



Dental Adhesives – Which Ones to Use & When to Use Them

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Instructions on how are on page 86.

Educational objectives:

Upon completion of this course, participants should be able to achieve the following:

- Understand the difference between wet-bonding and self-etching systems
- Understand why different adhesives have different directions and why the directions are so important
- Understand why total-etch systems occasionally are prone to post-operative sensitivity, but self-etch systems are not
- Understand how to sort out the hype you get from the various adhesive companies who all claim they have the “best” adhesives
- Understand what factors to look for in choosing which adhesive to buy and how many adhesive systems you really need to cover all your bonding needs

Abstract

This course will provide a study of the factors that determine how dental adhesives differ from one another and why some adhesives are more successful than others in certain situations.



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This CE activity is supported by an unrestricted grant from Kuraray America, Inc.

Like it or not, dental materials are in large part what determine our success or failure as clinicians. The purpose of this article is to give an overview of bonding adhesives to help you decide what materials to use and when to use them. Hopefully, by the end of it you will be able to decide what your bonding needs are and which bonding agents will best suit your particular practice.

Early on it was realized that when composite fillings penetrated into dentin there seemed to be a lot of sensitivity and an inordinate amount of pulpal death, so for years dentists had complicated schemes to avoid touching the dentin during bonding. Even with meticulous technique, pins and extra retention grooves the composites often failed. We came to realize that when composite sets it shrinks. In the old days of bonding, all composites were bulk placed and not highly filled. The bond strengths often were inadequate to compensate for that shrinkage. In addition, and perhaps more important, we couldn't bond to dentin because bonding resin is inherently hydrophobic and dentin inherently wet.¹

Since the 1980s, there has been an explosion of new products that produced generation after generation of bonding adhesives in an attempt to improve the bond and simplify the procedures. The most common classification of bonding agents has been chronologically based, more or less, on the products' time of release into the dental marketplace and the number of steps required. However, rather than classifying according to generation, it makes a little more sense to think of it in terms of acid etch and wash versus self etch and no wash.

Total Etch

Let's look at how the first system works. Total etch is the term usually used for the acid etch and wash technique. Most of the earlier systems took three or four steps: Etch, wash, prime, air dry and apply the bonding resin. The fourth generation primers had two bottles, which generally were mixed together, while the fifth generation simplified the primer by having only one bottle. What made these systems different from the original bonding generations was that the primer molecules were hydrophobic on one end and hydrophilic on the other. The hydrophilic component can go down the etched dentin tubules seeking out the moisture in the dentin while the hydrophobic components can bond with the bonding resin. The entire complex of primer plus bonding resin is termed the "hybrid layer." Since the top layer of the hybrid layer is hydrophobic, the composite placed on top of that is quite compatible and a firm bond forms.

The advantages of total etch

Etching eliminates the smear layer and the resin tags penetrate deeply into the dentin (3-5 microns vs. 1 micron for self etch). Total-etch systems give you the best bond to uncut enamel, which self-etch systems cannot achieve.

Problems with total etch

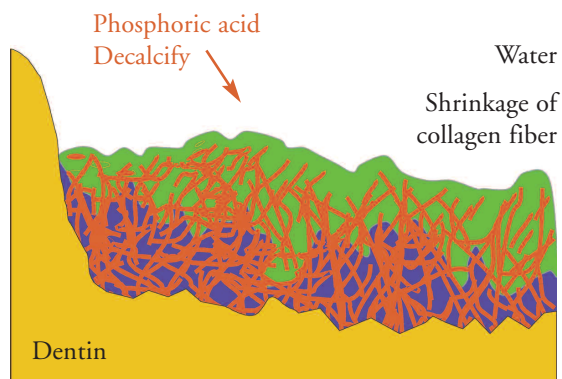
Total etch is extremely technique sensitive. Wet bonding is a total-etch technique of bonding to acid-prepared dentin. Wet bonding's biggest problem is that it is wet. But how wet is wet? One suggestion is to dry with a cotton pellet. But this still leaves the problem of cavity prep geometry. If you read the literature, you'll see that most dentin bonding strength tests are done on flat dentin surfaces. Cavity preps are not flat. More water pools along the sides of the prep and the bottom of the interproximal box than on the occlusal surface. Excess water dilutes the primer and interferes with the bond.

Furthermore, what happens when the dentin is dried too much? Pashley² in 1992 showed us why wet bonding gave the highest bond strengths even though it didn't seem to make sense. One would think that the primer would just get sucked down those little dentinal tubules with a dried tooth, but just the oppo-

Total-Etch Adhesives

All-Bond 2
Amalgambond
Bond 1
Bond-It!
Cabrio
Clearfil Photo Core
DenTastic UnoDuo
Excite
GC Fuji BOND LC
Gluma Comfort Bond
Integrabond
Multibond
One Step
OptiBond FL
OptiBond Solo Plus
Prime & Bond NT
Adper Scotchbond Multipurpose Adhesive
Adper Single Bond
Tenure
Tenure Quik

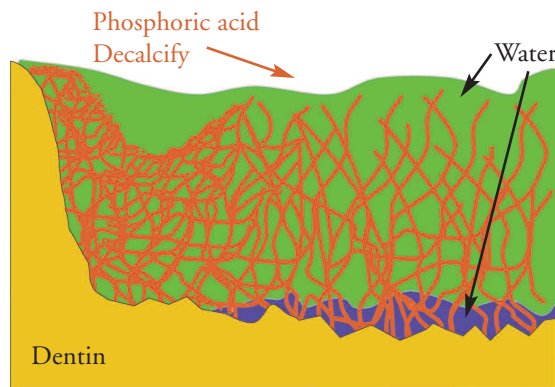
Technique sensitivity with wet bonding system (Too dry phenomenon)



- Excessively dry
- No filtration into the collagen fiber

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Technique sensitivity with wet bonding system (Too wet phenomenon)



- *Insufficiently dry*

site happens. The dentin tubules, which had their calcium etched out of them, simply collapse and form a thick mat that looks sort of like a dense forest at the top of bare trees. The foliage is the collapsed fibrils falling back on themselves and the primer can't penetrate this thick matted mess.

So then, what happens? You end up with what scientists call "naked fibrils," the collagen fibrils that are left over after etch and, no longer being supported by calcium, are left to flop around like a bunch of half-cooked spaghetti. Above it is the bonded adhesive and composite; below it the dentin. These gaps are what cause sensitivity since they allow the ingress of fluids both from the outside and from the osmotic fluid pressure of the wet dentin. So now we see why total etch is so technique sensitive.

The one bottle total-etch products, the so called fifth generation adhesives, seemed to make it easier and less technique sensitive. They DID make it easier since there were less steps. But...the problem is that these products failed to ever surpass the properties of the fourth generation. In fact, the fifth generation products seem even more technique sensitive, since the proportions of the primer and the adhesive resin need to be correct combined. Their higher solvent to monomer ratios make it more likely that they will be applied in too thin layers and not penetrate into the denuded collagen complex.

So, if you use these products, you need to be careful to apply more than one layer in order to get an adequate thickness of the hybrid layer.

This is particularly true of the primers that contain acetone as their solvent. Acetone evaporates very easily and if your assistant forgets to recap the bottle immediately the solvent to monomer ratio gets disturbed.

It turns out that the type of solvent in the primers is of critical importance. Wet bonding only works when the water left on the dentin can get completely displaced by the primer being sucked down into the holes created by the etching process. Acetone works well to displace the water, but only if the acetone doesn't evaporate before the primer gets into the tag areas. Tay³ showed that if you don't completely displace the water remaining inside the collagen network, the remaining water competes for space with the monomer or else gets trapped within the resin. This leads to blistering and a weakened resin-dentin interface – and eventual failure.

What this means is that acetone primers give us a very narrow window of opportunity. All adhesives need to be used exactly as the manufacturers direct, but the acetone based ones are particularly technique sensitive.

On the other hand, primers that contain ethanol and water as their solvents are generally less technique sensitive because they bond equally effectively to damp or dry dentin. In effect they rehydrate the collagen. OptiBond Dual Cure and Scotchbond Multi Purpose are two water-based primers that were studied by Maciel and Carvalho⁴ in 1996 and the authors found that they displaced the water in the wet technique and effectively rehydrated the collapsed collagen scaffold when air dried prior to placement.

One more word about the difference between fourth generation (two bottles in the primer step) and fifth generation adhesives (one bottle primers). Both risk contamination from saliva due to having to rinse off the etchant and both risk over etching. The fourth generation (two bottle) gives the strongest bond to enamel and is less technique sensitive, while the one-bottle fifth generation is more expensive, has more post-operative sensitivity and needs to be applied in more than one coat (less bottles, but more steps).⁵

Self-Etch Systems

Clearfil SE Bond was the first contemporary self etch on the market. Actually there was one before it, Scotch Prep, but it was quickly taken off the market because of problems with the maleic acid accelerating the breakdown of the HEMA in the primer, so the shelf life was too short.

Self-Etch Adhesives

Adper Prompt L-Pop
AdheSE
Brush&Bond
Clearfil Liner Bond 2V
Clearfil SE Bond
Clearfil Protect Bond
Fl-Bond
Nano-Bond
One-Up Bond F
OptiBond Solo Plus SEP
Simplicity
Solobond
Tenure Uni-Bond
Touch&Bond
Tyrian/One-Step Plus
UniFil Bond
Xeno III

Single-Bottle, Self-Etch Adhesives

Clearfil S³ Bond

G-Bond

iBond

Xeno IV

Clearfil SE Bond came on the market around 2001 and according to Christensen⁵ it still holds 62% of the market share. What made it so popular? For one thing, it stopped sensitivity virtually completely. It's easier to use, with less steps and the dentin can be dried, so there are less issues with the water being impregnated into the adhesive. It is far easier to produce uniform dryness than uniform wetness.

The most critical issue is that self etchers can only decalcify the dentin tubules as far as they can reach. With total bond you get situations where the dentin is etched deeper than the monomers can penetrate and this empty collagen space allows in fluids and bacteria.

With total etch, the smear layer is completely washed away in the rinse step, leaving any unfilled dentin tubules wide open. With self etch, the smear layer is decalcified by the primer and actually becomes part of the hybrid layer itself. Where the resin primer doesn't touch, the smear layer remains to keep the tubules plugged up. Where the primer does reach, the tubules are sealed with the light cured bonding resin. Although penetration into the dentinal tubules is only 1 micron or so, the self-etch primer actually forms not just a physical, but a chemical bond with the calcium in the dentin. What it lacks in depth it makes up in strength.

It is the chemical interaction between the monomers and the hydroxyapatite that seems to account for their strength. In fact, the bonds to dentin for self-etch adhesives is routinely stronger to dentin than to enamel, even stronger than the dentin bonds of the total-etch systems, which have tags five times longer into the dentin, but which don't have enough calcium left in the collagen fibrils for bonding.

If marked decreases in sensitivity, ease of handling, and better bonding to dentin are the main plusses for self etch, what are the tradeoffs?

Bonding to Enamel

The self-etch primers are weak acids and as such don't etch the enamel as well as phosphoric acid can. Although this produces a weaker bond to enamel, this does not seem to be so important clinically. Türkün⁶ evaluated fillings done by the two main players in each group: Prime & Bond NT for total etch and Clearfil SE Bond for self etch. They both did quite well even after two years.

Nonetheless, self etchers do not do as well when lab tested for enamel bond strengths. It is therefore prudent to bevel the enamel preps or to pre-etch the entire occlusal surface with phosphoric acid before starting the prep. You can then seal the entire surface with the primer and bonding agent to give additional sealant protection, not just for the filling, but for the entire tooth.

Let's take a look at some of the one bottle self-etching systems. One of them is L-Prompt, which is actually a two bottle system, but which gets mixed in its own self-contained well when the membrane separating the two components gets broken allowing the contents to mix. This is a good idea from two standpoints. First it eliminates cross contamination and second, it keeps the components from mixing prematurely. Unfortunately, it does not do well as far as bond strengths are concerned, although Adper Prompt seems to do better. Likewise, Parkell's simplified self-etching systems, Touch&Bond and Brush&Bond, have a unique delivery. Instead of two bottles, they have special microbrushes or small sponges impregnated with one of the primer components. Again; however, the lab bond strengths are weak, which generally correlates to poorer clinical performance.

Like these primers, Clearfil SE Bond is a two-bottle system. What makes it different from others in this category is its propri-

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etary molecule MDP (10 methacryloyloxydecyl dihydrate phosphate), which is in almost all of Kuraray's primers. The long chain has at one end a hydrophilic phosphate group to bind to the calcium (Ca) and amino groups in the tooth structure so that the molecules seek the wetness in the dentin. The length of the chain, with a long hydrophobic alkyl group at the other end, leaves the molecule free to bond to the hydrophobic resin of the composite. Other manufacturers do not have the MDP molecule in their formulations and are not as clinically successful as the Clearfil adhesives for that reason.

A new self etcher that came on the market last year is Clearfil Protect Bond, which is very similar chemically to the original Clearfil SE Bond, but is bactericidal and also releases fluoride. The low pH of acid-etch and the self-etch primers helps to control bacteria, but none of these can claim the bactericidal properties that Protect Bond can. Some other brands incorporate fluoride into their bonding, but the fluoride is released only either at the time of bonding or if water is leaking into the hybrid layer. In either case, the fluoride doesn't accomplish much. But with Protect Bond, the cured hybrid layer remains bacteriostatic. What makes it different is the addition of the MDPB (12methacryloyloxydodecylpyridium bromide) monomer which has at one end a quaternary ammonia and at the other a halide. Incidentally, it is not recommended to leave chlorhexidine on the tooth with any of the bonding systems because it weakens the primers and interferes with the bond.

The all-in-one bonding systems

The latest self-etch primers to come on the market are the all-in-one primers that contain both the primer and the resin in one bottle. Clearfil S³ Bond is unique in that hydrophilic and hydrophobic monomers coexist in a homogeneous state at the molecular level thanks to its molecular dispersion technology. Other brands use acetone to separate the components, but this risks phase separation due to the fast evaporation of the acetone. This phase separation phenomenon is thought to be one of the reasons why the osmotic pressure from the pulp forces water into the weakened hybrid layer of most all-in-one primers but not S³ Bond.

Consequently, S³ Bond typically does better in laboratory studies and is expected to do better than its competitors in clinical studies as well. Keep in mind that this adhesive needs to be light cured, so can't be used for posts and that it needs to be refrigerated. Others in its class also need to be agitated vigorously before application and may be less reliable due to the acetone evaporation.

I also should point out that all of the one-bottle systems, be they wet bonding or dry bonding, are more hydrophilic and act as permeable membranes allowing water from the pulp to seep up and infiltrate the hybrid layer, which eventually results in a degradation of the hybrid layer.⁷ In addition, the simpler the system, the more acidic the primers have to be, so the acid left in the uncured oxygen inhibited layer reacts with the tertiary amine initiator of the self-cured composite system forming an acid base reaction at the composite-hybrid layer interface. Thus, the interface area doesn't cure and a hydrogel remains sandwiched between the two layers leading eventually to bond failure.

Conclusions

In my practice, Protect Bond has become the workhorse for almost all my bonding needs. I like the idea of the speed and ease of the all-in-one systems, but Protect Bond does everything. It even bonds to self-cure composites without requiring an additional bonding component in the resin layer. It performs clinically as well as SE Bond and gives the additional peace of mind knowing that it is not only bactericidal on application but continuously bacteriostatic.

Whatever adhesive you choose to use, remember the most important thing: Read and follow the directions.

References

1. B. Van Meerbeek, M. Vargas, S. Inoue, Y. Yoshida, et al. (2001) *Adhesives and Cements to Promote Preservation Dentistry*, Operative Dentistry supplement 6, 2001, 119-144
2. Pashley, DH, (1992) *The effects of acid etching on the pulpodentin complex*, Oper Dent, 17:229-242
3. Tay FR, Gwinnett AJ, Wei SHY (1996) *Micromorphological spectrum from overdrying acid conditioned dentin in water free, acetone based, single bottle primers/adhesives*, Dent Mater 12: 236-244
4. Maciel, Carvalho (1996) *The effects of acetone, ethanol, HEMA, and air on the stiffness of Human Decalcified Dentin Matrix*, J. Dent. Res; vol 75, 1851-1858
5. Christensen, G, CRA Newsletter November 2003 and April 2005
6. Türkün SL (2003) *Clinical evaluation of a self-etching and a one bottle adhesive system at two years*, Journal of Dentistry, 31, 527-534
7. Tay, FR, Pashley, DH (2003) *Have Dentin Adhesives Become Too Hydrophilic?* J. of the Canadian Dental Assoc, Vol. 69, No. 11, 726-731



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Disclosure: Dr. Furuyama discloses having received an honorarium from Kuraray America, Inc.

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1. Wet bonding refers to:
 - a. Total etch technique of bonding to acid prepared dentin
 - b. Bonding to dentin that has been contaminated with saliva
 - c. Bonding to enamel even though it is not completely dry
2. Gluma, OptiBond FL, and Tenure are all examples of
 - a. Self-etch systems
 - b. Total-etch systems
3. The smear layer is incorporated into the hybrid layer in
 - a. Self-etch systems
 - b. Total-etch systems
4. “Naked fibrils” refers to
 - a. Decalcified collagen that is not infiltrated by resin tags in the self etch systems.
 - b. Decalcified collagen that is not infiltrated by resin tags in the total etch systems.
 - c. Resin tags that do not contain nanofillers even though nanofillers are incorporated in the hybrid layer.
5. True or False? Once the hybrid layer is cured fluids from the pulp can no longer penetrate the composite complex.
True
False
6. True or False? Using acetone as a solvent in the primer systems usually makes the placement of the primer less technique sensitive because it requires less steps to apply and evaporates quicker.
True
False
7. On an average, the length of the dental tags of the hybrid layer with total etch systems is:
 - a. 10-15 microns
 - b. 3-5 microns
 - c. 1-3 microns
8. True or False? Newer total etch systems with primers and bonding resin combined together (fifth generation) are generally weaker than total etch systems where the primer is applied in one step and the bonding resin in an additional step (fourth generation).
True
False
9. True or False? Leaving Chlorhexidine on the dentin improves the outcome because it kills microorganisms and strengthens the bond.
True
False
10. True or False? A total etch system is better for bonding when you have root caries because total etch gives the strongest bonds and is less apt to result in post op sensitivity.
True
False

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