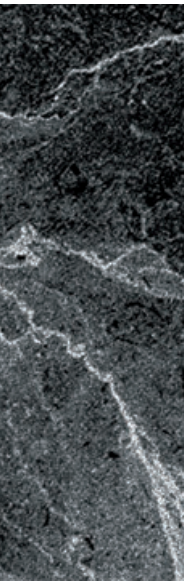

Ask the Experts

DENTIN/ENAMEL BONDING

Guest Expert
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QUESTION: Several different types of dentin/enamel adhesives are available and I am confused about which one(s) to use in my practice. Can you rate the various categories of resin-based adhesives for me?

ANSWER: Although some publications group resin-based dentin/enamel adhesives chronologically (i.e., from 1st to 7th generation), a classification according to the way various adhesives interact with the smear layer makes the identification of the bonding mechanism of each adhesive easier. This classification results in two bonding strategies and four types of adhesives:

1. Etch-&-rinse (or total-etch) adhesives include a separate acid-etching step, usually with 30–40% phosphoric acid applied simultaneously on enamel and dentin to remove the smear layer and superficial hydroxyapatite
   a. Three-step etch-&-rinse adhesives (acid + primer + bonding)
      Examples: Adper Scotchbond Multi-Purpose (3M ESPE, St. Paul, MN, USA); All-Bond 2 (Bisco Inc., Schaumburg, IL, USA); All-Bond 3 (Bisco Inc.); OptiBond FL (Kerr, Orange, CA, USA)
   b. Two-step etch-&-rinse adhesives (acid + primer/bonding)
      Examples: Adper Single Bond Plus (3M ESPE); ExciTE (Ivoclar Vivadent, Amherst, NY, USA); Opti-Bond Solo Plus (Kerr); Peak LC Bond (Ultradent, South Jordan, UT, USA); Prime & Bond NT (Dentsply Caulk, Milford, DE, USA); XP Bond (Dentsply Caulk)
2. Self-etch adhesives do not rely on a separate acid-etching step; they include an acidic monomer solution that is not rinsed off, making the smear layer permeable without removing it completely
   a. Two-step self-etch adhesives (acidic primer + bonding)
      Examples: AdheSE (Ivoclar Vivadent); Adper Scotchbond SE (3M ESPE), Clearfil SE Bond (Kuraray, Tokyo, Japan); Peak SE (Ultradent)
   b. One-step self-etch adhesives (one solution or all-in-one)
      Examples: AdheSE One F (Ivoclar Vivadent); Adper Easy Bond (3M ESPE), Clearfil S^3 Bond (Kuraray); G-Bond (GC America, Alsip, IL, USA); iBond SE (Heraeus Kulzer, Armonk, NY, USA);

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OptiBond All-In-One (Kerr); Xeno IV (Dentsply Caulk)

Laboratory (in vitro) studies with enamel/dentin adhesives are far more prevalent than clinical trials for several reasons, including the fact that laboratory tests are less time-consuming and less expensive. Therefore, a new version of a specific adhesive is often launched even before the previous one has been fully tested.[1,2]

In spite of being less abundant than laboratory studies, clinical trials are critical to test the effectiveness and durability of any dental material. With this in mind, I will try to answer your question by relying exclusively on the evidence provided by published clinical trials.

According to the 2001 American Dental Association (ADA) guidelines for enamel and dentin adhesive materials,[3] resin-based adhesives gain "provisional acceptance" at 6 months if their retention rate in non-carious cervical lesions (NCCL) is at least 95% without mechanical retention features. Full acceptance requires a 90% retention rate at 18 months. A systematic review by the Catholic University of Leuven research group[4] analyzed 85 peer-reviewed full papers and abstracts published between January 1998 and May 2004, which were focused on the clinical effectiveness of adhesives in NCCL. Their findings are summarized below:

1. The lowest annual failure rate (i.e., best retention rate) was shared by glass ionomer-based materials and three-step *etch-&-rinse* adhesives
2. The number of two-step *etch-&-rinse* adhesives that did not meet the ADA full acceptance guidelines was greater than that of three-step *etch-&-rinse* adhesives
3. Acetone-based *etch-&-rinse* adhesives had a tendency for lower retention rates than ethanol-based *etch-&-rinse* adhesives. The authors attributed this difference to the higher technique sensitivity of acetone-based adhesives
4. The three-step *etch-&-rinse* adhesive OptiBond FL (Kerr) was the gold standard for *etch-&-rinse* adhesives
5. The two-step *self-etch* adhesive Clearfil SE Bond (Kuraray) was the gold standard for *self-etch* adhesives
6. One-step *self-etch* adhesives had the highest annual failure rate (i.e., worst retention rate) of all types of adhesives studied

Several published clinical trials for the subsequent period between 2004 and July 2009 might be of additional clinical relevance for dentists:

1. A clinical trial of restorations in NCCL compared all four types of resin-based adhesives made by the same manufacturer.[5] Out of four different adhesives in the All-Bond (Bisco Inc.) family, only the three-step *etch-&-rinse* All-Bond 3 (93.5% retention rate at 18 months) met the ADA requirement for full acceptance
2. Another clinical study[6] in NCCL compared an ethanol-based two-step *etch-&-rinse* adhesive (Adper Single Bond, 3M ESPE) with an acetone-based two-step *etch-&-rinse* adhesive (One-Step, Bisco Inc.). Retention rates were higher for the ethanol-based adhesive than for the acetone-based adhesive. For example, the 36-month retention rates were 92.3 and 56.4%, respectively
3. A 2-year clinical study in posterior composite restorations[7] compared the two-step *etch-&-rinse* adhesive One-Step Plus (Bisco Inc.) with three one-step *self-etch* adhesives (Adper Prompt L-Pop, 3M ESPE; Clearfil S^3 Bond, Kuraray; and iBond, Heraeus Kulzer). Only the *etch-&-rinse* adhesive resulted in excellent marginal adaptation at 2 years. One of the *self-etch* adhesives, iBond, resulted in unacceptable clinical performance. Authors concluded that *etch-&-rinse* adhesives are still the benchmark for all adhesives

4. Clearfil SE Bond (Kuraray), a two-step *self-etch* adhesive, solidified its reputation as the reference against which all other *self-etch* adhesives are compared.[8–11] The retention rate for this material was excellent up to five years;† however, because of the primer's mild acidity, enamel marginal adaptation and discoloration remain a concern. Additional enamel etching resulted in an improved marginal adaptation at 5 years[10]
5. Although the one-step *self-etch* adhesive Clearfil S^3 Bond (Kuraray) did not meet (77.3% retention rate) the ADA 18-month full acceptance guidelines in one study in NCCL, it reached 93.4% retention rate in the same study when a coat of a hydrophobic resin was applied over the adhesive, transforming it in a two-step *self-etch* adhesive.[13] In the same study, iBond, a one-step *self-etch* adhesive, resulted in a 60% retention rate at 18 months. However, the retention increased to 83% when a coat of a hydrophobic resin was applied over the adhesive, also transforming it in a two-step *self-etch* adhesive
6. Although only a few studies have included resin-modified glass-ionomer-based (RMGI) materials, their retention rate is similar to that of three-step *etch-&-rinse* adhesives in studies up to 13 years.[11,14–17] In one study,[14] the 5-year retention rate in NCCL of the RMGI Vitremer (3M ESPE) was 96.4%, whereas that of ExciTE (Ivoclar Vivadent), a two-step *etch-&-rinse* adhesive, was 51.5%. In the 13-year study, the annual retention rate of Vitremer was 97.3%.[17] However, RMGI restorations tend to be less esthetic than composite restorations.

The findings of the most recent studies confirm the trend observed in the 1998–2004 systematic review: three-step *etch-&-rinse* adhesives still result in the best clinical outcome of all resin-based adhesives; one-step *self-etch* adhesives have not yet matched the clinical reliability provided by the other types of adhesives; and ethanol-based *etch-&-rinse* adhesives might be less technique-sensitive than acetone-based *etch-&-rinse* adhesives.

Newer does not always mean better. A giomer (Reactmer, Shofu Inc., Kyoto, Japan), one of the recent additions to the armamentarium of restorative materials available to clinicians, did not perform well in a 5-year clinical trial, as only 49% of the restorations were retained and had protruded out of the tooth, probably as a result of excessive water sorption.[18] On the contrary, at least one resin-based adhesive has outlasted its initial expectations. Two studies reported a retention rate of 89% at 12 years (with roughened dentin)[19] and 97% at 13 years for the original OptiBond adhesive.[20] In each study, dentin was etched for half of the restorations, but only enamel was etched in the others. Another 13-year follow-up reported an annual retention rate of 96.9% for OptiBond with enamel and dentin etching.[17]

†One study[12] reported a 10-year retention rate of 100% with Clearfil Liner Bond 2, a two-step self-etch adhesive with a primer based on a slightly different chemistry (phenyl-P molecule). However, the restorations were inserted in all types of classes (I to V) in which carious dentin was removed with the help of Caries Detector. Marginal integrity and adaptation deteriorated significantly over the study period.

REFERENCES

1. De Munck J, Van Landuyt K, Peumans M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res 2005;84:118–32.

2. Perdigão J, Carmo APR, Geraldeli S. Eighteen-month clinical evaluation of two dentin adhesives applied on dry vs. moist dentin. J Adhes Dent 2005;7:253–8.

3. ADA Council on Scientific Affairs. Revised American Dental Association acceptance program guidelines: dentin and enamel adhesives. Chicago (IL): American Dental Association; 2001. pp. 1–9.

4. Peumans M, Kanumilli P, De Munck J, et al. Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials. Dent Mater 2005;21:864–81.

5. Loguercio AD, Amaral RC, Stanislawczuk R, et al. A 18-month randomized clinical trial of four bonding strategies.

J Dent Res 2009;84:(Spec Iss A): abstract number 553. Available at: http://www.dentalresearch.org (accessed October 28, 2009).

6. Reis A, Loguercio AD. A 36-month clinical evaluation of ethanol/water and acetone-based etch-and-rinse adhesives in non-carious cervical lesions. Oper Dent 2009;34:384–91.

7. Perdigão J, Dutra-Corrêa M, Anauate-Netto C, et al. Two-year clinical evaluation of self-etching adhesives in posterior restorations. J Adhes Dent 2009;11:1–159.

8. Türkün ŞL. Clinical evaluation of a self-etching and a one-bottle adhesive system at two years. J Dent 2003;31:527–34.

9. Perdigão J, Carmo APR, Anauate-Netto C, et al. Clinical performance of a self-etching adhesive at 18 months. Am J Dent 2005;18:135–40.

10. Peumans M, De Munck J, Van Landuyt K, et al. Five year clinical effectiveness of a two-step self-etching adhesive. J Adhes Dent 2007;9:7–10.

11. Burrow MF, Tyas MJ. Three adhesive systems for the restoration of non-carious cervical lesions. Oper Dent 2007;32:11–5.

12. Akimoto N, Takamizu M, Momoi Y. 10-year clinical evaluation of a self-etching adhesive system. Oper Dent 2007;32:3–10.

13. Reis A, Leite TM, Matte K, Michels R, Amaral RC, Geraldeli S, Loguercio AD. Improving clinical retention of one-step self-etching adhesive systems with an additional hydrophobic adhesive layer. JADA 2009;140(7):877–85.

14. Franco EB, Benetti AR, Ishikiriama SK, et al. 5-year clinical performance of resin composite versus resin modified glass ionomer restorative system in non-carious cervical lesions. Oper Dent 2006;31:403–8.

15. Van Dijken JWV. Six-year evaluation of a RMGIC adhesive in Cl V lesions. J Dent Res 2004;83:(Spec Iss A): abstract number 2840. Available at: http://www.dentalresearch.org (accessed October 28, 2009).

16. Carvalho CAR, Fagundes TC, Barata TDJE, et al. 7-year clinical performance of restorative systems in non-carious cervical lesions. J Dent Res 2007;86:(Spec Iss A): abstract number 1582. Available at: http://www.dentalresearch.org (accessed October 28, 2009).

17. van Dijken JWV, Pallesen U. Long-term dentin retention of etch-and-rinse and self-etch adhesives and a resin-modified glass ionomer cement in non-carious cervical lesions. Dent Mater 2008;24: 915–22.

18. Ozer F, Unlu N, Gunal S. Five-year clinical performance of a glass-ionomer based restorative material. J Dent Res 2009;88:(Spec Iss A): abstract number 1001. Available at: http://www.dentalresearch.org (accessed October 28, 2009).

19. Wilder AD, Ritter A, Heymann H, et al. 12-year clinical evaluation of a dual-cured hydrophilic dental adhesive. J Dent Res 2008;87:(Spec Iss B): abstract number 0239. Available at: http://www.dentalresearch.org (accessed October 28, 2009).

20. Boghosian AA, Drummond JL, Lautenschlager E. Clinical evaluation of a dentin adhesive system: 13 year results. J Dent Res 2007;86:(Spec Iss A): abstract number 0228. Available at: http://www.dentalresearch.org (accessed October 28, 2009).

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Editor's Note: If you have a question on any aspect of esthetic dentistry, please direct it to the Associate Editor, Dr. Edward J. Swift, Jr. We will forward questions to appropriate experts and print the answers in this regular feature.

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