

Review article:

Hybrid layer: Foundation of Dental bonding

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ABSTRACT:

In contemporary dentistry total-etch and self-etch are the most commonly used adhesive systems. The strength of the bond formed by these systems and subsequently the longevity of the restoration is dependent on the hybrid layer characteristics. This review attempts to highlight the effect of the total-etch and self-etch adhesive systems on the morphology of hybrid layer and its subsequent effect on bond strength.

Keywords: Dental adhesion

INTRODUCTION

The science of dental adhesion originated in the early 1950's and now bonding agents are used routinely in restorative, cosmetic and preventive dentistry.¹ Successful bonding depends on infiltration of demineralised collagen fibers with resins, resulting in the formation of Hybrid layer with Resin tags thus, creating micromechanical retention of the resin to the demineralised substrate. Resin penetration into the intertubular dentin seems to be a major factor influencing the bond strength.

Depending upon whether the smear layer is to be retained, removed or modified, bonding systems have evolved from "no-etch" to "total-etch" to "self-etch". Presently total-etch also known as etch-and-rinse and self-etch strategy are being followed in bonding systems. To understand hybrid layer formation using total etch technique and the self etch technique we first need to understand the following:

COMPONENTS OF BONDING SYSTEMS

Etchant – In total-etch technique the etchant used is 35-37% phosphoric acid. It prepares enamel and

dentin to receive the primer. It creates micro-porosities, upto 7.5 microns which helps to create the resin tag formation and thereby results in micro mechanical bonding. The etchant in self-etch bonding agents is typically an acidic monomer that also serves as the primer.

Primer – The primer is composed of hydrophilic monomers usually carried in a water-soluble solvent (acetone, ethanol, water) to promote good flow and penetration into hydrophilic dentin, which can influence the resulting bond strength. Self-etch bonding agents utilize primers that are acidic monomers.

Dentin bonding agent(or Dentin Adhesive)-can be defined as a thin layer of (usually unfilled) resin applied between the conditioned dentin and resin matrix of a composite. The adhesive promotes bonding between enamel or dentin and resin composite restorative material or resin cement. Adhesives act as a link between the hydrophilic resin primer and the hydrophobic resin composite. Proper curing is required to provide good retention and

sealing. Seventh-generation bonding agents utilize primer-adhesives that are acidic monomers.

Fillers –Recently nanofillers have been added ranging from 0.5% to 40% by weight in the 8th generation adhesive systems. Fillers control handling and may improve strength. Fillers may increase film thickness of the adhesive layer.

Solvent - Solvents include acetone, ethanol and water. The solvent affects the evaporation rate on the tray and in the mouth. Acetone evaporates quickly and requires the shortest drying time in the mouth. Ethanol evaporates more slowly and requires moderate drying time. Water evaporates very slowly and requires longest drying time. Bonding agents should be dispensed immediately before use to prevent premature evaporation of the solvent.²

Total-etch bonding agents

Total-etch bonding agents (4th- and 5th-generation) were introduced in the early 1990s.

Total-etch involves 3 steps.

1. Acid- it uses 35-37% phosphoric acid which removes the smear layer and demineralizes the most superficial hydroxyapatite crystals, thus exposing both intertubular and peritubular collagen.
2. Primer- Includes bifunctional molecules (simultaneously hydrophilic and hydrophobic).
3. Resin- Includes monomers that are mostly hydrophobic; such as Bis-GMA. The resin monomers permeate the water filled spaces between adjacent dentin collagen fibers that used to be occupied by hydroxyapatite crystals.⁸ This infiltration results in a hybrid tissue composed of collagen, resin, residual hydroxyapatite, and traces of water known

as the resin-dentin interdiffusion zone, first described in 1982 as the hybrid layer.

4th-generation: the primer and adhesive are applied in separate layers.

5th-generation: the primer and adhesive are in one bottle.

Advantages:

1. The intimate micromechanical entanglement of resin monomers with etched dentin may result in decreased postoperative sensitivity.
2. It has a better marginal fit.
3. It acts as an elastic buffer that compensates for polymerization shrinkage stress during contraction of the restorative composite.
4. Hybrid layer is thicker and more uniform so gives better bond strength.
5. Resin tags formed are longer.

Disadvantages

1. Involves multiple steps.

Self-etch bonding agents

Self-etch (non-rinsing) adhesives do not require a separate acid-etch step as they condition and prime enamel and dentin simultaneously by infiltrating and partially dissolving the smear layer and hydroxyapatite to generate a hybrid zone that incorporates minerals and the smear layer.

6th-generation, Type I: Bonding agents have a self-etch primer and a resin adhesive, which are applied in separate layers. The light-cured products typically require two steps, whereas the dual-cured products typically require three steps.

6th-generation, Type II: Bonding agents combine the self-etch primer and adhesive in one component (two steps) and simplify the bonding procedure.⁴

7th-generation: The light-cured products typically require one step, whereas dual-cured products typically require two steps.

8th generation: Recently, single dose system containing nanofillers(20 nm) have been introduced in an attempt to increase bond strength.

ADVANTAGES

1. All-in-one adhesives are user-friendly in that fewer steps are required for the bonding protocol.
2. No rinsing is required.

DISADVANTAGES

1. Resin tag formed are smaller and inconsistent.
2. The hybrid layer formed is thinner and less uniform and discontinuous with lots of debris.

Table 1. Comparison of bond strength of different bonding agents

Ranges of Shear Bond Strengths		
Bonding Agent	Enamel	Dentin
4 th -generation	20-35 MPa	20-35 MPa
5 th -generation	20-35	20-30
6 th -generation (Type I)	20-30	15-35
6 th -generation (Type II)	10-30	10-30
7 th -generation	20-30	20-30

ROLE OF SMEAR LAYER AND HYBRID LAYER IN DENTIN BONDING

Whenever tooth structure is prepared with bur or other instrument, residual organic and inorganic components form a smear layer of debris on the surface. The smear layer fills the orifice of dentinal tubules and forms smear plugs that will decrease dentin permeability by 86%.

Smear layer is composed of hydroxyapatite and altered denatured collagen. Smear layer can be removed by an acid such as 37% phosphoric acid.¹ Initial demineralisation of the dentinal surface with an acidic conditioner, exposes a collagen fibril network with interfibrillar micro-porosities that subsequently becomes inter diffused with low viscosity monomers.

This zone, in which the resin of the adhesive system micromechanically interlocks with dentinal collagen is “HYBRID LAYER”

Dentin bonding creates a hybrid layer of resin, collagen fibers, dentin surface structure and inter-tubular structures.

Formation of Hybrid layer is an integral part of dentin bonding. The quality of Hybrid layer formed decides the strength of resin dentin interface. The thicker and more uniform the Hybrid layer, better is the bond strength. Along with the thickness of Hybrid layer, the uniformity in the formation of hybrid layer is also important. A uniform hybrid layer is seen with total etch technique whereas the hybrid layer formed with self etch technique is less uniform and discontinuous with lots of debris.



Fig. 1 Hybrid Layer as seen in Total-etch adhesives. Hybrid layer is observed to be uniformly thick.

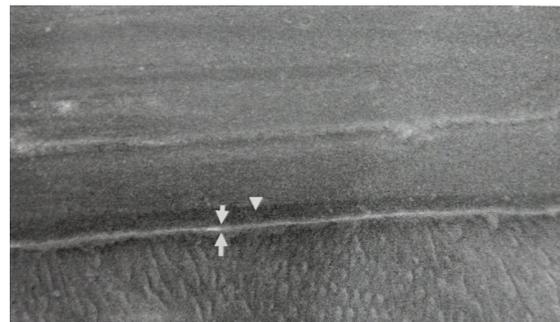


Fig. 2: Hybrid Layer as seen in self-etch adhesives. Hybrid layer is seen to be thin and discontinuous.

S Bouillaguet⁵ et al in the year 2001 compared the dentin bonding performance of eight adhesive

systems using a microtensile bond strength test. Two conventional adhesive systems, four one step adhesive systems, two self etching adhesive systems were evaluated. He concluded that the conventional adhesive systems produced higher bond strengths to dentin than most one-step adhesives and self-etching adhesives.

Ana Paula Martini, Rodolfo Bruniera Anchieta⁶ in the year 2009 studied the micromechanical behavior of the Hybrid layer with voids based on a Self- etching adhesive system using a 3-D Finite Element analysis. Their result showed the lower bond strengths of self-etching and single bottle adhesives.

ArioSantini⁷ et al in the year 2011 concluded that more recently marketed adhesives with simplified application procedures are less successful compared to conventional total-etch adhesives in the long run.

RESIN TAG FORMATION IN DIFFERENT ADHESIVE SYSTEMS

Resin tags and Lateral branches formation is also an integral part of bonding mechanism. Resin tags and lateral branches infiltrate into the dentinal tubule and help in increasing the bond strength. The thicker and more longer the Resin tags more closer is it's adaptation within the dentinal tubule.

Resin tags formed with total-etch adhesives are much longer than those found in self- etch adhesives and have marked conical swelling at their bases, as a result of removal of the peritubular dentin by previous acid- etching of dentin.

Resin tags formed by total etch revealed numerous small lateral extensions of micro tags(lateral branches) branching off at right angles from the main resin tags which is a clear sign of proper adaptation and sealing. Whereas the resin tags formation in self etch adhesive system are smaller and inconsistent.

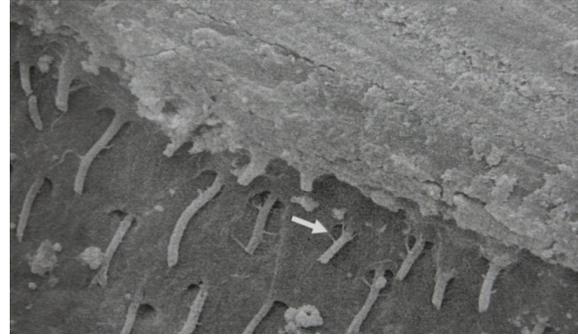


Fig 3: *Resin tag formation with lateral branches as seen in total-etch adhesive system*

SMEAR LAYER REMOVAL IN DIFFERENT ADHESIVE SYSTEMS

Scanning Electron Microscope studies have shown a clear distinction based on morphological observations, made only between systems that removed or completely dissolved the smear layer and systems that preserved or modified this debris layer.

Self etch adhesive system retain or modify the smear layer. Due to the low acidity of self etch adhesives as compared to etchant used in total-etch systems, the smear layer is not completely removed which then interferes with resin tags penetration resulting in shorter resin tags and thinner Hybrid layer formation affecting the long term bond strength.

In total-etch adhesive systems, smear layer is completely removed due to high acidity of etchant used and remaining debris is rinsed off. Hence thicker hybrid layer and long and dense resin tags are formed which results in better long term bond strengths.⁸

It is concluded that two opposite adhesion strategies are followed by modern dentin adhesive systems. The majority of products demineralizes the dentin surface to a certain depth and allow the adhesive resin to infiltrate in an attempt to attach it micromechanically into the cushion of loosely packed collagen fibers.

Their counterparts favor preservation of the smear

layer by infiltrating it with hydrophilic monomers that have an affinity for the organic and/or inorganic components of the underlying dentin surface.

A third group functions in between these opposite-adhesion strategies.

Whether the smear layer should or should not be removed is a matter to be decided in clinical trials. In addition, the extent of impregnation by resin in the dentin surface-layer or the modified smear layer needs further research. However, in both cases, an interdiffusion zone between the deeper dentin structures and the filling material is clearly present

with all modern dentin adhesive systems regardless of its thickness.

Simultaneously, this layer might have a protective potential if it blocks the normal passage of micro-organisms and toxins. Hence, a more durable clinical result can be expected.

CONCLUSION

Thus, in conclusion in spite of their user friendliness and low technique sensitivity, all-in-one adhesives have resulted in low bonding effectiveness.¹ The enamel-etching pattern and the penetration into the dentinal substrate reinforce the idea that total-etch adhesives are still the benchmark for other adhesives.

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