Critical Appraisal

OPTIONS FOR DENTIN/ENAMEL BONDING: PART II

Author and Associate Editor

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Four categories of resin-based dentin/enamel adhesives are currently available. These include the three-step etch-and-rinse, "one-bottle" etch-and-rinse, two-step self-etch primer systems, and "all-in-one" self-etch adhesives. In consecutive issues of the journal, the Critical Appraisal series will present salient publications on research in each of the categories. The first installment focused on the three-step etch-and-rinse systems and the series continues with this paper on the one-bottle etch-and-rinse systems.

THE EFFECT OF SIX YEARS OF WATER STORAGE ON RESIN COMPOSITE BONDING TO HUMAN DENTIN

R. Frankenberger, W.O. Strobel, U. Lohbauer, N. Krämer, A. Petschelt Journal of Biomedical Research Part B: Applied Biomaterials 2004 (69B:25-32)

ABSTRACT

Objective: This study evaluated the effects of water storage for up to 6 years on the push-out bond strength and marginal adaptation of several etch-and-rinse adhesive systems.

Materials and Methods: Midcoronal dentin discs (2-mm thick) were sectioned from 360 human third molars. A standardized cylindrical cavity was prepared into each dentin disc. The prepared discs were embedded in an extrusion device using a provisional restorative material. Specimens were assigned to eight groups of 45.

Composite resins were bonded into the preparations using these adhesive systems: Syntac Classic (Ivoclar Vivadent, Schaan, Liechtenstein), Syntac Classic preceded by etching with 36% phosphoric acid, A.R.T. Bond (Coltène, Alstätten, Switzerland), A.R.T. preceded by acid etching, Scotchbond Multi-Purpose Plus (3M ESPE, Seefeld, Germany and St. Paul, MN, USA), EBS (3M ESPE, Seefeld, Germany), Prime & Bond 2.0 (DeTrey Dentsply, Konstanz, Germany), and Syntac Single-Component (Ivoclar Vivadent). The first six systems listed were multistep systems with separate priming and bonding

steps. The final two adhesives were one-bottle systems with primer and bonding agent combined in a single solution.

The bonded specimens were stored in water at 37°C for 1 day, 90 days, or 6 years. They were thermocycled after storage and push-out bond strengths were determined using a universal testing machine.

From specimens scheduled for the 6-year push-out test, polyvinylsiloxane impressions were made after 1 day, 90 days, and 1, 2, 3, 4, 5, and 6 years. Epoxy replicas

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were cast from these impressions and evaluated with scanning electron microscopy (SEM) for marginal adaptation. An image analysis system was used to assess the presence or absence of gap-free margins. Marginal quality was calculated as the percentage of gapfree margins relative to the entire length of the margin.

Results: After 90 days of water storage, the bond strengths of all adhesives had remained stable relative to the initial 1-day test. However, the mean bond strengths of the two simplified systems, Prime & Bond 2.0 and Syntac Single-Component, were significantly lower than those of the more complex systems. After 6 years, all of the adhesives had undergone a significant reduction in bond strength. However, this was more pronounced for the one-bottle adhesives.

Specimens bonded with the threestep etch-and-rinse systems had significant deterioration in marginal quality between the 1- and 2-year evaluations. The deterioration was more rapid for the one-bottle adhesives, being already evident between the 90-day and 1-year evaluations. The deterioration for the onebottle adhesives continued to 3 years but was stable thereafter. Overall, the marginal quality after 6 years was worse for the one-bottle than for the three-step systems.

Conclusions: Resin-dentin bond strengths decrease significantly after 6 years of water storage. Etch-and-rinse multistep adhesives maintain higher bond strengths than the simplified one-bottle adhesives. Also, the multistep adhesives appear to be more resistant to water degradation and would be preferred in restorations that lack enamel margins.

COMMENTARY

At 6 years, this study is almost certainly the longest in vitro evaluation of resin-based adhesives. The materials tested represented an excellent cross-section of the materials that were available when the project was initiated. Two aspects of the adhesives were evaluated—dentin bond strengths and marginal quality.

As would be expected, bond strengths and marginal quality deteriorated over time for all of the adhesives. However, the degradation was more pronounced for the one-bottle systems than for the three-step systems. In their conclusions, the authors state that the three-step adhesives are the preferred choice for restoring cavities that lack enamel margins, and this conclusion is supported by the study that is reviewed next (but was published prior to the Frankenberger et al. study).

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FOUR-YEAR WATER DEGRADATION OF TOTAL-ETCH ADHESIVES BONDED TO DENTIN

J. De Munck, K. Van Landuyt, Y. Yoshida, S. Inoue, M. Vargas, K. Suzuki, P. Lambrechts, G. Vanherle *Journal of Dental Research* 2003 (82:136–40)

ABSTRACT

Objective: This study compared the bond strengths of two three-step

and two one-bottle etch-and-rinse adhesives systems after 24 hours and 4 years of storage in water. Materials and Methods: The occlusal dentin of 28 extracted human molars was exposed and

polished to 600-grit to create standardized smear layers. Specimens were assigned to four groups for treatment with the three-step adhesives: OptiBond Dual-Cure (Kerr Corporation, Orange, CA, USA) or Scotchbond Multi-Purpose (3M ESPE), or the simplified ("one-bottle") versions of these materials, OptiBond Solo (Kerr) or Scotchbond-1 (known as Single Bond outside Europe, 3M ESPE).

Composite was applied and cured, and the bonded specimens were stored in water at 37°C for either 24 hours or 4 years. Before water storage, half of the teeth to be stored for 4 years were sectioned so that the resin-dentin interface was exposed to water. The others were sectioned just prior to testing. Microtensile bond strengths were determined using a standard method (hourglass-shaped specimens fractured using a mechanical testing device). Failure modes were evaluated using field-emission scanning electron microscopy and digital image analysis. Representative specimens were processed for evaluation with transmission electron microscopy.

Results: At 24 hours, the mean bond strength of OptiBond Dual-Cure was significantly greater than that of OptiBond Solo (53.6 MPa versus 34.8 MPa); Scotchbond Multi-Purpose and Scotchbond-1 were not significantly different (at 52.2 MPa and 45.6 MPa, respectively).

Indirect exposure of the resindentin interface (i.e., the interface was protected by composite and enamel) did not cause a reduction in bond strengths of any adhesive after 4 years. In contrast, when the resin-dentin interface was directly exposed to water, the bond strengths of both one-bottle adhesives decreased significantly. Reductions in the bond strengths of the three-step systems were not significant, with OptiBond Dual-Cure being particularly unaffected. The proportion of adhesive failures increased with increasing degree of water exposure.

Conclusions: Resin bonded to enamel protects resin-dentin interfaces, but direct exposure to water degraded bonds produced by one-bottle adhesives.

COMMENTARY

This is an interesting study because it is one of the few and one of the first to evaluate dentin bond strengths after an extended period of time. The most important finding was related to the protective effect of enamel on resin-dentin bonds. When resindentin interfaces were protected against direct exposure to water by resin bonded to enamel, bond strengths of the four adhesives tested declined only slightly after 4 years of storage in water. However, when the resin–dentin interfaces were directly exposed to water, the bond strengths of the one-bottle adhesives declined significantly.

Therefore, the study raises two obvious questions. First, do the three-step total-etch adhesives provide more durable bonds than their simplified counterparts? The results suggest that the answer is yes, they do. Also, is the resin– dentin interface as stable as the resin–enamel interface? The results suggest that it is not and that resin–dentin margins are much more likely to degrade than are resin–enamel margins.

It should be noted that OptiBond Dual-Cure is no longer available. However, a similar adhesive, Opti-Bond FL, remains available, as do the other three adhesives tested in this study.

INFLUENCE OF ENAMEL BORDER AND REGIONAL VARIABILITY ON DURABILITY OF RESIN—DENTIN BONDS

G.P. Gamborgi, A.D. Loguercio, A. Reis Journal of Dentistry 2007 (35:371-6)

ABSTRACT

Objective: The purpose of this study was to test the hypothesis that an adjacent composite–enamel bond protects the composite– dentin bond against degradation (similar to the De Munck et al. study reviewed above) and that degradation is not related to location of the dentin (peripheral versus central).

Materials and Methods: Thirty extracted teeth were assigned to six groups of five. The occlusal enamel of each tooth was ground off, and the flat dentin surface was polished to 600-grit, forming a standardized smear layer. Half of the specimens were restoring using Single Bond (3M ESPE), a one-bottle etchand-rinse system, and half were restored using Scotchbond Multi-Purpose Plus (3M ESPE), a threestep etch-and-rinse system. A moist bonding technique was used for both adhesives: the dentin was dried and then re-wet with a controlled volume of water. Composite "crowns" were built up on each bonded surface.

Following storage in distilled water at 37°C for 24 hours, five specimens of each adhesive were sectioned into rectangular sticks with a cross-sectional area of 0.8 mm². Another five specimens were sectioned into sticks only after the enamel had been removed and they had been stored in water for 6 months. The five specimens of each adhesive were stored in water, with the enamel intact, for 6 months before they were sectioned. In each case, sections were identified as having come from the peripheral or inner aspect of a specimen. Microtensile bond strength testing (MTBS) was accomplished using a universal testing machine. Bond failures were examined at 400x magnification.

Results: For Scotchbond Multi-Purpose, mean MTBS values ranged from 29.4 MPa to 33.0 MPa in peripheral dentin specimens. With inner dentin, the means ranged from 35.5 MPa to 45.3 MPa. In each location, differences were not statistically significant.

For Single Bond, the mean MTBS values for both peripheral and inner dentin specimens were significantly lower for the specimens that had been directly exposed to water for 6 months. The mean MTBS of 24-hour inner dentin specimens was 49.0 MPa. The

mean for inner dentin specimens protected by enamel was almost identical, at 48.3 MPa. However, when the dentin was directly exposed to water for 6 months, the mean was only 35.5 MPa. The findings were similar for peripheral dentin.

Conclusions: Direct exposure to water significantly decreased the dentin bond strength of a two-step etch-and-rinse adhesive but did not affect the bond strength of a threestep system. The location of the dentin did not have a consistent effect on bond strength.

COMMENTARY

This study confirms previous research (De Munck et al., 2003) showing that a border of resinbonded enamel protects the resin bond to dentin. Of the two etchand-rinse adhesives tested, the onebottle system was more susceptible to degradation than the threestep system when dentin was not surrounded by enamel during prolonged exposure to water. Degradation might be caused by hydrolysis or enzymatic breakdown of collagen fibers that are not completely coated with resin or perhaps by deterioration of the resin material itself. The most

pertinent clinical implication of this study relates to Class II posterior composite restorations in which the weak link is the gingival margin and where the presence of enamel is critical to long-term success of the restoration.

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AN EIGHT-YEAR CLINICAL EVALUATION OF FILLED AND UNFILLED ONE-BOTTLE DENTIN ADHESIVES

A.V. Ritter, E.J. Swift, H.O. Heymann, J.R. Sturdevant, A.D. Wilder *Journal of the American Dental Association* 2009 (140: 28–37)

ABSTRACT

Objective: The purpose of this study was to evaluate the 8-year clinical performance of a filled and an unfilled one-bottle adhesive used to restore noncarious cervical lesions without retention grooves or enamel bevels.

Materials and Methods: The adhesives tested in this study were OptiBond Solo (Kerr) adhesive and Prime & Bond 2.1 (Dentsply Caulk, Milford, DE, USA). OptiBond Solo was an ethanol-based adhesive that was filled approximately 25% by weight with barium glass and silica. Prime & Bond 2.1 was an unfilled acetone-based adhesive. (Both materials have been superseded by newer productsOptiBond Solo Plus and Prime & Bond NT, respectively.)

Seven operators restored approximately 100 noncarious cervical lesions under isolation with cotton rolls and retraction cord. Tooth preparation was limited to producing a definite finish line where needed; no bevels or mechanical retention were placed. The composite restorative materials were applied and light cured incrementally.

The restorations were evaluated after 6 months, 18 months, 3 years, and 8 years of clinical service and were rated according to standard modified USPHS (United States Public Health Service) criteria. Although eight criteria were evaluated, the primary outcome variables were restoration retention, marginal integrity, and marginal discoloration.

Results: The 8-year recall rate was 57%. The cumulative retention rates were 65.6% for OptiBond Solo and 60.6% for Prime & Bond 2.1. The difference was not statistically significant. These retention rates had declined from the 3-year rates of 93.3% and 89.4%, respectively. Marginal integrity and discoloration worsened progressively over time, but differences between the two materials were not significant.

Conclusions: Despite a relatively high rate of marginal discoloration, both of the adhesives tested in this study provided reasonably good clinical restoration retention without mechanical retention.

COMMENTARY

This study is among the longest clinical trials of dentin adhesives yet published. The original purpose of the study was to determine whether there was any difference in performance of filled and unfilled one-bottle adhesives. The authors concluded that the filled adhesive might have provided slightly better dentin bond durability but acknowledged that the difference was not statistically significant.

The most relevant aspect of this study is its length; 8-year recalls in this area are uncommon. A 12-year study from the same group (reviewed in the previous issue of the *Journal*) reported a retention rate of 93% for a filled three-step etch-and-rinse adhesive. Thus, while the one-bottle adhesives evaluated in this study performed reasonably well, they were certainly less effective than the three-step "gold standard."

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THE BOTTOM LINE

- As noted in Part I of this series, the three-step etch-and-rinse adhesives are considered the gold standard for bonding resin-based materials to tooth structure.
- The dentin bond of one-bottle etch-and-rinse adhesives is less durable than that of three-step systems.
- The durability of etch-and-rinse adhesives, particularly the one-bottle type, is better when the dentin is surrounded by a bonded resin–enamel rim.

Editor's Note: We welcome readers' suggestions for topics and contributors to Critical Appraisal. Please address your suggestions to the section editor:

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