding to the organic part of dentin involves interaction with Amino (-NH), Hydroxyl (-OH), Carboxylate (-COOH), Amide (-CONH) groups present in dentinal collagen. Dentin bonding agents have isocyanates, aldehydes, carboxylic acid anhydrides and carboxylic acid chlorides which extract hydrogen from the above mentioned groups and bond chemically.

Classification of Dentin Bonding Agents

Historically, dentin bonding agents have been classified based on chemistry and the manner in which they treat the smear layer into 7 generations.

The first three generations failed to provide adequate bond strength to dentin.

Fourth Generation Dentin Bonding Agents

They were made available in the mid-1990s. Fourth generation bonding agents represented significant improvements in the field of adhesive dentistry. These agents are based on total etch technique (now it is called etch and rinse technique) and moist bonding concept.

Mechanism of Bonding

Fourth "generation" is characterized by the process of hybridization at the interface of the dentin and the composite resin. Hybridization is the phenomenon of replacement of the hydroxyapatite and water at the dentin surface by resin. This resin, in combination with the collagen fibers, forms a hybrid layer. In other words, hybridization is the process of resin interlocking in the demineralized dentin surface. This concept was given by Nakabayashi in 1982.

Components of Fourth Generation Adhesives

1. Conditioner (Etchant): Commonly used acids are 37% phosphoric acid, nitric acid, maleic acid, oxalic acid, pyruvic acid, hydrochloric acid, citric acid or a chelating agent e.g. EDTA.

Use of conditioner/etchant causes removal or modification of the smear layer, demineralizes peritubular and intertubular dentin and exposes collagen fibrils.

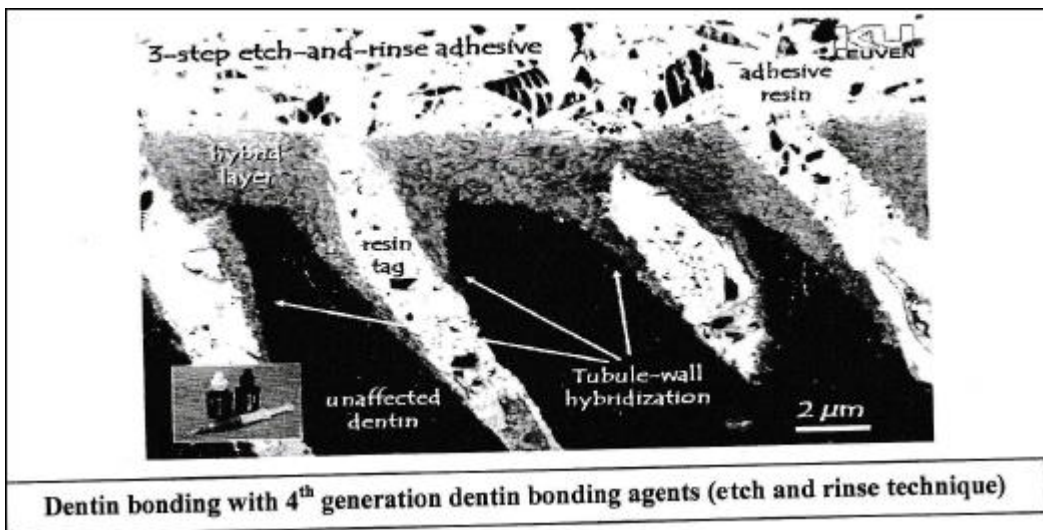
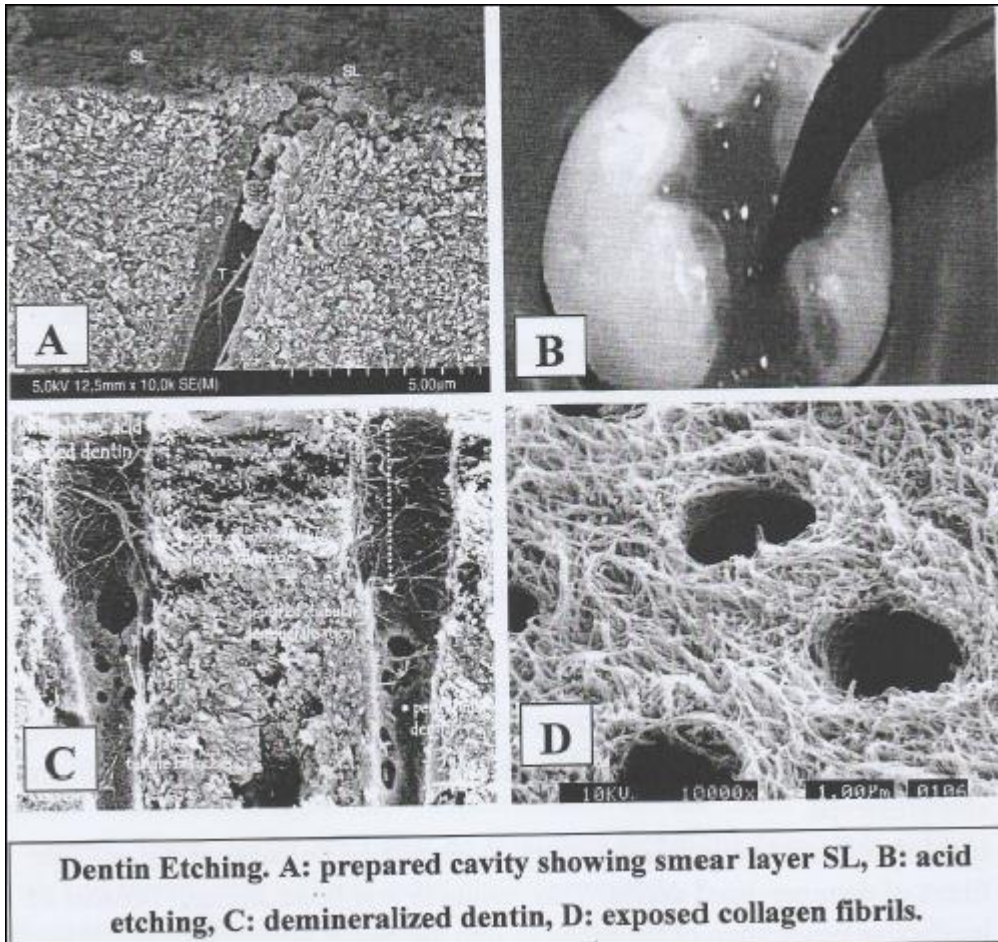
2. Primer: Primers consist of monomers like HEMA (2-Hydroxyethyl methacrylate) and 4-META (4-Methacryloxyethyl trimellitate anhydride) dissolved in acetone or ethanol. Thus, they have both hydrophilic as well as hydrophobic ends which have affinity for the exposed collagen and resin respectively. Use of primer increases wettability of the dentin surface, bonding between the dentin and resin, and encourages monomer infiltration of demineralized peritubular and intertubular dentin.
3. Adhesive: The adhesive resin is a low viscosity, filled or unfilled resin which flows easily and matches the composite resin. Adhesive combines with the monomers to form a resin reinforced hybrid layer and resin tags to seal the dentin tubules.

Etching of dentin results in removal of smear layer and minerals from dentin structure, exposing the collagen fibers. Areas from where minerals are removed are filled with water. This water acts as a plasticizer for collagen, keeping them in an expanded soft state. Thus, spaces for resin infiltration are also preserved.

If the dentin surface is made too dry, there will be collapse of the collagen fibers of demineralized dentin. This results in low bond strength because of ineffective penetration of the adhesive into the dentin.

Primers are used to increase the diffusion of resin into moist and demineralized dentin and thus optimal micromechanical bonding. For optimal penetration of primer into demineralized dentin, it should be applied in multiple coats.

Total etch technique involves the complete removal of the smear layer by simultaneous acid etching of enamel and dentin. After total etching, primer and adhesive resin are applied separately or together.



Advantages:

- Ability to form a strong bond to both enamel and dentin.
- High bond strength to dentin (17-25 MPa)
- Ability to bond strongly to moist dentin.

- Can also be used for bonding to substrates such as porcelain and alloys (including amalgam).

Disadvantages:

- Time consuming.
- More number of steps.
- Technique sensitive

Fifth Generation dentin Bonding Agents (Two-Step Etch- and- Rinse Adhesives)

Fifth generation DBAs were made available in the mid-1990s similar to the fourth generation, they are based on the total etch technique (a separate step of acid etching is needed) they are also known as “one-bottle” or “one component” bonding agents. In these agents the primer and adhesive resin are in one bottle. Basic differences between fourth and fifth generation is the number of basic components of bottles.

Fourth generation bonding system is available in two bottles, one primer and other adhesive, fifth generation dentin bonding agents are available in one bottle only.

Sixth Generation Dentin Bonding Agents (Two-Step Self-Etch Systems)

These were made available in 2000. In fifth-generation, primer and adhesive are available in single bottle, and etchant in separate bottle. In sixth generation etching step is eliminated, because in sixth Generation etchant, primer in one bottle and bonding are available in another bottle.

Most self-etching primers are moderately acidic with a pH that ranges between 1.8 and 2.5. Because of the presence of an acidic primer, sixth generation bonding agents do not have a long shelf-life and thus have to be refreshed frequently.

In these agents as soon as the decalcification process starts, infiltration of the empty spaces by the dentin bonding agent is initiated

Advantages

- Reduces postoperative sensitivity because they etch and prime simultaneously.
- It etches the dentin less aggressively than total etch products.
- Demineralized dentin is infiltrated by resin during the etching process.
- Since they do not remove the smear layer, the tubules remain sealed resulting in less sensitivity

- They form a relatively thinner hybrid layer than traditional product, which results in complete infiltration of the demineralized. Dentin by the resin monomers.
- Much faster and simpler technique.
- Less technique sensitive as few number of steps are involved for the self-etch system

Seventh Generation Dentin Bonding Agents (One-Step Self-Etch Adhesives)

They achieve the same objective as the sixth generation systems except that they simplified multiple sixth generation materials into a single component, single bottle one-step self-etch adhesive, thus minimizing the number of steps and avoiding any mistakes that could be encountered (the bottle contains all the components which are the weak acid, primer, and the adhesive)