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for "Achieving Excellence Using an Advanced Biomaterial: Part 2," beginning on page xx.

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Achieving Excellence Using an Advanced Biomaterial: Part 2


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This is Part 2 of a 2-part article series. Part 1 of Dr. Terry's article was published in the August 2009 issue of Dentistry Today and can be found in our archived articles at dentistrytoday.com. This, and all future articles that are presented in multiple parts, will now be available to our readers for review in their entirety at our Web site dentistrytoday.com. This is being done to help those readers who may have missed a portion of any multiple-part article, and will also facilitate the ability to review a complete article in its entirety for others.

The longevity of the composite restoration has been a topic of concern for many private practitioners, clinical studies, and research articles.

The longevity of the composite restoration has been a topic of concern for many private practitioners, clinical studies, and research articles.[1-16] Early attempts to utilize composite resins in the posterior region of the mouth revealed complications, including: an elevated rate of occlusal wear, inadequate bonding systems, high polymerization shrinkage and lack of adaptation to the margins after polymerization, and an increased incidence of microleakage with frequent secondary caries and postoperative sensitivity.[17-21] Improving serviceability of posterior composite resins in the oral cavity requires one to address these obstacles while developing an optimal protocol for placing these restorations.[22,23] A successful restorative procedure for posterior composite resins relies on the interrelation of 3 primary elements: restorative material selection, adhesion, and clinical technique (Figure 1). The fundamental principles of this process require maintaining sound tooth structure, achieving a sterile gap-free hybrid layer, and eliminating microleakage by securing a stress-free restorative-tooth interface.

This article discusses the primary elements and fundamental principles required for successful posterior composite resin restorations, and presents 2 clinical cases which demonstrate proper technique for placement of these restorations.

THE RESTORATIVE-TOOTH INTERFACE

The integrity of the bond and marginal adaptation to the tooth structure are critical for clinical success in composite restorations.[24] The restorative-tooth interface is constantly subjected to stress and strain imposed by polymerization shrinkage forces, thermal stimuli, and functional occlusal loads. These stresses may be the mechanism for the clinical challenges with adhesive restorations in clinical dentistry. These include microleakage, marginal breakdown, fractures, secondary caries, postoperative sensitivity, inadequate marginal adaptation, staining, and potential pulpal irritation.[25-28]

Before a restoration is even subjected to functional loads and thermal strains there is an initial interfacial stress developing during polymerization of the restorative materials and adhesion to tooth structure.[29] In a restorative technique using composite resins, the polymerization reaction of the resin matrix phase could compromise dimensional stability.[25] Therefore, a comprehensive understanding of the complex interplay between polymerization shrinkage and adhesion is necessary. This conversion of the monomer molecules into a polymer network is accompanied by a closer packing of the molecules, leading to bulk contraction.[30] Alternatively, when a curing material is bonded on all sides to rigid structures, bulk contraction cannot occur and shrinkage must be compensated for by increased stress, flexure, or gap formation at the adhesive interface.[25]

Figure 1. A successful restorative procedure for posterior composite resins relies on the interrelation of 3 primary elements: restorative material selection, adhesion, and clinical technique.

Polymerization shrinkage or curing contraction is the amount of volumetric decrease a composite system undergoes because of the curing process.[31] The cross-linking of resin monomers into polymers is responsible for an unconstrained volumetric shrinkage of 2% to 5%.[32] During the polymerization reaction, the visco-elastic behavior of the composite changes from viscous to viscous-elastic to elastic. While stress development is nonexistent in the viscous stage, in the visco-elastic stage stresses can partly be relieved by flow and elastic strain.[33]

The moment at which the material can no longer provide viscous flow to keep up with the curing contraction is referred to as the gel point.[25] When the composite material develops an elastic modulus, a volumetric polymerization contraction results in shrinkage stresses. The shrinkage stresses are transferred to the surrounding tooth structure because it restricts the volumetric changes.[33] The uncompensated forces may exceed the bond strength of the tooth-restoration interface, resulting in gap formation from a loss of adhesion.[34] The factors that influence polymerization shrinkage include: type of resin,[31] filler content of the composite,[31,35,36] elastic modulus of the material,[36] curing characteristics,[37] water sorption,[38-40] cavity configuration,[26] and the intensity of the light used to polymerize the composite.[33,41,42] By understanding this complex mechanism between polymerization shrinkage and adhesion, the clinician can select application techniques and restorative materials that prevent gap formation at the time of placement for each individual clinical situation.

In addition, the restorative interface is constantly subjected to functional loads after placement of the composite restoration. The cervical regions of the dentition may experi-

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ence excessive eccentric loading from parafunctional habits such as clenching and bruxism.[43,44] These repeated flexural forces can cause adhesive failure of cervical composite restorations at the dentin-resin interface which can result in microleakage, and/or partial or complete debonding of the restoration.[45] Interceptive occlusal equilibration and occlusal guard therapy prior to restorative treatment in conjunction with specific incremental placement techniques can provide restorative solutions.

THE PRIMARY RESTORATIVE ELEMENTS

The clinical success of composite restorations is determined by the interrelation of 3 essential elements: restorative material selection, adhesion, and technique. The proper integration of these 3 elements can result in an optimal restorative-tooth interface with improved clinical performance. However, an improper interrelation of these elements can lead to microleakage, gap formation, staining, sensitivity, and partial or complete debonding of the restoration that can result in long term clinical failure (Figure 1).

Restorative Material Selection

In the past, the physical and mechanical properties of the individual composite systems (ie, hybrid, microfill) had inherent limitations that confined their use to specific procedures. To achieve an optimal restorative result and compensate for these inequities required one to select and layer both a hybrid and a microfill resin system. These intricate layering techniques further complicated some clinicians' ability to achieve consistent and reliable results.

Newer formulations of nanohybrid composite resins have been designed with the concept of combining dentin color and enamel value in relationship to the natural tissue anatomy. These composite restorative systems not only simplify the replication of the natural tooth but have similar physical and mechanical properties to that of tooth structure. These advanced nanohybrid formulations provide composite resin with filler particle size that are dramatically smaller in size, can be dissolved in higher concentrations, can be polymerized into the resin system with molecules that can be designed to be compatible when coupled with a polymer, and provide unique characteristics (physical, mechanical, and optical). Further, optimizing the adhesion of restorative biomaterials to the mineralized hard tissues of the tooth is a decisive factor for enhancing the mechanical strength, marginal adaptation, and seal, while improving the reliability and longevity of the adhesive restoration.

Figure 2. Preoperative occlusal view reveals caries in the fissures surrounding a pre-existing sealant on the mandibular right first molar.

Figure 3. Shade determination was performed before dental dam placement with a custom fabricated composite shade tab.

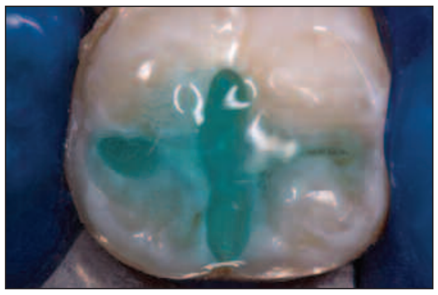

Figure 4. After the carious dentin was removed with a minimal preparation design, the preparation was etched for 15 seconds with 32% phosphoric acid (Uni-Etch with BAC, Bisco) rinsed for 5 seconds, and gently air-dried.

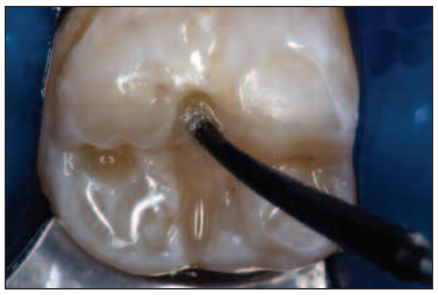

Figure 5. A single component adhesive (Adper Single Bond Plus, 3M ESPE) was applied for 20 seconds to the entire preparation, air-thinned and light-cured.

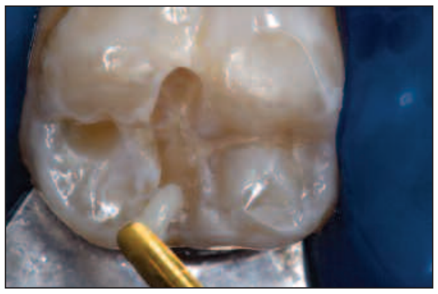

Figure 6. An increment of A-1 shaded hybrid composite (Kalore, GC America) was placed with a long-bladed interproximal instrument to the cavity wall and light cured for 40 seconds.

In the past, the particle size of conventional composites was so dissimilar to the structural sizes of the hydroxyapatite crystal, dental tubule, and enamel rod, there was a potential for compromises in adhesion between the macroscopic (40 nm to 0.7 um) restorative material and the nanoscopic (1 to 10 nanometers in size) tooth structure.[46] However, advanced resin technology has the potential to improve this continuity between the tooth structure and the nanosized filler particle and provide a more stable and natural interface between the mineralized hard tissues of the tooth and these restorative biomaterials. With the selection of these improved biomaterials, the clinician is able to preserve, conserve, and reinforce tooth structure with more conservative preparation designs.

Adhesion

The word "adhesion" is derived from the Latin roots that translate as "to" and "stick together." Defined as the "molecular attraction exerted between the surfaces of bodies in contact," the force referred to as adhesion occurs when unlike molecules are attracted. Conversely, cohesion occurs when molecules of the same kind are attracted. The adhesive, frequently a viscous fluid, is comprised of a material or film that joins 2 substrates together and solidifies. The adherend is the material or initial substrate to which the adhesive is applied.[47]

In dentistry, a surface sealant would be defined as a single adhesive "joint," since only one interface exists. Adhesion or bonding is the process of forming an adhesive joint,[48] traditionally comprised of 2 substrates being joined so that the adhesive produces 2 interfaces which are part of the adhesive joint. While most adhesive joints involve only 2 interfaces, a bonded composite restoration would be an example of a more complex adhesive joint.[48] The physical and chemical properties of the adhesive are the most important factors in the performance of adhesive joints, since these are the properties that maintain the integral bond. Ensuring adequate performance of the adhesive joint requires knowledge and experience in the types of adherend (ie, enamel, dentin, metal alloy, composite material) and the nature of the surface pretreatment or primer. The adhesive, adherend, and surface all impact the durability of the bonded structure.

The mechanical behavior of the bonded structure is influenced by the details of the joint design and by the way in which the applied loads are transferred from one adherend to the other. The specific energy of adhesion defined by chemical, physical, and mechanical attributes of the substrate and adhesive determines the ability to form a joint and the resistance of the joint to failure.[48] Achievement of such interfacial molecular contact is a necessary first step in the formation of strong and stable adhesive joints. Inherent in the formation of an optimal adhesive bond is the ability of the adhesive to wet and spread on the adherends being joined. Good wetting usually occurs with solids that demonstrate high surface energy. Adhesives should exhibit low viscosities or low surface tension to increase their wetting capabilities.[49]

Once wetting is achieved, intrinsic adhesive forces are generated across the interface through mechanisms of mechanical interlocking, adsorption, diffusion, or any one of their combinations. Mechanical interlocking occurs when adhesive flows into pores in the adherend surface or around projections on the surface. In adsorption, adhesive molecules adsorb onto a solid surface and bond to it. This process may involve the chemical bonding between the resin (adhesive) and the inorganic or organic elements (adherend) of the tooth structure. Diffusion involves a mechanical or chemical bonding between polymer molecules (resin) and a precipitation of substances on the tooth surface (adherend). Most often, more than one of these mechanisms play a role in achieving the desired level of adhesion for various types of adhesive and adherend.[48]

The bonded restorative complex includes the outer layers of the substrate, the adhesive layer, and the restorative material. The integrity of the adhesive bonded interface is subject to failure arising from defects along the interface which can result in adhesive joint failure from debonding caused by crack formation and propagation. These defects at the interface come from trapped air voids, voids formed from solvent evaporation, areas of poor wetting, bubbles within the adhesive, curing shrinkage pores, areas of interfacial contamination, and excess moisture contamination.[48] A restorative material properly joined to the tooth substrate is able to provide the following: an improved marginal seal[50] while reducing marginal contraction gaps, microleakage, marginal staining, and caries; restoration retention from a durable interfa-

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cial adhesion between tooth and biomaterial[50]; a reduction of stress at the tooth-restorative interface[51]; biomechanical reinforcement of tooth structure; biological preservation of tissues; sealing of dentin tubules; and providing long-term functional success.[51-56]

A durable interfacial adhesion between the tooth and biomaterial requires a clean surface of the substrate, a low contact angle that allows the adhesive to spread over the entire surface of the substrate, and an optimal internal adaptation of the biomaterial to the substrate. This allows an intimate approximation of the material with the substrate without the entrapment of air pockets, which can result in adhesive failure. Further, the interface should have sufficient physical, chemical, and mechanical strength to resist stress from polymerization or occlusal forces, and a sufficient degree of cure of the adhesive.[47,48] Furthermore, the clinician should have an understanding of the morphologic, histologic, and physiologic characteristics of the substrate (enamel and dentin) in order to achieve optimal adhesion.

Technique

In addition to enhancing the aesthetic result from multilayering of color, incremental layering techniques provide enhanced control of condensation of the individual increments of composite resin, densification, improved marginal adaptation and seal, thorough polymerization of the restorative material, and optimal bond formation. Further, these techniques allow control of overhangs in the lateral margins prior to curing, reduce the effects of polymerization shrinkage, allow the orientation of the curing light beam according to the position of each composite layer, and provide precise placement of optimal anatomical contours of the restoration.[57]

The margin quality and strength of a composite resin restoration is influenced by many factors which include: polymerization shrinkage, adhesion to the margins, cavity design and use of liners and bases, finishing and polishing techniques, viscosity and stiffness of the composite resin, flexibility of the cavity walls, position of increments of composite resin placement in cavity preparations, and the restorative application techniques.[27,34,58-61] A better understanding of these effects can influence the marginal integrity and strength of the composite restoration. Therefore, restorative techniques have been developed to reduce these effects, improve the marginal adaptation and seal,[61-65] and provide the clinician with maximum benefit for their application.[25] Numerous restorative techniques and innovations have been developed and proposed to overcome these shortcomings of deficient marginal adaptation, which include the following: light reflecting wedges,[66,67] wand position variation,[66,68] use of condensation and polymerization tips,[69-71] sandwich technique with self-cured composite, glass-ionomer cement or amalgam combined with the composite resin, and placement of glass inserts into prepolymerized resin to reduce the volume of the shrinkage material.[69-72] Other techniques include reducing the volume of composite restorative material to allow better control of shrinkage,[73,74] incremental overlap and spot-cure methods,[66,75] and multilayering obturation methods.[62-65,76]

Figure 7. Using an oblique layering technique, successive increments of A-1 shaded hybrid composite (Kalore) were adapted to the cavity wall with a ball-tipped instrument (M-1, American Eagle Instruments).

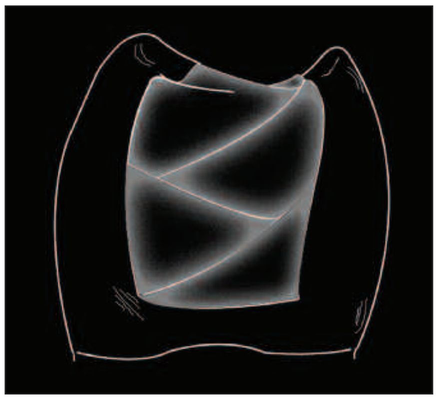

Figure 8. The oblique layering technique reduces the ratio of cavity volume to area of the cavity walls which results in a substantial reduction in the marginal contraction gap.

The positions of placement of the composite increments are described as vertical, horizontal, and oblique layering techniques. These techniques are the original multilayered methods and are used on small to large cavity preparations, and are adequate for compensating for polymerization shrinkage. The multilayering techniques that the authors use include: horizontal layering, vertical layering, oblique layering, 3-sited, centripetal, direct-shrinkage, and successive cusp build-up. The selection of a particular incremental technique is determined by the type and dimension of the cavity preparation.

Knowledge and a desire to create are limited by the products clinicians have available to them for restorative procedures, and knowledge must be integrated with the proper selection of material and technique for each clinical situation. Maintaining the balance between restorative material selection, adhesion, and technique requires the skill and experience of the operator. The following procedures will illustrate the integration of these primary restorative elements to develop a stress-free tooth-restorative interface utilizing a low-shrinkage nanohybrid composite resin (Kalore, GC America).

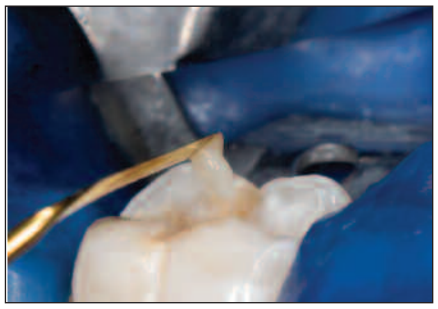

Figure 9. The artificial dentin core was developed in relationship to the anatomical morphology, while preserving an adequate dimension for the artificial enamel layer.

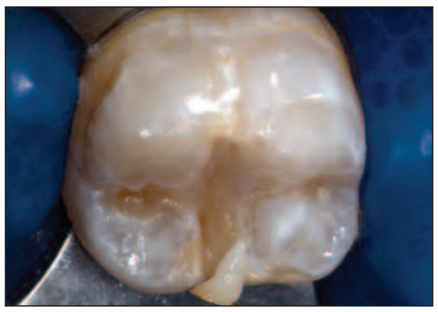

Figure 10. The artificial enamel layer, a natural translucent shaded nanohybrid composite (Kalore) was applied over the dentin core with a long-bladed instrument to the ideal anatomical contours and light-cured for 40 seconds.

Figure 11. The postoperative result reveals a natural integration of composite resin with tooth structure.

PREOPERATIVE RESTORATIVE CONSIDERATIONS

In the 2 clinical presentations of a Class I and Class V composite restoration the following considerations were completed before any restorative treatment was initiated. First, prior to administering anesthesia and dental dam isolation, the preoperative contact zone and excursive occlusal patterns were recorded and evaluated. This initial registration is valuable in the occlusal preparation design when determining placement of centric stops beyond or within the confines of the restoration and in minimizing finishing procedures.[77] In some clinical situations, it may be necessary to distribute the forces generated by the cusp over a larger surface area by recontouring the surface of the antagonistic cusp, thereby reducing the stress concentration at the interface. In addition, since anatomical form defines color, this occlusal evaluation can provide a more accurate anatomical placement of the restorative material within the confines of the occlusal parameters.

Occlusal evaluation is also paramount for the long-term clinical success of the Class V adhesive restoration. In the restored tooth (ie, cervical restoration), lateral flexure resulting from eccentric forces produce tensile stresses at the marginal interface of the restoration, whereas heavy centric forces generate compressive stresses along the marginal interface of the cervical restoration. These repeated flexural forces can cause adhesive failure of cervical composite restorations at the dentin-resin interface which can result in microleakage, and/or partial or complete debonding of the restoration.[45] These occlusal considerations should be addressed at the treatment planning stage, prior to administering any restorative treatment. Intraoral elimination of interferences in the static and dynamic occlusion to achieve an ideal occlusion with maximal distribution of occlusal load should be performed only after splint therapy. Furthermore, interceptive occlusal equilibration should be initially performed on accurately mounted diagnostic models. Intraoral modifications in the occlusal pattern before any operative procedure is initiated can reduce cuspal flexure and cervical stresses that are capable of causing adhesive failure of cervical composite restorations. These preventative measures include equilibration with occlusal guard fabrication, coronoplasty, or orthodontic treatment.[78-81]

Next, the shade of the tooth should be determined before any

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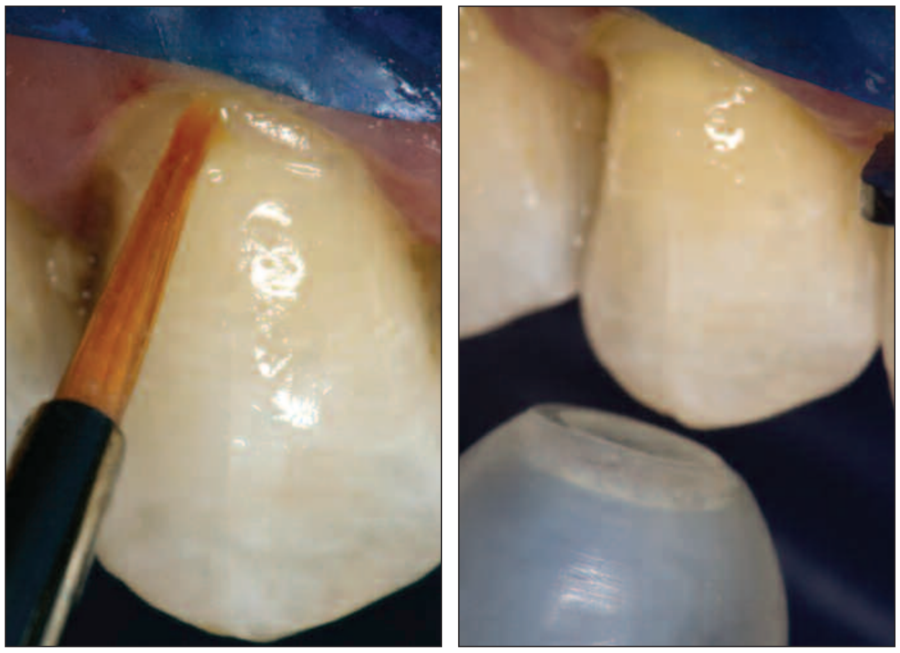
restorative treatment is initiated. Shade selection should be accomplished prior to dental dam placement to prevent improper color matching as a result of dehydration and elevated values.[82] When teeth dehydrate, air replaces the water between the enamel rods, changing the refractive index, which makes the enamel appear opaque and white.[83] A preoperative selection of composite resins for the "artificial dentin" and "artificial enamel" shade and orientation was recorded using a custom-fabricated layered shade guide of polymerized composite resin. The shade tab is hand-layered with an opaque dentin layer and encased with a superficial layer of enamel corresponding to the specific shade. This shade matching technique using this system (2 Layer shade system, Heraeus Kulzer) provides excellent replication of dental composite color since it is synchronized with the same polymerized restorative material as the composite system which is being matched. This synchronization process allows the clinician to compare the actual polymerized restorative material of the composite system to the natural tooth color for a more accurate aesthetic color matching.

Upon request, the manufacturer provides the clinician with additional empty tabs that can be used to create individual patient shade tabs from the actual batch of restorative material the clinician is using for the restoration. The clear plastic shade tab provides a depth of restorative material from 1.5 mm to 1 mm in thickness. The advantages of the custom shade guide include the following: provides a full range of natural colors; variability between shade guides can be minimized; the actual polymerized restorative material is used in fabricating the restoration; any technique sensitivity affecting the parameters of color can be incorporated into the custom shade tabs; tabs can be fabricated to conform to specific space limitations for opacious dentin and enamel layer; characterizations at any depth in the restoration may be placed and described in terms of the color parameters and a more accurate representation and design of the anatomical surface morphology such as macro and micro morphological characteristics; provides a more accurate shade guide, an efficient verification of color, ease of correction (increasing or decreasing hue, chroma, and value), and communication for laboratory processed composites; compensates for adjustment to lot variations of composite resin materials; and provides for color combinations.[84-86]

Figure 12. Preoperative facial view of wedge-shaped cervical lesions on the maxillary right premolars.

Figure 13. Development of a custom shade tab of the exact restorative material (Kalore) allows a more accurate and realistic representation of the natural tooth structure.

Figure 14. A retraction cord was placed to gain adequate access to the gingival margin and to allow moisture control during the adhesive procedure.



Figures 15a and 15b. A self-etch adhesive was placed on the dentin surface, using a No. 0 sable brush (15a); and allowed to dwell for 10 seconds, dried for 5 seconds and light-cured for 10 seconds (15b).

THE OCCLUSAL LESION RESTORED WITH A CLASS I COMPOSITE RESTORATION

Case Report

A 21-year-old patient presented with initial carious lesions in the occlusal fissures surrounding the pre-existing sealant on the mandibular right first molar (Figure 2). Clinical evaluation and consultation revealed numerous other incipient carious lesions in posterior teeth of different quadrants that were the result of a recent change in dietary pattern with an increased consumption of carbonated beverages containing sugar. The predisposing environment was altered by cessation of the habit and introduction of 1.1% neutral sodium home fluoride treatments (Fluoridex, Discus Dental).

Prior to administering anesthesia and dental dam isolation, the preoperative occlusal stops and excursive guiding planes were recorded with articulation paper and were transferred to a hand drawn occlusal diagram, recorded on an intraoral or digital camera and/or indicated and reviewed on a stone model. A preoperative selection of composite resins with their shade and orientation was recorded (Figure 3). The use of a color corrected daylight source of 5500 K (Rite•Lite Shade Matching Lite, AdDent) was used for proper color registration.

The cavity configuration (C-factor) has a significant influence on the magnitude of the shrinkage stresses generated from polymerization shrinkage. The C-factor is defined as the ratio between the free and bonded restoration surfaces.[26] The Class I cavity has the highest C-factor (ie, Class I-5/1, Class II- 4/2) and the greatest internal stress. The following clinical presentation focuses on managing and minimizing these stresses by utilizing a combination of stress-reduction techniques.

Once anesthesia was administered, the treatment site was isolated with a dental dam to achieve adequate field control and protect against contamination.[87,88] Quantitative light-induced fluorescence (DIAGNOdent, KaVo) was used in conjunction with radiographic findings to aid in the detection and identification of the irreversible infected carious tissue on the mandibular right first molar and served as a guide for its removal.[89,90] The carious dentin was removed with a slow-speed carbide round bur (No. 4, Midwest Dental) and spoon excavators, and reexamined for caries with quantitative light-induced fluorescence. The preparation was designed so as to remove the carious process. Removal of healthy tooth structure should be carried out only when the occlusal outline requires extension beyond or within the functional stops. The width of the preparation should be as narrow as possible, since the wear resistance of the restoration is a direct function of dimension.[91] The occlusal margins of the preparation generally should not be beveled. Beveling automatically increases the width of the preparation, which in turn increases the potential for including the centric holding areas. This in turn increases the potential for increasing wear of the restoration.

One restorative technique for reducing shrinkage stress at the interface involves utilizing resin modified glass-ionomer as a cavity base. By reducing the volume of composite resin material the shrinkage stress is minimized. A polyacrylic acid solution (Cavity conditioner, GC America) was applied to the dentin surface for 10 seconds, rinsed with water, and lightly air-dried. A radiopaque glass-ionomer (Fuji IX GP, GC America) was injected and condensed with a ball-tipped instrument (M-1, American Eagle Instruments). After 2 minutes and 30 seconds, the cavity walls were finished with a fine diamond under water spray. The preparation was scrubbed with a 2% chlorhexidine solution, (Consepsis, Ultradent Pro-

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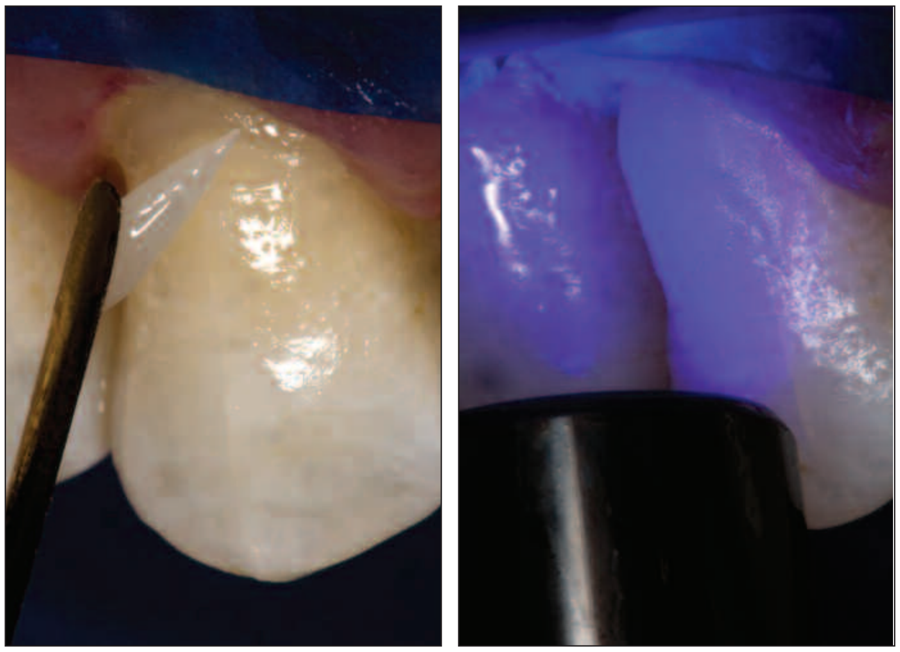
ducts), rinsed, and lightly air-dried. The "total etch" technique was used to minimize the potential of microleakage and enhance bond strength to dentin and enamel.[92-94] The preparation was etched for 15 seconds with 32% phosphoric acid (Uni-Etch with BAC, BISCO), rinsed for 5 seconds, and gently air-dried for 5 seconds (Figure 4). A single-component adhesive (Adper Single Bond Plus, 3M ESPE) was applied with a disposable applicator for 20 seconds with a continuous motion, reapplying every 5 seconds (Figure 5). Any excess was removed with the applicator, and the adhesive agent was light cured for 30 seconds. Although a small amount of excess adhesive can be applied over the margins to improve sealing, this excess should be removed during finishing procedures.

The cavity preparation was filled incrementally, utilizing an A-1 shaded hybrid composite (Kalore) from the preoperative shade selection (Figure 6). Each increment was gently condensed with a clean, nonsticking ball-tipped instrument (M-1) to ensure complete adaptation to the underlying resin and tooth structure (Figure 7). Each increment was light cured for 40 seconds using a ramp curing mode. Using low-intensity curing light sequences to reduce shrinkage stress controls the plasticity (flow capacity) of the restoration during curing, while the final mechanical stability of the restoration remains unaffected.[33,42] When composites are polymerized with high-curing light intensities, larger gaps between the cavity walls and the restorative material are created than are found with the use of low-intensity lights. Considerable stress reduction occurs during the first 10 seconds of light activation.[33] Employing a lower-intensity light power during the first 20 seconds extends the visco-elastic stage of setting—an interval in which stress can be partly relieved by flow and elastic strain.[95] Since the rate of conversion determines the rate of shrinkage stress development, a moderation of the reaction may result in an overall stress reduction by allowing more yielding of the free surface of the restoration to the underlying contracting bulk, as a result of a slower stiffness development.[33] This initial reduced conversion rate of the resin material results in a higher degree of marginal adaptation at the interface of the cavity and restoration,[42] causing less damage at this interface.[25,33,41,42,96,97]

Figure 16. A small amount of A-2 shaded flowable composite (Gradia, GC America) was applied to the axial wall and uniformly distributed over the dentin surface.

Figure 17. After acid etching the remaining preparation, an adhesive was applied, air-thinned, and light-cured for 20 seconds.



Figures 18a and 18b. The artificial dentin layer, an A-1 shaded nanohybrid composite (Kalore) was applied with a long bladed composite instrument (**18a**); and light-cured for 40 seconds (**18b**).

Furthermore, to reduce the possibility of cuspal flexure, a composite hybrid (Kalore) with a low volumetric polymerization shrinkage was selected.[98] Additionally, this problem may be reduced by a diagonal layering of the hybrid in increments of 1mm and feathering the material up the cavity wall in a "V" shape[99,100] (Figure 8). Opposing enamel walls should not be contacted by the same increment[101]; this will minimize the wall-to-wall shrinkage and thus reduce intercuspal stress.[102] The application of the composite in oblique layers results in fewer contraction gaps at the margins. Continue to condense and shape the composite resin to correspond to cusp development and dentin replacement (Figure 9). It is important to anticipate the final result and not trespass in the final artificial enamel zone, and allow space for the overlying translucent enamel shade.

Once the artificial dentin layer was developed a final artificial enamel layer, a natural translucent shaded nanohybrid (Kalore), was placed and contoured with a long bladed instrument (TNCVIPCL, Hu-Friedy) to an ideal functional and anatomical occlusal morphology, and polymerized for 40 seconds (Figure 10). A thin layer of glycerin was applied to the surface and polymerized for a 2-minute post-cure, ensuring complete polymerization of the composite resin at the margins.

Developing the restoration in increments and considering the occlusal morphology and occlusal stops allows the clinician to minimize finishing procedures[77] and results in a restoration with improved physical and mechanical characteristics and less potential for microfracture. At least one study has revealed that a reduction in finishing results in less damage to the composite, as well as improved wear and clinical performance.[100] However, a proper meticulous finishing protocol can also increase the longevity of the restoration,[103,104] since a smooth surface can reduce plaque retention, thus minimizing the potential for gingival inflammation, surface staining, and secondary caries.[105-107]

The occlusal refinement was achieved with No. 30 fluted pyramidal-shaped finishing bur (H274, Brasseler USA), closely observing the tooth-resin interface and using a dry protocol. After the initial finishing procedure, the margins and surface defects were sealed. All accessible margins were etched with a 37.5% phosphoric acid, rinsed, and dried. A composite surface sealant was applied and cured to seal any cracks or microscopic porosities that may have formed during the finishing procedures. The use of a surface sealant has been shown to reduce the wear rate of posterior composite resin restorations.[108] The final polish was accomplished with pre-polish and high shine silicone rubber points (Diacomp, Brasseler USA) and polishing cups (Enhance Polishing Cups, DENTSPLY Caulk) with a synthetic diamond polishing paste (Diamond Paste, Leach and Dillon).

The dental dam was removed and the patient was asked to perform closure without force, and then centric, protrusive, and lateral excursions. Any necessary equilibration was accomplished with No. 12 and No. 30 pyramidal-shaped finishing burs (H274) and the final polish was repeated. The contact was tested with unwaxed floss to ensure the absence of sealant in the contact zone and the margins inspected. The clinical postoperative result achieved through the use of direct composite resin reflects the harmonious integration of color with anatomical form and function while enhancing marginal integrity and wear resistance (Figure 11).

THE CERVICAL LESION RESTORED WITH A CLASS V COMPOSITE RESTORATION

Case Report

The patient, a 42-year old male, presented with sensitivity of the maxillary right premolars. Clinical examination revealed irregular V- or wedged-shaped cervical defects with no caries, plaque, or gingival inflammation (Figure 12). Wear patterns were present on the occlusal surfaces

continued on page ##

of these teeth. After review of the patient's medical and dental history and considering all the activities and effects from the loss of tooth substance, a differential diagnosis indicated multifactorial abrasive-abfraction lesions[109] caused from tensile stresses and toothbrush abrasion.

Upon successful stabilization with occlusal splint therapy and a careful mock equilibration on accurately mounted diagnostic models, an occlusal equilibration was performed to eliminate interferences in the static and dynamic occlusion and provide maximal distribution of occlusal load.[81] A preoperative selection of composite resins with shade and orientation was recorded and photographed (Figure 13).

The Class V "erosion" lesion continues to present an aesthetic and functional dilemma to the restorative dentist. As shown, the abfraction lesion is a noncarious lesion caused from deflective occlusal contacts. The teeth bend and the stresses at the cervix of the tooth cause a loss of tooth structure. To complicate matters, many of these patients present because of sensitivity to brushing and temperature changes, and may require anesthesia. Once anesthesia had been administered, the teeth were isolated with a dental dam to achieve adequate field control and to protect against contamination.[87,88] A modified technique was used to create an elongated opening that allowed placement of the dam over the retainer.[110] A nonmedicated retraction cord was placed since the lesion was located below the free gingival margin. This provides improved access and reduces the potential for crevicular fluid contamination. (Figure 14). A bevel was placed on all margins that were in enamel to prevent microleakage, however, a butt joint should be prepared if the gingival margin is in cementum/dentin. To improve the aesthetic results, a long bevel was placed on the coronal margin. Although mechanical retention is not required for successful adhesion, groove placement can also provide resistance to the internal and external components of stress-polymerization shrinkage and tooth flexure.[111] In clinical situations where there is sclerotic dentin, a slow speed bur or air abrasion may be used to roughen the dentin surface to allow better resin penetration through the sclerotic dentin and into the tubules.[94]

For patients with extreme tooth sensitivity, a specific tooth conditioning procedure can be employed to reduce technique sensitivity and the potential for microleakage, while

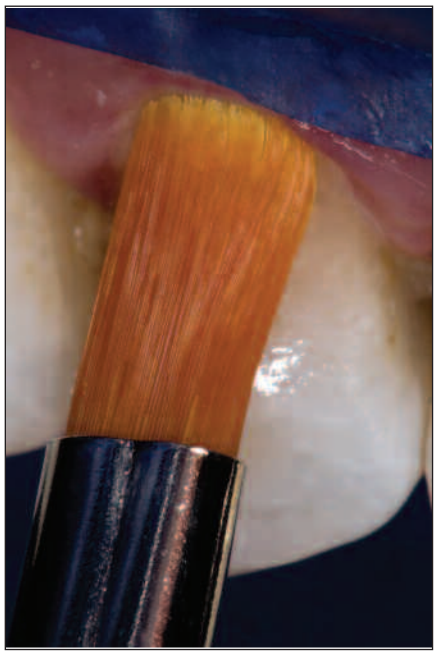


Figure 19. An artificial enamel layer, a clear translucent shaded nanohybrid composite (Kalore) was applied with a interproximal instrument, adapted, and smoothed with a No. 2 sable brush.

Figure 20. The cervical region was contoured and finished using a 30-fluted short tapered finishing bur (ET-3, Brasseler USA).

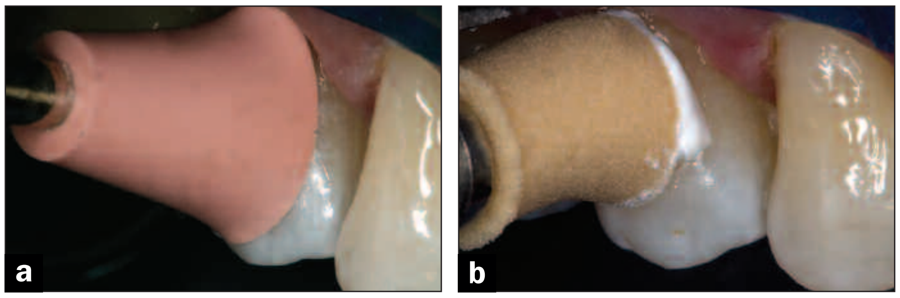


Figure 21. Polishing of the facial surface was completed with rubber cups as well as diamond polishing paste and a foam cup.

increasing the potential for enamel bonding. This procedure involves combining adhesive strategies, ie, use of a self-etch adhesive with the dentin and total-etch adhesive with enamel. Since self-etching adhesives do not require rinsing and drying, technique sensitivity often associated with dehydration and rehydration of dentin in the total-etch (or etch-and-rinse) technique is eliminated. In comparison to total-etch adhesives, self-etch adhesives do not allow a discrepancy between the depth of demineralization and depth of resin infiltration because both processes occur simultaneously.[112] Further, since the smear plugs are not removed before the application of the self-etch adhesive, the potential for postoperative sensitivity is less than with total-etch adhesives.[112] Finally, by only allowing phosphoric acid etching of the enamel substrate, the bonding potential at the restorative-tooth interface may be improved.

The preparations were scrubbed with a slurry mixture of disinfectant and pumice. A self-etch adhesive (G-Bond, GC America) was placed on the dentin surface using a No. 0 sable brush, allowed to dwell for 10 seconds, dried for 5 seconds, and light-cured for 10 seconds (Figures 15a and 15b). An

Figure 22. The postoperative view reflects an ideal integration of composite, tooth structure, and soft tissue at the restorative interface.

A-2 shaded flowable composite (Gradia Direct Flo, GC America) was placed over the entire dentin surface with a No. 0 sable brush and light cured for 40 seconds (Figure 16). The remaining preparation (ie, composite and enamel) was etched for 15 seconds with a 35% orthophosphoric acid (Gluma Etch 35 Gel, Heraeus Kulzer), rinsed for 5 seconds, and gently air-dried for 5 seconds. This technique minimizes the potential of microleakage and enhances the bond strength to enamel.[92-94] A single component adhesive (Adper Single Bond Plus) was applied with a disposable applicator for 20 seconds using a light continuous scrubbing motion (Figure 17). The adhesive was gently air dried for 5 seconds and light-cured for 20 seconds.

An artificial dentin layer of A-1 shaded nanohybrid composite resin (Kalore) was applied and adapted with a long bladed interproximal instrument and light cured for 40 seconds (Figures 18a and 18b) An artificial enamel layer, a clear translucent shaded nanohybrid composite (Kalore), was placed with a long bladed interproximal instrument and contoured to the proper emergence profile with a No. 2 sable brush, and light-cured for 40 seconds (Figure 19).

Shaping and contouring was performed with a series of finishing burs, dry, in order to replicate natural form and texture. Dry finishing allows for better visualization of the contour and margins. It is important not to overheat the resin by using excessive pressure. Also, it is imperative not to ditch or scar the cementum at the gingival margin. The gingival tissue was retracted and protected during finishing using a gingival protector (Zekrya Gingival Protector, DMG America) (Figure 20). Any excess resin can be removed with a No. 12 scalpel and the retraction cord removed to inspect for overhangs.

The restorations and all margins were re-etched for 15 seconds and rinsed for 5 seconds, and a layer of composite surface sealant (OptiGuard, Kerr) was applied over the margins and the restoration. This will prevent leakage and seal any microfractures in the material caused from the finishing procedures. To increase the smoothness of the restorations, polishing was completed with prepolish and high shine silicone cups, points, and a synthetic foam cup with diamond polishing paste (Figures 21a and 21b). The completed restorations reinstated a harmonious integration with the surrounding tissues while eliminating excessive eccentric forces and cervical sensitivity for the patient (Figure 22).

CONCLUSION

Securing and maintaining a stress-free restorative-tooth interface defines restorative success. The restorative process requires an integration of 3 primary elements of restorative dentistry: restorative material selection, adhesion, and technique. The restorative dentist must have knowledge of the physical properties of these restorative materials and their appli-

Achieving Excellence...

continued from page

cation in a variety of adhesive procedures in prosthodontics and restorative dentistry in order to make a proper selection. However, studies indicate that the accuracy of a procedure may be controlled more by the technique than the material.[113] Thus, this knowledge must be integrated with the proper technique for each specific clinical situation. Consequently, the ultimate success of the final restoration depends on the skill of the operator and the experience acquired with a given technique. Therefore, since clinical success begins and ends with dimensional stability at the interface, a balance between these primary restorative elements can improve the long-term clinical success for posterior composite resins.✦

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ce Test 119

To submit Continuing Education answers, use the answer sheet on page xx. Place an X in the box corresponding to the answer you believe is correct, detach the answer sheet from the magazine, and mail to Dentistry Today Department of Continuing Education. This article is available for 2 hours of CE credit.

The following 16 questions were derived from the article *Achieving Excellence Using an Advance Biomaterial, Part 2* by Douglas A. Terry, DDS, et al on pages xx through xx.

Learning Objectives
After reading this article, the individual will learn:

• The 3 essential elements and fundamental principles for achieving clinical success with posterior composite resin restorations.
• An adhesive technique and protocol for the development of the Class I and Class V composite restoration.

1. A successful restorative procedure for posterior composite resins relies on which of the following elements?
a. adhesion
b. clinical technique
c. restorative material selection
d. all of the above

2. In a restorative technique using composite resins, the polymerization reaction of the resin matrix phase could compromise dimensional stability. Therefore, a comprehensive understanding of the complex interplay between color and adhesion is necessary.
a. the first statement is correct and the second is incorrect
b. both statements are correct
c. both statements are incorrect
d. the first statement is incorrect and the second statement is correct

3. Polymerization shrinkage or curing contraction is the amount of volumetric increase a composite system undergoes because of the curing process. The cross-linking of resin monomers into polymers is responsible for an unconstrained volumetric shrinkage of 2% to 8 %.
a. the first statement is correct and the second is incorrect
b. both statements are correct
c. both statements are incorrect
d. the first statement is incorrect and the second statement is correct

4. Factors that influence polymerization shrinkage include which of the following?
a. filler content of the composite
b. cavity configuration
c. water sorption
d. all of the above

5. Repeated flexural forces from functional loads after placement of a cervical composite restoration can cause adhesive failure at the dentin-resin interface, which can result in which of the following?
a. microleakage
b. partial or complete debonding of the restoration
c. a and b
d. none of the above

6. Optimizing the adhesion of restorative biomaterials to the mineralized hard tissues of the tooth can enhance the following:
a marginal adaptation and seal.
b. reliability and longevity of the adhesive restoration.
c. mechanical strength.
d. all of the above.

7. The word "adhesion" is derived from the Latin roots that translate as "to" and "stick together." The adherend is the material or initial substrate to which the adhesive is applied.
a. the first statement is correct and the second is incorrect
b. both statements are correct
c. both statements are incorrect
d. the first statement is incorrect and the second statement is correct

8. Inherent in the formation of an optimal adhesive bond is the ability of the adhesive to wet and spread on the adherends being joined. Good wetting usually occurs with solids that demonstrate low surface energy.
a. the first statement is correct and the second is incorrect
b. both statements are correct
c. both statements are incorrect
d. the first statement is incorrect and the second statement is correct

9. The bonded restorative complex includes which of the following?
a adhesive layer
b. restorative material.
c. outer layers of the substrate
d. all of the above

10. The integrity of the adhesive bonded interface is subject to failure arising from defects which can be the result of which of the following?
a. trapped air voids
b. areas of interfacial contamination
c. bubbles within the adhesive
d. all of the above

11. A restorative material properly joined to the tooth substrate is able to provide the following:
a. restoration retention.
b. reduction of stress at the tooth-restorative interface.
c. biomechanical reinforcement of tooth structure.
d. all of the above.

12. A durable interfacial adhesion between the tooth and biomaterial requires which of the following?
a. a low contact angle
b. voids formed from solvent evaporation
c. a clean surface of the substrate
d. a and c

13. Incremental layering techniques of composite resin can provide which of the following?
a densification and improved marginal adaptation
b. thorough polymerization of the restorative material
c. a and b
d. none of the above

14. The factors that influence the margin quality and strength of a composite restoration include:
a viscosity and stiffness of the composite resin.
b. finishing and polishing techniques.
c. polymerization shrinkage and restorative application techniques.
d. all of the above.

15. Shade selection should be accomplished prior to dental dam placement to prevent improper color matching as a result of dehydration and elevated values. When teeth dehydrate, water replaces the air between the enamel rods, changing the refractive index, which makes the enamel appear translucent.
a. the first statement is correct and the second is incorrect
b. both statements are correct
c. both statements are incorrect
d. the first statement is incorrect and the second statement is correct

16. A smooth restorative surface and/or restorative-tooth interface provides which of the following?
a. minimizes the potential for gingival inflammation
b. reduces the potential for surface staining and secondary caries
c. increases plaque retention
d. a and b

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For more information see *Aesthetic & Restorative Dentistry: Material Selection & Technique* at everestpublishingmedia.net and quintpub.com.

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