Failure modes were recorded as adhesive, mixed, or cohesive failures in either dentin or resin.

Results: When bonded to hydrated dentin, delayed light activation had no effect on the control three-step adhesive but significantly reduced the bond strengths of all simplified adhesives ($p < .05$). This adverse effect of delayed light activation was not observed for the three single-step adhesives that were bonded to either dehydrated dentin or processed composite. Morphologic manifestations of delayed light activation of composite in the hydrated dentin bonding substrate were exclusively located along the composite-adhesive interface and were present as large voids, resin globules, and honeycomb structures that formed partitions around a myriad of small blisters along the fractured interfaces.

Conclusion: As delayed light activation of resin composite adversely affected only the bond strengths of hydrated dentin bonded with single-step adhesives but not the control three-step adhesive (experiment 1), the authors rejected the first null hypothesis. The cured adhesive layer in single-step adhesives might act as a semipermeable membrane that allows water diffusion from the bonded hydrated dentin to the intermixed zone between the adhesive and the uncured composite. Osmotic blistering of water droplets along the surface of the cured adhesive layer and emulsion polymerization of immiscible resin components probably account for the compromised bond strength in single-step adhesives after delayed activation of light-cured composites.

COMMENTARY

This study is interesting in its approach to investigate the phenomenon of adhesive-composite incompatibility. The authors used several self-etch adhesives that are more acidic than total-etch, single-bottle adhesives. As a control, they used a three-step total-etch adhesive that includes a final layer of a nonacidic resin to be in contact with the composite. Based on the assumption that adverse interactions that occurred with self-cured composites could be enhanced because of the slow-setting reaction, the authors employed a light-cured composite but delayed its activation to permit reactions between its components and the acidic monomers of the adhesives. Additionally, they strategically used dehydrated dentin and processed composite to investigate the role of the water.

The major finding of this work was that adverse chemical interactions between acidic adhesives and resin composites are not the only factor that may compromise bonding. Simplified acidic adhesives function as permeable membranes that allow water from hydrated dentin to migrate across the adhesive layer and accumulate at the adhesive-composite interface. This water movement is driven by an osmotic gradient generated by the prolonged contact of the uncured resin with the adhesive. Penetration of water into the interface represents an additional factor (besides the interaction of the acidic monomers and tertiary amines) contributing to incompatibility of specific adhesives and self- and dual-cured composites.

ADHESIVE PERMEABILITY AFFECTS COUPLING OF RESIN CEMENTS THAT UTILISE SELF-ETCHING PRIMERS TO DENTINE

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ABSTRACT

Objective: This study examined the effect of adhesive permeability on the coupling of resin cements that employ self-etching primers for bonding to dentin. The null hypothesis tested was that the use of a more hydrophobic resin coating would have no effect on the

coupling of either resin cement to hydrated dentin.

Materials and Methods: Extracted human third molars were sectioned to produce middle to deep dentin surfaces. Dentin was polished with silicon carbide abrasive papers to create standard smear layers. The teeth were divided into four experimental groups of seven teeth each. For each group, two teeth were used for examination with transmission electron microscopy (TEM) and the other five teeth for microtensile bond strength evaluation and fractographic analysis using SEM. The four experimental groups were as follows:

1. Panavia F (Kuraray, Tokyo, Japan), with dentin treated using self-etch ED primer, according to the manufacturer's instructions.
2. Panavia F, with the primed dentin covered by a layer of low-viscosity bonding resin (LVBR) (Scotchbond Multi-Purpose Plus Adhesive, 3M ESPE, St. Paul, MN, USA). This adhesive contains dimethacrylate, 2-hydroxyethyl methacrylate, and a blend of amine initiators to render it compatible with auto- or dual-cured composites. The resin coating was air thinned and light cured prior to the coupling of the resin cement.
3. Bistite II DC (Tokuyama, Tokyo, Japan), with dentin treated using its two-step self-etching primer according to the manufacturer's instructions.
4. Bistite II DC, with the primed dentin covered by a layer of LVBR. The bonded resin was similarly air thinned and light cured prior to the coupling of the resin cement.

Composite blocks were produced using a heat- and light-activated hybrid resin composite (Tescera, BISCO Inc., Schaumburg, IL, USA). After processing, the composite blocks were reduced to approximate the dimensions of the teeth to be bonded and were sectioned to produce 3 mm thick, parallel-sided composite overlays. The intaglio surface of each composite block was sandblasted and silane treated. The resin cements were mixed according to manufacturer's directions and placed on the treated surface of the composite. The resin blocks were then luted to the treated tooth surfaces.

The bonded assemblies were stored for 24 hours in water and subsequently were prepared for microtensile bond strength testing. Beams of approximately 0.8 mm^2 were tested in tension at 0.5 mm/min. Fractured surfaces were examined using SEM. Additional specimens were prepared and examined with TEM using a silver nitrate staining technique.

Results: The results demonstrated that the self-etching ED primer permitted water-induced interfacial changes that resulted in lower cement-dentin bond strengths. By covering the primed dentin with a more hydrophobic adhesive layer, these interfacial changes did not occur and the bond strengths increased 35%. When bonded according to manufacturer's directions, Panavia F produced bond strengths that were significantly lower than those of Bistite II DC. The placement of an additional layer of a LVBR significantly improved the bond strengths of Panavia F but not those of Bistite II DC. There were no differences between results with the manufacturer's recommended protocol and with the use of an additional resin coating for Bistite II DC. SEM observation of the fractured surfaces in Panavia F showed rosette-like features that were exclusive for specimens bonded according to manufacturer's instructions. The application of the additional layer of the LVBR reduced the amount of silver impregnation for both adhesives, suggesting that reduced permeability of the adhesives resulted in improved coupling of the resin cements to dentin.

Conclusion: Placement of an intermediate LVBR layer between the bonded dentin surface and the resin cements resulted in improved coupling of Panavia F to dentin.

COMMENTARY

This study corroborates the findings that both acidity and permeability of simplified, self-etch adhesives are characteristics that make them

incompatible with self- and dual-cured composites. It is interesting to note that although the manufacturer claims that Panavia must be luted on contact with ED primer because these products possess a complementary polymerization reaction, significantly higher bond strengths were obtained when an intermediary layer of a LVBR was placed between them. The authors of this Critical Appraisal have demonstrated that bond strengths of Panavia to dentin were significantly improved when Clearfil SE Bond (a two-step self-etch adhesive) was used instead of ED primer (unpublished results). Apparently, the placement of an intermediate layer of a relatively hydrophobic, nonacidic resin prevents the adverse interaction of acidic monomers with the self-/dual-cured composites and the migration of water from dentin underneath to the resin-adhesive interface. The use of an intermediate layer of a nonacidic resin supports the favorable results obtained with three-step total-etch adhesives in previous studies.

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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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The Bottom Line feature and Suggested Readings will follow in Part II of the series.