CLINICAL materials REVIEW

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The Use of Resin-Modified Glass Ionomer Liners Under Composite Resins: Should They be Used to Help Control Microleakage?

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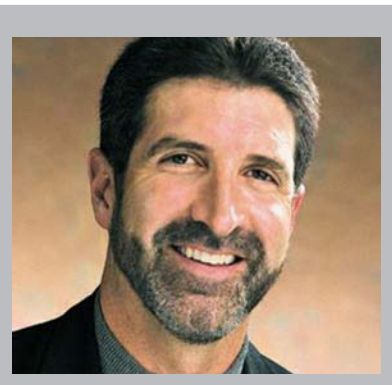

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Specific direct resin composites have been shown to be reasonably predictable alternatives to amalgam, assuming they are utilized in the appropriate clinical situation and are properly placed. In fact, the increasing demand for tooth-colored restorations, conservation of tooth structure, and cosmetic dental procedures has encouraged the widespread use of these restorations.[1,2]

The clinical success of direct composites is due in part to material improvements and dramatic advances in adhesive technology.[3] However, like all dental restorations, the long-term success of direct composites is contingent upon many factors, including their ability to resist microleakage. Inadequate marginal sealing can contribute to secondary caries, marginal staining, sensitivity, pulpal involvement, breakdown of the adhesive interface, and eventual restoration failure. While current adhesive techniques and materials have the potential to virtually eliminate microleakage at the enamel/restoration interface, consistent and long-term control of microleakage at the dentin/restoration interface is still a significant clinical challenge (Figures 1 through 4).

DENTIN VS. ENAMEL

The reason clinicians can generally bond so predictably to enamel, but not nearly as predictably to dentin, is because of the morphologic, histologic, and compositional differences between the 2 substrates.[4] Dentin is a highly variable substrate. Superficial, middle, and deep dentin can be quite different in their structural and chemical composition.[5] Enamel, on the other hand, is quite consistent throughout and is also a significantly more mineralized tissue than dentin. The inorganic content of mature enamel is approximately 96% hydroxyapatite by weight, the remainder being water and organic material. Dentin is approximately 70% hydroxyapatite by weight, 18% organic material (mainly collagen), and 12% water.[6] These percentages are not consistent and can vary significantly depending upon a number of factors, including dentin depth, age of the teeth, and history of tooth trauma and/or pathology.[7] This, coupled with the relatively high water content of dentin, presents a significant challenge for consistent and reliable long-term bonding. This is not to say that clinicians cannot generate stable and strong initial bonds to dentin. On the contrary, numerous studies have shown that many current adhesive systems are capable of producing bond strengths to dentin that equal or surpass those of acid-etched enamel controls.[8-12]

The problem is that most of these are short-term studies (i.e., often 24 hours), and clinicians need to think long-term. It is of concern that the literature is replete with longer-term studies (both in vitro and in vivo) that demonstrate a worrisome trend toward eventual breakdown of the dentin/adhesive interface.[13-19] The clinical problem of porcelain veneers sometimes de-bonding over time when preparations are largely in dentin (Figures 5 and 6) may be attributed to the variability in bonding to dentin. In contrast, rarely is veneer de-bonding a problem when preparations are largely in enamel.

When a Class II composite fails clinically due to recurrent caries, the failure is rarely at the enamel/restorative interface. This author has observed that it is frequently at the dentin and/or cementum interface with the composite where the failure occurs. While today's dentin bonding agents have come a long way and are generally very good, perhaps they are not quite as good as we think they are, at least over the long term. Microleakage, nanoleakage, hydrolysis, dentin permeability, pulpal pressure, shrinkage stress, "water tree" formation, insufficient hybrid layer formation, phase separation, dentin tubule orientation, occlusion, enzymes released by bacteria, and operator error have all been implicated as potential causes of

Figure 1 View of the intaglio surface of a displaced laboratory-processed composite onlay that de-bonded 8 years after placement with a 3-step total-etch system and dual-cure luting resin. I have seen this sometimes happen, over time, with all classes of dentin bonding agents.

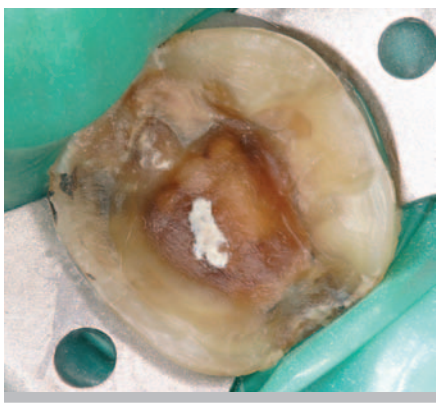


Figure 2 Tooth preparation of the failed onlay is isolated with a rubber dam.

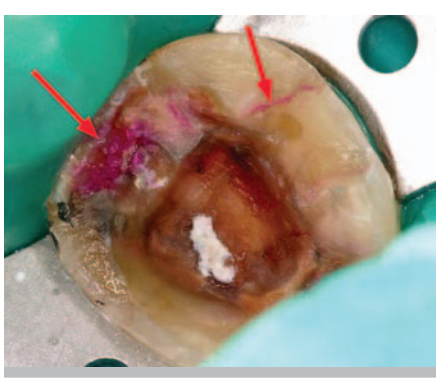


Figure 3 Caries detecting solution indicates significant microleakage at the interproximal dentin/cementum margin. A crack in the enamel is also visualized and a potential source of microleakage. The tooth was restored with a porcelain-fused-to-metal (PFM) crown.

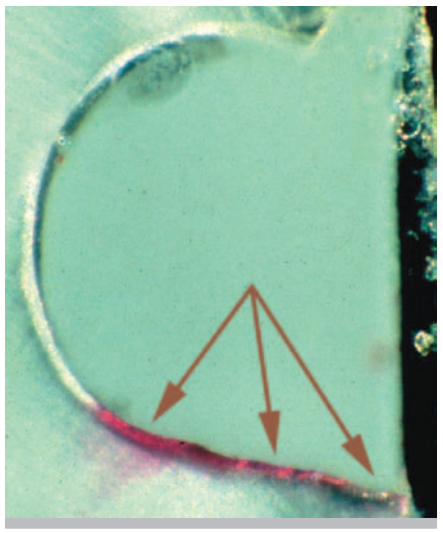
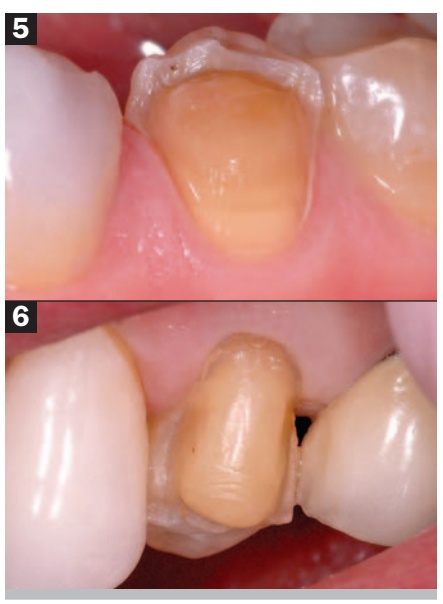


Figure 4 View of the leakage pattern often observed in Class V microleakage testing. Rarely is leakage observed at the enamel margin. Leakage is frequently found at the dentin and/or cementum interface with the restorative material.



Figures 5 and 6 Preparations of porcelain veneers that de-bonded approximately 5 years after placement. The preparations are largely in dentin. The luting resin was left on the inner surface of the veneers, indicating failure of the adhesive interface with the tooth tissues. While occlusion could be a contributing factor, problems such as this are considerably more likely in aggressive preparations that expose significant amounts of dentin.

deterioration of the dentin/adhesive interface over time.[2,15,18,20-25]

MINIMIZING MICROLEAKAGE AND/OR NANOLEAKAGE

While it appears there could be many reasons the dentin/adhesive interface might fail, I personally believe that microleakage and/or nanoleakage are of major significance. I have also come to the disappointing conclusion that dentin bonding agents, in and of themselves, cannot predictably prevent long-term microleakage. I do not make this statement lightly. I base my assumption on personal testing, years of careful clinical observation, the reading of hundreds of research papers, and discussions with dozens of friends and colleagues actively involved with adhesive and materials research. Recent and very comprehensive literature reviews by Hilton, DeMunck, and Ferrari strongly support my position.[18,26-28]

The question then, as it relates to this article, is: What clinical protocols can help us minimize microleakage when placing direct composites? One common clinical technique thought to reduce microleakage when placing direct composite restorations is the use of flowable composites. With this technique, a flowable composite—which is minimally filled—is placed in a thin layer after a dentin bonding agent has been placed but prior to placing a more heavily filled composite restorative (Figure 7). In principal, flowable composites, by virtue of their low viscosity, are able to get into all of the "nooks and crannies" of the preparation. This may facilitate the adaptation of the higher viscosity composites that are subsequently placed. One could also argue that flowable composites, which have a relatively low modulus of elasticity (i.e., they are flexible), are able to act as stress reducing liners. However, this potential benefit could be offset by increased polymerization shrinkage stress due to the significant amount of unfilled resin found in flowables relative to filler load.[29] The literature is equivocal regarding the use of flowables under direct composite restorations in terms of reducing microleakage, with some studies strongly supporting this technique and others showing no benefit.[30-35] Irregardless of the research, this technique has been used with generally good success by many dentists, including me. With that said, I personally believe there is yet a better alternative.

Figure 7 A heavily filled composite restorative is placed over a thin layer of translucent shade flowable. A dentin bonding agent was placed and cured prior to placement of the flowable composite.

My personal belief is that the utilization of resin-modified glass ionomers is the easiest and most predictable way to manage microleakage under direct composites. The literature is replete with in vivo and in vitro studies supporting this belief.[35-48] I specifically like resin-modified glass ionomer liners that require no preconditioning of the dentin prior to use (e.g., Vitrebond™, 3M™ ESPE™, St. Paul, MN; Fuji Lining™ LC, GC America, Inc., Alsip, IL). These resin-modified glass ionomer liners have the ability to both micromechanically and chemically interact with dentin.[49] They are easy to mix and place, release high sustained levels of fluoride,[50] have antimicrobial properties,[51,52] have very low solubility,[53,54] and have a favorable modulus of elasticity and coefficient of thermal expansion and contraction (i.e., similar to that of dentin).[55] There is also anecdotal evidence from clinicians reporting a significant reduction in postoperative sensitivity after switching from flowable composite to resin-modified glass ionomer liners. It is hard to tell if these reports are due to the specific properties of resin-modified glass ionomers or differences in technique sensitivity during placement. The success of a flowable composite's bond to dentin is highly contingent upon the operator's

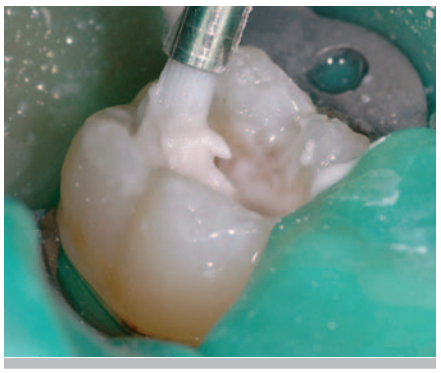
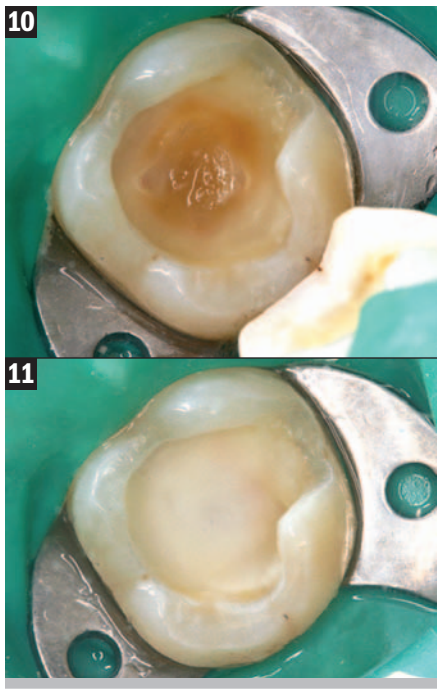


Figure 8 Prior to placing the resin-modified glass ionomer, I like to clean the preparation with a water/pumice mix (Pumice Preppies) on an ICB Brush. Wash thoroughly with an air/water spray and briefly dry.

Figure 9 Box areas in Class II restorations and locations where the external preparation margin ends in dentin and/or cementum are particularly vulnerable to microleakage. In this preparation, Vitrebond has been placed in the box area prior to treatment with a dentin bonding agent.



Figures 10 and 11 In this very deep preparation, virtually all of the exposed dentin has been covered with the resin-modified glass ionomer prior to placing the adhesive system.

ability to first correctly place a dentin bonding agent. A resin-modified glass ionomer such as Vitrebond is placed with no preconditioning of the dentin, so it is much less technique sensitive in this regard. Some other resin-modified glass ionomer restorative materials exist that do require preconditioning of the dentin with a polyacrylic acid derivative for optimal performance.

SUGGESTED TECHNIQUE

The direct composite placement protocol I recommend and have used successfully for many years is the following:

1. After the preparation is complete, clean the dentin and enamel surfaces with slurry of fine pumice and water. I use disposable Pumice Preppies™ (Whip Mix Corp., Louisville, KY) for this on an ICB® Brush (Ultradent Products, Inc., South Jordan, UT). These small brushes are excellent for getting into the internal aspects of your preparation (Figure 8). I do not recommend the use of an antimicrobial at this point, because in-house studies at 3M ESPE have shown that some antimicrobials may have an adverse effect on the bonding of the resin-modified glass ionomer.[56] In any case, the resin-modified glass ionomer to be placed is—in and of itself—antimicrobial.
2. Wash thoroughly with an air/water spray and quick air-dry.
3. Mix and place a thin layer (i.e., .50 mm or so) of Vitrebond. Box areas in Class II restorations (Figure 9) and locations where the external preparation margin ends in dentin and/or cementum are particularly vulnerable to microleakage and should be addressed. I generally prefer a "closed sandwich technique"; i.e., I leave the resin-modified glass ionomer liner just short of the external margin. I also like to place Vitrebond in deep or uneven areas and often at the dentino-enamel junction (Figures 10 and 11). The material is also useful for blocking out undercuts and/or filling small defects during crown preparation.
4. Light polymerize for 20 seconds. If you feel you missed an area or would like to add more resin-modified glass ionomer, you can do so and light polymerize again.
5. At this point, you can continue with your usual bonding protocol and materials. I personally use a 2-step total-etch system at this juncture. I know I am achieving a good etch of the enamel and the "wet bonding" protocol,[57] as it relates to dentin, is much less of a concern because a substantial amount of the dentin is covered by the resin-modified glass ionomer.

CONCLUSION

The trend in adhesive dentistry has been toward the *simplification* of adhesive systems and clinical protocol. However, caution is urged because the cost of simplification may be compromise. Long-term bonding to phosphoric acid-etched enamel surfaces has proven to be very reliable and predictable; long-term bonding to dentin is not as predictable, regardless of the adhesive system used. The concept espoused by some that we can consistently create a long-term hermetic seal of the dentin with a dentin bonding agent alone is a myth.[3] My suggestion to the busy clinician is to re-visit the use of resin-modified glass ionomers as a way to increase the predictability, comfort, and longevity of direct composite restorations.

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