Critical Appraisal

ADHESIVE-COMPOSITE INCOMPATIBILITY, PART I

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Apart from some questions related to the repairability of resin composite restorations, dentists have always assumed that methacrylate-based resins are compatible with each other. For example, there is no clinically relevant problem in using a microfilled composite to laminate a Class IV restoration made with a hybrid composite, even if they are not of the same brand or manufacturer. In the context of adhesive systems, we have always believed that resin composites, regardless of their type or composition, bond well to all types of bonding agents. However, unexpected debonding of self-cured, core buildup composites that had been bonded with single-bottle adhesive systems was reported about 5 years ago. Subsequent studies demonstrated that there were, indeed, compatibility problems between simplified adhesive systems and self- or dual-cured resin composites. Apparently, when such combinations are used, reduced bond strengths and subsequent failures at the resin-adhesive interface can occur because of adverse reactions between the acidic resin monomers, an integral part of the simplified adhesive systems, and the chemicals involved in the polymerization mechanism of the self- or dual-cured composites, particularly the basic tertiary amines.

At least one research group has expanded the information on this issue by further investigating the mechanisms involved in this phenomenon. This group demonstrated that not only adverse chemical reactions but also the permeability of such simplified systems contribute to the compromised bonding. This issue has profound clinical implications in view of the wide use of self- and dual-cured composites as core buildup materials and in the bonding of indirect restorations and endodontic posts. Some of the most representative studies of this group are described in this Critical Appraisal. Part II will appear in the next issue of the Journal.

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ADVERSE SURFACE INTERACTIONS BETWEEN ONE-BOTTLE LIGHT-CURED ADHESIVES AND CHEMICAL-CURED COMPOSITES

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ABSTRACT

Objective: This study examined the effect of four one-bottle adhesives with different acidities on the microtensile bond strength of chemical-cured and light-cured resin composites to dentin. It also compared the ultrastructural features observed in specimens that had adhesive failures in both curing modes.

Materials and Methods: Flat dentin surfaces were prepared in 24 noncarious, human third molars. Teeth were randomly assigned for bonding with one of four adhesives: Prime & Bond NT (Dentsply De Trey, Konstanz, Germany), OptiBond Solo (Kerr Corporation, Orange, CA, USA), Single Bond (3M ESPE, St. Paul, MN, USA), and One-Step (BISCO Inc., Schaumburg, IL, USA). The adhesives were applied according to their respective manufacturers' instructions. Each adhesive group was further divided into two subgroups, based on the curing mode of the resin composite used. Z100 light-cured composite (3M ESPE) was employed in subgroups LC and the BisFil 2B chemical-cured composite (BISCO) in subgroups CC. Resin composite buildups were constructed on each tooth to form a core 5 mm in height, and the specimens were stored at 37°C for 24 hours. After storage, the specimens were serially sectioned in the x and y directions to produce beams with cross-sectional areas of approximately 0.81 mm^2. Beams were tested in tension at a crosshead speed of 1 mm/min. Failures were classified as adhesive, mixed, or cohesive. Bond strength data were analyzed using a two-way analysis of variance design and a post hoc test. Four fractured beams of each subgroup that were initially classified as adhesive failures were prepared for scanning electron microscopy (SEM). Additionally, the pH of the adhesives was measured.

Results: Significant differences were observed for the dentin adhesive and curing mode factors ($p < .01$), as well for the interaction between these two factors ($p < .01$). The microtensile bond strengths of the different adhesive systems bonded with light-cured composites were not significantly different ($p > .05$). However, bond strengths were significantly lower when these adhesives were used with chemical-cured composites. Of the chemical-cured subgroups, One-Step had the highest mean microtensile bond strength (33.1 MPa) and Prime & Bond NT had the lowest (5.4 MPa). OptiBond Solo and Single Bond were intermediate and not significantly different from each other. A linear relationship was observed between the pH of the adhesives and their mean microtensile bond strength when bonded to the chemical-cured composite. A significant positive correlation was detected between the two variables ($r^2 = .92$). Failure analysis showed that failures occurred predominantly along the composite-adhesive interface. Scanning electron microscopic observation showed globular structures and microporosities on the adhesive surface and voids within the chemical-cured composite.

Conclusions: Bond strength of one-bottle adhesives was negatively affected by the use of a chemical-cured composite resin. Ultrastructural features suggested the presence of a surface interaction between the one-bottle adhesives tested and the chemical-cured composite. The strong relationship between the low pH of the adhesives and the reduced bond strengths suggested that the surface interactions are probably related to an incompatibility between the initiator components in the uncured, acidic resin monomers contained in the oxygen inhibition layer of the adhesive and initiator components in the chemical-cured composite.

COMMENTARY

This is the first study that described a hypothetic mechanism to explain the phenomenon of incompatibility between simplified adhesives and

self-cured composites. The authors provided strong evidence that the uncured acidic monomers present in the oxygen-inhibited layer interact with the basic initiators of the resin, consuming them and preventing them from generating free radicals that are required to properly polymerize the resin layer that is in contact with the adhesive. Reductions in bond strength with chemical-cured composite were in the order of 45 to 90%, which could easily explain the previously reported debonding of self-cured resin cores.

SINGLE-STEP ADHESIVES ARE PERMEABLE MEMBRANES

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ABSTRACT

Objectives: This in vitro study tested the null hypotheses that (1) prolonged contact of light-cured resin composite to cured single-step adhesives before light-activation does not result in compromised bond strengths to sound, hydrated dentin; and (2) the presence or absence of water on the substrate side of the bonded interface of single-step adhesives does not affect the results of delayed activation of a light-cured composite.

Materials and Methods: Bonding to dentin was performed on deep coronal dentin surfaces of extracted human third molars.

Experiment 1. Twenty-eight teeth were used in this part of the study. They were randomly divided into seven groups of four teeth each. All were bonded in their normal hydrated status. The adhesives tested were a three-step total-etch control and six simplified systems:

1. All-Bond 2 (BISCO Inc., Schaumburg, IL, USA)—control
2. One-Up Bond F (Tokuyama, Tokyo, Japan)
3. Etch & Prime 3.0 (Degussa, Hanau, Germany)
4. Xeno CF Bond (Dentsply Sankin, Tokyo, Japan)
5. AQ Bond (Sun Medical, Shiga, Japan; also marketed in North America as Touch & Bond by Parkell Inc, Farmingdale, NY, USA)
6. Reactmer Bond (Shofu, Kyoto, Japan)
7. Prompt L-Pop (3M ESPE, St. Paul, MN, USA)

Each adhesive group was further divided into two subgroups of two specimens each, based upon the contact time of the resin composite with the cured adhesive layer prior to light activation. In one subgroup the first layer of composite was light cured immediately. In the other subgroup, the first layer of composite was left in the dark for 20 minutes before being light cured.

Experiment 2. Three single-step "all in one" adhesives (Etch & Prime 3.0, Xeno CF Bond, and AQ Bond) were similarly bonded to completely dehydrated dentin using the same delayed light-activation protocol. Dehydrated dentin was obtained by passing the tooth crowns through a series of ascending ethanol concentrations up to 100%.

Experiment 3. A piece of processed composite was used as the bonding substrate for the same three single-step adhesives used in experiment 2. The composite was applied to the cured adhesives using the same immediate and delayed light-activation protocols.

After storage in water for 24 hours at 37°C, bonded specimens from experiments 1 and 2 were prepared for microtensile bond strength testing with a cross-sectional area of approximately 0.9×0.9 mm^2. In experiment 3, each slab obtained was hand trimmed to 0.9×0.9 mm^2. Specimens were tested in tension using a universal testing machine (Model 4440, Instron Corporation, Canton, MA, USA) at a crosshead speed of 1 mm/min.