Dentin Bonding
* Regardless of the type dentinal adhesive used, the primary mechanism for adhesion is still establishment of the hybrid layer. As seen below in the elegant TEM from Dr. Bart Van Meerbeek, the hybrid layer is a resin-reinforced layer that “connects” the underlying intertubular dentin to the adhesive resin (Fig. 1).

Figure 1

* For traditional dentin bonding techniques (etch-prime-bond) that require “wet bonding,” the dentin must not be dehydrated at the time of primer application, or bond strengths will be compromised.

Rewetting/Desensitization
* Probably the best way to desensitize the tooth when using a total-etch adhesive is to use Gluma Desensitizer, or one of the new Gluma-like materials (see examples listed below), as a rewetting agent. As seen in Fig. 2 below, the Gluma is placed after acid etching, but before placing the resin primer. The Gluma disinfects, seals the dentinal tubules, and also enhances bond strengths, because it is a very effective cross-linking agent. It may also reduce MMP activity. Gluma Desensitizer is particularly effective as a rewetting agent according to research reports (Li et al. JDR 2000; 79:509, Abstr # 2928), and results in profound concomitant desensitization. G5 by Clinician’s Choice, Calmit by Caulk or Microprime G from Danville are great, inexpensive Gluma substitutes for re-wetting that also afford great desensitization.
Bonding Systems

*Currently, four basic types of dentinal adhesives exist: Two total-etch (multi-bottle systems & one-bottle) and two self-etch systems (two-step and all-in-ones). The steps involved in each system are seen below in Figure 3.

**Multi-Bottle Systems**

* Classic multi-bottle adhesive systems such as and All Bond 2 (BISCO), OptiBond FL (Kerr), and Scotchbond MP Plus (3M ESPE), are still the “gold standards” in adhesive dentistry (Figure 4). Their clinical performance has been validated with clinical trials that reveal superior results when compared to virtually all subsequent adhesive systems. Newer versions of some of these materials have since been reintroduced, some in unidosed versions. Many are also now radiopaque.

**One Bottle Systems/Primer Types**

* Two primary primer types are used in DBA’s today: ethanol and acetone.

* Examples of ethanol-based one bottle DBAs include Adper Single Bond (3M ESPE), OptiBond Solo Plus (Kerr), and Excite (Vivadent). See Figure 5-A.

* Examples of acetone-based one bottle DBAs include One Step Plus (Bisco), Prime and Bond NT (Caulk), and Gluma Comfort Bond (Heraeus Kulzer). See Figure 5-B.

* For most one-bottle systems, the bond strengths are not as high as for their multi-bottle precursor. However, the differences are not thought to be clinically significant for most products.
**Self Etching Primers**

* Self-etching primers simultaneously condition (etch) and prime the dentin (and enamel?).

* Two primary types of self-etching primers exist:
  
  - Two-step, self-etch adhesives, where an acidic self-etch primer is used instead of phosphoric acid to etch the enamel and dentin, followed by the application of the adhesive.
  
  - One-step "all-in-one" adhesives where etching, priming and bonding occur simultaneously through application of the self-etch primer.

Examples of two-step self-etch materials include Clearfil SE Bond (Kuraray), Tyrian (Bisco), Adhese SE (Vivident). Examples of "all-in-one" self-etching primers include Adper Prompt L-Pop (3M-ESPE), Xeno IV (Caulk), i-Bond (Heraeus Kulzer), S3 Bond (Kuraray) and Optibond All-in-One (Kerr). Most other manufacturers are following suit with their own versions. (See Figures 6-A & B).

**Advantages of Self-Etching Primers:**

- Simple to use. Don't underestimate this quality. These are virtually "idiot proof."
- Eliminates variables associated with “wet bonding” (eg. how wet is wet? Etc.)
- Depth of etch is self-limiting.
- Sensitivity is reduced, even with incomplete coverage (smear plugs still intact in areas not covered).

**Disadvantages of Self-Etching Primers:**

- Bond strengths to enamel are typically lower than for total-etch adhesives.
- Clinical performance not yet time proven; bond durability questionable, especially for all-in-one types (hydrolysis?).

**NOTE:** The most important bond for clinical success is the enamel bond; problem is most self-etch materials do not offer great enamel bonds, especially to uncut enamel. If you elect to use a self-etch material, a “selective etch” of enamel with phosphoric acid is not a bad idea. However, total-etch systems used with a Gluma-type desensitizer are still best.
Good News! New Promising SE Systems are Being Introduced.

Fortunately, new very promising SE systems are being introduced that address the concerns regarding bonds to enamel and durability. 3M ESPE’s Universal Bond, and Kerr’s Optibond XTR are both very promising. Of particular note is the high bond strength exhibited by Optibond XTR to enamel (Swift et al., 2011). This material in particular is surprisingly effective based on studies to date. But as with all new materials, clinical validation is ultimately needed.

Compatibility with Self-Cured Composites

* As noted above for self-etching adhesives, categorically light-cured adhesives of any type that are inherently acidic are not very compatible with self-cured composites (Swift, et al. J Prosthodont 1998; 7:256-260 and Sanares et al. Dent Mater 2001; 17:542-556). For that reason, some adhesives offer dual-cured versions that consist of the adhesive and a self-cure activator that affords the resulting adhesive some compatibility with self-cured composites (core materials, etc.). BISCO's One Step Plus is one of the notable exceptions to this rule, since it is effectively neutral in pH and is compatible with both light and self-cured resin materials.

Stress Breaking Liners/Tooth Flexure

* Stress breaking liners are filled bonding agents or GIC liners that provide a thicker adhesive layer that can help resist polymerization or flexural stresses.

* Examples of stress breaking liners include: OptiBond Solo Plus (Kerr), Clearfil Liner Bond 2V (Kuraray), Vitrebond Plus (3M ESPE), and Fuji Bond LC (GC).

* Do teeth really flex? Yes, numerous studies have documented that teeth flex under centric and eccentric loading. For the restoration of Class V lesions, a material with a lower elastic modulus (eg. microfilled resins) that allows for better flexural qualities may perform better long-term in patients that exhibit evidence of stressful occlusion or parafunction. Elastic materials may better accommodate tooth biodynamics.

* Some more fluid flowable composites have favorable elastic qualities and the ability to “wet” tooth surfaces well. They, too, can be used as very effective stress breaking liners. However, if using flowable composites under packable posterior composites, KEEP THEM THIN (less than 0.5 mm thickness). Flowable composites exhibit as much as 2-3x the polymerization shrinkage of hybrids, higher CTE’s, and higher water sorption than hybrid composites.

* Based on clinical trials, it is clear that Class V retention failures are highest among patients exhibiting stressful occlusion (wear facets, history of bruxism, etc.) or who have highly sclerotic root surfaces.

* In “high risk” patients, Class V preparations should include additional retention form from placement of a gingival retention groove prepared with a No. ¼ round bur.

Lower durability when bonding to dentin compared with enamel:

* Despite improvements in dentin bonding agents, bonding to enamel is still far more predictable and durable long-term. When given the option (veneer preps, for example), always opt for preparations in enamel.


**Less predictable when bonding to caries affected or sclerotic dentin:**

**Great Sources for Objective, Unbiased Dental Information:**

*Dental Evaluation and Consultation Service or CES* (formerly the USAF Dental Investigation Service) See website: [https://decs.nhgl.med.navy.mil](https://decs.nhgl.med.navy.mil)

*Journal of Esthetic and Restorative Dentistry*
- Peer reviewed journal that is searchable on-line; included in Index Medicus; has impact factor.
- Features clinical, review and research papers on adhesive, esthetic and restorative dentistry with high quality color illustrations.
- Includes regular features such as "Contemporary Issues," "Critical Appraisal" that all include "Bottom Line," evidence-based information on products and techniques.


Harald O. Heymann, DDS, MEd, Editor-in-Chief
Ed Swift, DMD, MS, Associate Editor

**Speaker Info:**
Harald O. Heymann, DDS MEd
Professor, Department of Operative Dentistry
School of Dentistry
University of North Carolina
Chapel Hill, North Carolina 25799-7450
Bus. Tel. 919-537-3985

Email: harald_heymann@dentistry.unc.edu

**DISCLOSURE**
Dr. Heymann has no financial interest in any of the companies whose products are mentioned in this handout, but is a past consultant for Procter and Gamble and Colgate, and is a past scientific advisor for Clinician's Choice Dental Co. and his son is an employee of Sybron Kerr. Dr. Heymann is the paid Editor-in-Chief of the *Journal of Esthetic and Restorative Dentistry* noted above.