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Adhesive Technologies

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In his introduction to this special section, Dr. Sesemann points out that adhesive technology—once a cutting-edge, innovative science—is now an essential element of all restorative dentistry.

Today's clinicians have an array of dental adhesive technologies at their disposal. The evolution of adhesives has taken the technology from hydrophobic materials with low bond strength to the total- and self-etch systems and integrated adhesive products in use today, which allow dentists to provide treatments that are much more conservative than in the past.

In this special section, a variety of manufacturers highlight their latest adhesive offerings; innovative self-etch and total-etch technologies that provide superior bond strength and additional features that would have been inconceivable just one generation ago. Our contributors also detail some of the educational initiatives they currently offer to help clinicians get a grip on the latest adhesion technology, and share their thoughts on where that technology may be headed in the future.

Compendium would like to thank Dr. Sesemann for lending his expertise to this Special Report section, as well as thank the following companies for their participation:

NEXT MONTH'S SPECIAL REPORT:

Digital Radiography
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Adhesive Technologies: Innovative Science Becomes Essential Element

By Michael R. Sesemann, DDS

In less than a generation of dental science, adhesive technology—once an innovative science—is now an essential element of all restorative dentistry. For many dentists practicing today, there is not one single restorative material or technique employed during a typical clinical day that does not include adhesive technology.

HISTORY

The earliest dental adhesives were placed directly on enamel and dentin smear layers[1]. Because researchers did not know of the presence of the smear layers, the relatively hydrophobic material they utilized could not penetrate them, yielding low bond strengths that were essentially the intrinsic, cohesive strength of the smear layer, approximately 5 MPa to 10 MPa.[2]

Fortunately, in 1955 Buonocore[3] found that acid etching the enamel increased bond strengths considerably to 20 MPa to 25 MPa. This discovery was made even though the smear layer had still not yet been identified. Unfortunately, the following year, Buonocore et al[4] found that the same procedure carried out on dentin yielded very low bonds, approximately 5 MPa to 10 MPa. Over the next 20 years, little progress was made with dentin bonding.

Yet, because of the innovation of this early work, in 1978 the author was taught at dental school about the benefits of acid etching to help seal the margins of anterior composite restorations. Crude by today's standards, wisps of cotton with liquid phosphoric acid were used to attempt to etch only the enamel margins of our preparations. Other than this single adhesive technique, all of the other restorative procedures the author learned and used in school, and shortly thereafter in practice, were based on retentive form, not adhesive technology.

In 1982, Nakabayashi et al[5] published their classic paper that would clarify the process of dentin bonding and distinguish the formation of the "hybrid layer." Their research showed how resin infiltration of acid-etched dentin completely transforms the surface from one that is crystalline, acid-sensitive and relatively hydrophilic to a structure that is organic, acid-resistant and hydrophobic.[2] In essence, the acid-solubilized mineral phase of the original dentin was extracted and replaced by resin during resin infiltration. The new surface was neither dentin nor resin, but a hybrid of both. The findings that were presented illustrated the essence of the total-etch concepts that are practiced today, put forth by Fusuyama two years earlier.[6] To this day, total-etch adhesive technology is still considered to be the gold standard of adhesive technology when comparisons are made in contemporary literature.[7-9]

Adhesive technology was not really in demand prior to the advancement of metal-free restorations and the advent of the philosophy of conservative dentistry. In the late 1970s, a pre-fabricated acrylic veneer was chemically bonded to etched tooth structure.[10] In the 1980s came the introduction of the fabrication and placement of the porcelain veneer.[11,12] The writings of Calamia and Simonsen further outlined surface treatments such as hydrofluoric acid etching and silanation for improved retention[13] of these revolutionary porcelain restorations. With these new restorative treatments in play, the drive for proven and reliable adhesive technology shifted into high gear.

Researchers and dental material companies dedicated significant time and money to evolve the science of adhesive technology, giving dentists more knowledge and precision to apply a variety of techniques. For example, innovative evolutions such as the wet (or moist) bonding technique by Kanca[14] provided significant steps forward in the dental industry's understanding of adhesive processes. Through his electron microscopy studies two years later, Gwinnett found that Kanca's techniques yielded thicker hybrid layers[15] that could be associated with higher bond strengths and a more impervious seal.

Over time, and primarily based upon marketing considerations, dental adhesives were classified as generational, giving rise to a nomenclature of first generation, second generation, third generation, etc, through seventh. In an effort to clarify the discerning difference in technique and clinical application, the "generational classification system" gave way to more descriptive organization. Currently, the two main classifications in use today can be categorized as one of two types: etch-and-rinse or "total-etch" adhesive systems (previously referred to as fourth- and fifth-generation adhesives), and "self-etch" adhesive systems (previously referred to as sixth- and seventh-generation adhesives).

ETCH-AND-RINSE ADHESIVES

Etch-and-rinse adhesives are available as three-step (fourth-generation) and two-step (fifth-generation) systems. Typically, etch-and-rinse adhesives produce high and substantive adhesion values for both enamel and dentin. If the surface to which the adhesive will be applied consists of significantly more enamel than dentin, or has a circumference of enamel that will help provide marginal integrity, an etch-and-rinse system is preferred.

The basic steps of etch-and-rinse adhesive systems include the following: demineralization of the surface by an acid etchant including removal of the smear layer, penetration of adhesive monomers into the spaces created by the etchant, and curing of the adhesive monomers to form a microscopic mechanical bond to the enamel and dentin. Two common technical parameters that must be controlled clinically and are related to the success of the procedure are moisture control and solvent elimination.[16] The literature is clear in refuting claims of postoperative sensitivity if the techniques are carried out as directed.[17]

SELF-ETCHING ADHESIVES

Self-etch adhesives are available as two-step (sixth-generation) and one-step (seventh-generation) systems. Neither system decrees the need for a separate acid-etching step though there is a distinctive difference in performance when the bondable surface is enamel, particularly whether it has been instrumented and/or separately etched.[18,19] The self-etching primers use the smear layer of the instrumented dentin as a legitimate bonding substrate. Because of the variance in acidities of the self-etching primers in different commercial products, differences can exist as to the depth they penetrate into the smear layer and the resulting thickness of the bonded layer formed. Self-etching applications can include procedures where the primary bondable surface is dentin such as bonding of endodontic posts, core build-ups and full crowns.

INTEGRATED ADHESIVE PRODUCTS

Glass ionomers, compomers, and resin-modified glass-ionomer materials can serve as excellent choices when considering certain restorative and cementing options. The combined ionomer-composite restoration, commonly referred to as the "sandwich technique," provides a long-term, reliable bond and seal to dentin through Ca^{+} ion chelation[20] of the glass-ionomer component with the dentin, micromechanical bonding of the composite to the ionomer surface, and an acceptable esthetic result with the completed restoration.[21]

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