Surface treatments for tooth-colored restorations

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This is the first in a 2-part article that will provide a discussion of the various surface treatments for tooth-colored restorations including: laboratory processed composite resin, silica-based ceramic, and high-strength ceramic materials.

The dental luting procedure involves cement adaptation to surface irregularities in a manner that prevents the restoration s dislodgement. The primary objective of each cementation procedure is to achieve a durable bond and a good marginal adaptation of the luting material to the restoration and the tooth.[1] Successful cementation of the luting material to both is essential for retention,[2,3] clinical performance, and longevity of indirect restorations.[4]

The search continues for the ideal luting cement. Such a material should preserve and stabilize tooth hard tissues, provide a durable bond between dissimilar materials, possess high compressive and tensile strengths, adhere to tooth structure and restorative materials, and possess anticariogenicity by preventing caries at the restoration-tooth interface. It should be biocompatible with pulpal tissue, possess antimicrobial properties, provide resistance to microleakage, ease of manipulation with increased working and setting time, low film thickness, low solubility, high proportional limit, translucency, and radiopacity. In addition, this material should possess increased fracture toughness to prevent dislodgement as a result of interfacial or cohesive failures, exhibit a low contact angle as a measure of optimum wettability, provide adequate viscosity to ensure complete seating, and exhibit aesthetics compatible with the selected restorative material.[5-7] There are 2 basic categories of contemporary adhesive cements which include glass-ionomer cements and composite resin cements.

Adhesive resins provide the most optimal bond for indirect restorations while distributing stress along the restorative interface. In addition, microleakage studies suggest that resin cements are superior to traditional cements in their sealing ability.[8-10] With these contemporary adhesive cements, composite resin cements, there are 2 different adhesive strategies: total-etch and self-etch. Within this group of composite resin cements are adhesive resin cements and self-adhesive resin cements. The adhesive resin cements require an initial phosphoric acid etching of the tooth structure and a separate adhesive application to the tooth structure. The self-adhesive resin cements, however, do not require an initial separate acid etching or a separate adhesive application to the tooth structure.

During the last century, the quest for an ideal luting cement has been influenced by other variables. These variables include more conservative tooth preparation designs, improved mechanical properties of ceramic and resin-based materials, advanced formulations of adhesive systems, numerous diverse adhesive techniques and luting procedures, and various tooth and biomaterial surface conditioning.[11]

Adhesion at the restorative interface

Before discussing these different surface treatments, an understanding of adhesion at the restorative interface may provide the clinician and dental technician with more predictable methods for achieving an optimally bonded restoration. 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

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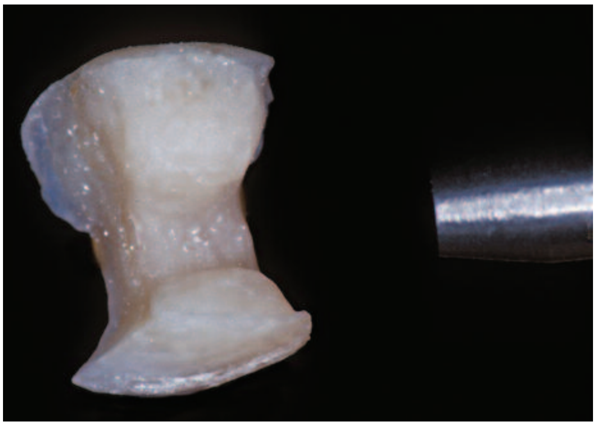
of bodies in contact," the force referred to as adhesion occurs when unlike molecules are attracted. The adhesive, frequently a viscous fluid, is comprised of a material or film that joins 2 substrates together and solidifies. The adherend is the material or initial substrate to which the adhesive is applied.[12] While most adhesive joints involve only 2 interfaces, a bonded composite restoration would be an example of a more complex adhesive joint.[13] Ensuring adequate performance of the adhesive joint requires knowledge and experience in the types of adherends (ie, enamel, dentin, metal alloy, composite material) and the nature of the surface pretreatment or primer. The adhesive adherend and surface all 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.[13] 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.[14]

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 plays a role in achieving the desired level of adhesion for various types of adhesive and adherend.[13]

The bonded restorative complex includes the outer layers of the substrate, the adhesive layer and the restorative material. The latter, when properly joined to the tooth substrate, is able to provide an improved marginal seal while reducing marginal contraction gaps, microleakage, nanoleakage, marginal staining, and secondary caries.[14] Also resulting from the adhesion between tooth and biomaterial is restoration retention and a reduction of stress at the tooth-restorative interface. Biomechanically, this bond reinforces tooth structure and biologically preserves tissues, seals dentin tubules, and provides long-term functional success.[15-17]

Figure 1: Preoperative occlusal view of a maxillary left second premolar with recurrent decay that was previously restored with a gold inlay restoration.

Figure 2: Proximal caries was removed on the mesial and distal aspect of the premolar, and an inlay preparation design was completed. The preparation was cleaned with a 2% chlorhexidine and rinsed with water.



Figures 3a and 3b: The internal surface of the laboratory-processed composite inlay was microetched with silicate ceramic sand (Rocatec/Cojet System 3M ESPE) for to 2 seconds and air-dried (a). A silane coupling agent (Silane primer Kerr) was applied to the internal surface of the restoration with a brush and then air-dried (b).

Biomaterial surface treatments

Different surface treatments have been introduced to pretreat the biomaterial surface and improve the bond at the restorative material-resin interface.[18-22] Adhesive bonding is dependent on the surface energy and wettability of the adherent (ie, internal surface of the restorative material) by the adhesive. The adhesion between biomaterial and adhesive cement is the result of a physico-chemical interaction at the restorative material-resin interface involving 2 simultaneous mechanisms: chemical bonding and micromechanically interlocking. Some of the various surface treatments that have been recommended for achieving these mechanisms of adhesion with different types of biomaterials include mechanical roughening of surface with a coarse diamond bur, airborne-particle abrasion using alumina particles, and etching with hydrofluoric acid.[18-22] Because of the different chemical structure between biomaterials (ie, laboratory processed composite, silica-based ceramics, and high strength ceramics), different surface treatments are required.

Surface treatment of composite restoration for adhesive resin cementation

Adhesive bonding of laboratory-processed composite resins increases their resistance to fracture.[23] A principal determinate in the long-term success of these restorations relies on the strength and durability of the interface between the resin cement and the bondable surface of the processed resin.[24] The surface of laboratory-processed composite resins is highly polymerized with minimal unreacted free-end radicals for bonding to the resin cement.

While microleakage has been reported to occur at this interface between the internal surface of the inlay/onlay and the resin cement in the absence of composite softening agents,[25] several surface treatments have been advocated to promote adhesion between the resin cement and the indirect composite restoration. Mechanical roughening of the internal surface of the inlay can be accomplished with small particle diamond burs or microetching with either 50 μm aluminum oxide particles or 30 μm silanized silica-coated aluminum oxide particles, which creates a micromechanical retention bond at a microscopic level between the restorative material and the resin cement. In addition to mechanical roughening, an application of proprietary softening agents, wetting agents, or silane has been reported to enhance the bond strength between the restoration and the resin cement.[26]

Various precementation protocols have been recommended by the manufacturers of indirect resin systems. The authors standard cementation protocol for laboratory-processed composite resins includes microetching with a silicate ceramic sand (Cojet-Sand 3M ESPE), and then a subsequent application of silane to restore any coating on the original fillers that may have been removed by sandblasting. As a bifunctional molecule, the silane acts as a coupling agent between the filler particles on the indirect resin surface and the resin cement. Newer formulations of silane that include a monomer (ie, unfilled resin) further simplify the bonding process. Microetching of aged composite resin with silica-coated aluminum oxide particles results in higher bond strengths compared to other surface treatments for intraoral repair of composites.[27] CoJet, a tribochemically assisted bonding system is designed to create potential micromechanical retention and a chemical bond between composite and most types of restorations. The mechanism of action allows the silicate particles to become embedded in the surface of the restoration during sandblasting, which then reacts with the silane to improve bond strengths.[28] Reports indicate, however, that etching or rinsing after such surface treatment can significantly decrease shear bond strengths (Figures 1 to 7).[26,29]

Conclusion

The restorative success of any indirect restoration begins and ends at the adhesive interface. While new products and technological advances impact our profession positively, a new burden rests on clinicians to continually educate themselves on the properties and applications of the new materials. Part 1 of this discussion has defined adhesion at the restorative interface and provided the standard surface treatment and adhesive cementation protocol for laboratory processed composite resin restorations.

Part 2 of this article series will describe the surface treatment protocols for different ceramic microstructures and their clinical application.

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Figure 4: The preparation was etched for 15 seconds with a 37.5% phosphoric acid semi-gel (Gel Etchant Kerr), rinsed for 5 seconds, and lightly air-dried.

Figure 5: A thin layer of adhesive was applied to the preparation with an applicator for 20 seconds with continuous motion, lightly air-thinned for 5 seconds, and light-cured for 10 seconds per surface.

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Figure 6: A resin cement (NX3 Nexus Kerr) was injected into the entire preparation, and the restoration was positioned firmly in place. The excess resin cement was removed with a No. 000 sable brush using the "wet brush" technique. This procedure involved applying a small amount of bonding resin to the tip of the sable brush, then wiping it over the restorative interface to remove any excess resin cement. (Note: A residual amount of resin cement is left at the interface to compensate for polymerization shrinkage.)

Figure 7. Postoperative view of the definitive restoration. Note the harmonious integration of the composite resin with the existing tooth structure.

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