Educational Objectives
Upon completion of this course, the clinician will be able to do the following:

1. List and describe the types of dental adhesive systems available.
2. Describe the clinical application of etch-and-rinse dental adhesives and the types of cases for which these are best suited.
3. Describe the clinical application of self-etch dental adhesives and the types of cases for which these are best suited.
4. Describe the newer adhesives that have been developed and their benefits.

Abstract
Most of the commonly performed tasks in dentistry have benefited from the development of modern dental adhesives, which are used for a wide range of applications. Dental adhesives enable minimally invasive dentistry. It is believed that dental adhesives can reinforce weakened dentin or enamel, reduce marginal staining, reduce microleakage, and may also reduce postoperative sensitivity when used appropriately. The resin-based adhesive systems developed to date can be categorized as one of two types: etch-and-rinse (total-etch) adhesive systems and “self-etch” adhesive systems. Both systems result in a unique interface at the juncture of tooth surface and adhesive. In the last decade, most new developments in dental adhesives have been focused on simplifying the components required for the bonding systems and improving performance of the resulting self-etching adhesives. Enamel bonding is superior with etch-and-rinse adhesive systems, while self-etch systems may be more suitable for restorations with large areas of dentin. Careful consideration of several factors is essential in selecting an adhesive system.

Introduction
Modern dental adhesives are used for a wide range of applications. Direct anterior and posterior composite resin restorations all require bonding, while amalgam restorations may (optionally) also be bonded. Similarly, indirect resin inlays, onlays, and veneers require bonding and, depending on their design, crowns, bridges, and posts and cores may either require and/or benefit from the use of dental adhesives in conjunction with resin luting materials. In addition, dental adhesive technology is used in pit-and-fissure sealants, some endodontic obturation materials, fixed orthodontic appliances, and dentinal hypersensitivity treatments. In total, most of the commonly performed tasks in dentistry have benefited from the development of dental adhesives.

Dental adhesives were originally developed as an extension of industrial adhesives used to help paint and resin coatings bond to metal. Dr. Michael Buonocore is widely considered to be the first person to propose the application of adhesion technology in dentistry. His groundbreaking research in 1955 demonstrated for the first time that acid-etching of enamel could provide a surface suitable for bonding with resins. By the mid-1960s, the first commercially available pit-and-fissure sealants and composite resin materials utilizing this new adhesive technology were used clinically. Buonocore theorized that resin tags filling the defects created by the etchant were responsible for enamel adhesion, and by the late 1960s, he also proposed that bonding to dentin was possible. Since then, dental adhesives have been developed that provide numerically higher bond strengths and more substantive bonded interfaces to both enamel and dentin. By the 1980s, etch-and-rinse adhesives had gained widespread acceptability. By the 1990s, the concept of the “hybrid layer” was accepted, and both multi-step and single-step adhesives were available (Table 1).

Table 1. Development of dental adhesives

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>Proposed dental application of adhesive technology</td>
</tr>
<tr>
<td>Mid-1960s</td>
<td>Commercially available pit-and-fissure sealants and composite resins utilizing bonding</td>
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<tr>
<td>Late 1960s</td>
<td>Proposed bonding of dentin</td>
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<tr>
<td>1980s</td>
<td>Widespread acceptability of etch-and-rinse adhesives</td>
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<tr>
<td>1990s</td>
<td>Acceptance of the “hybrid layer” concept</td>
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<td></td>
<td>Availability of multi-step and single-step adhesives</td>
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Dental adhesives promote conservation of tooth structure and enable minimally invasive dentistry. For example, bonded bridges are based on the concept of minimal tooth preparation, by taking advantage of the adhesion of the “wings” of the bridge to abutment teeth. Chemical retention, either alone or in combination with mechanical retention (depending on the preparation’s configuration), has been demonstrated in various laboratory tests. Thus, it is believed that dental adhesives can reinforce weakened dentin or enamel, reduce marginal staining, reduce microleakage, and may also reduce postoperative sensitivity when used appropriately (Table 2).

Table 2. Potential effects of dental adhesives

<table>
<thead>
<tr>
<th>Effect</th>
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<tbody>
<tr>
<td>Promotion of tooth structure conservation</td>
</tr>
<tr>
<td>Reinforcement of weakened dentin and enamel</td>
</tr>
<tr>
<td>Reduction of microleakage</td>
</tr>
<tr>
<td>Reduction of marginal staining</td>
</tr>
<tr>
<td>Reduction of postoperative sensitivity</td>
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Over time, and primarily based on marketing considerations, dental adhesive systems have been classified as generational. In fact, the resin-based adhesive systems developed to date can be categorized as one of two types: etch-and-rinse (total-etch) adhesive systems, available as three-step and two-step systems and “self-etch” adhesive systems, available as two-step and one-step systems (Figure 1). Regardless of the system selected, etching and demineralization of the tooth surface can be demonstrated to a greater or lesser degree, depending on the chemistry of the system selected. Both systems result in a unique interface at the juncture of tooth surface and adhesive. The difference in the interface that exists for enamel, as compared to dentin, is an important consideration in the selection of either an etch-and-rinse or a self-etching adhesive system. Each system requires the use of a specific, and often different technique. Different considerations are required with each system to enable successful bonding, resulting in technique sensitivity for a given bonding procedure. The total application time varies from system to system, but generally is within a similar timeframe for both systems.

**Etch-and-Rinse Adhesives**

Etch-and-rinse adhesives are available as a three-step system (e.g., OptiBond FL; Scotchbond Multi Purpose Plus; All Bond 3;) and two-step systems (e.g., OptiBond Solo; Adper Single Bond Plus; Prime&Bond NT; Excite; XP Bond). Typically, etch-and-rinse adhesives produce high and substantive adhesion values for both enamel and dentin. In comparison, self-etch adhesives generally demonstrate better adhesion to dentin than to enamel. These are key considerations for anterior restorations. If the surface to which the adhesive will be applied consists of significantly more enamel than dentin — and particularly if the surface consists of intact enamel, such as with an anterior diastema, an unprepared veneer, or a minimally prepared adhesive bridge — an etch-and-rinse system is preferred.

**Mechanisms of action — enamel and dentin**

The basic mechanism for enamel and dentin bonding using etch-and-rinse systems consists of the following steps: demineralization of the surface by the acid (etchant), penetration of the adhesive monomers into the microscopic spaces created by the etchant, and curing of the adhesive monomers to form resin tags that microscopically provide a mechanical bond and seal to dentin and enamel (Figure 2).

**Acid etching of enamel** creates a porous layer 5μm to 50μm in depth that is available for resin penetration. Macro resin tags are created peripherally around the demineralized surface of the hydroxyapatite crystals, and micro tags are formed by resin penetration into demineralized crypts within the crystals (Figure 3).

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**Figure 1. Dental adhesive systems**

**Figure 2. Enamel and dentin bonding**

**Figure 3. Ground enamel surface etched for 15 seconds with 34% phosphoric acid.** Preferential dissolution of the enamel prism core is seen (A) with prism boundary visible (arrows).
With dentin bonding, the etchant creates a demineralized surface 3 μm to 5μm in depth while also removing the smear layer debris created during instrumentation. Failure to remove the smear layer reduces dentin permeability, as that layer acts as a barrier and prevents adhesion to the underlying, intact tooth structure (Figure 4). Demineralization results in the exposure of the collagen contained in the dentin. The primer and adhesive (or combined primer-adhesive, in the case of two-step systems) then interpenetrates with the exposed collagen and remaining mineral, penetrating to the residual intact mineralized dentin within this microscopic etched surface and providing retention upon curing of the adhesive. This newly created interface is referred to as the “hybrid layer” and is observed in three distinct areas: within the dentinal tubules, in the microscopic branches lateral to the tubules, and in the intertubular dentin (Figure 5).

Three-step etch-and-rinse systems contain an etchant, a primer, and a bonding resin (adhesive). The primer is used to displace residual moisture, thus creating a surface upon which the hydrophobic bonding resin can adhere. The primer assists the adhesive to flow into and penetrate the etched tooth surface. The primer often contains a hydrophilic portion that interacts with the moisture present in the tooth structure, as well as a hydrophobic end that provides bonding sites for the methacrylate monomers in the bonding resin. The subsequently applied bonding resin (adhesive) fills the residual space and seals the dentinal tubules (Figure 6). Polymerization of the bonding resin stabilizes the hybrid layer and also provides a polymerizable surface layer upon which the final composite resin is bonded. Two-step systems combine the primer and adhesive materials into one component, thus condensing that application process into only one step. Several authors have suggested that the two-step systems may introduce greater variability into bonding results. However, these systems have exhibited excellent clinical performance over the years.

One key performance factor that influences the success of etch-and-rinse systems includes the thorough removal of the etchant prior to bonding. In addition, it is critical to ensure that the dentin remains moist when the primer and adhesive (or primer-adhesive combination) are applied, so that adequate penetration of the etched surface is obtained for maximal resin tag formation (Figure 7). Restorations comprising greater dentin surface area relative to the enamel surface area are more demanding in regard to this consideration. For example, large posterior cavities and full crown preparations with extensive dentin surface areas particularly prone to the effects of etching and moisture controls.

While it has been suggested that self-etch adhesive systems result in less postoperative sensitivity, a recent study by Perdigão et al. found no differences in postop-
erative sensitivity between patients treated with self-etch adhesives and those treated with etch-and-rinse adhesives — nor have any differences been discovered in marginal integrity. It was concluded that restorative technique influences postoperative sensitivity. 20

There is proven long-term bond stability using etch-and-rinse systems with both enamel and dentin. Some studies have shown bonding to enamel is more consistent, with higher initial bond-strength values and less breakdown at the enamel margin over time than with self-etching adhesive systems. 21 An important consideration when selecting between etch-and-rinse and self-etch systems is the condition of the enamel that will be bonded.

If the enamel comprises mostly intact or uninstrumented enamel, the choice of an etch-and-rinse system is preferred (Figures 8a, 8b). If the tooth surface to be etched consists mainly of dentin, self-etching systems may be a better choice in order to avoid the need to reinfiltrate the dentin after exposing the dentinal tubules with the etchant of the etch-and-rinse system (Figure 9).

Self-etching Adhesives
Self-etch adhesives are available as one-step systems and two-step systems. They offer an advantage over etch-and-rinse systems: they do not require a separate etching procedure. Thus there is no need to rinse and then dry the preparation prior to application of the adhesive. In addition, these systems are more tolerant of the presence of moisture on the preparation. Finally, the etching process proceeds in conjunction with the penetration of the adhesive, thus eliminating the potential for over-etching when treating dentin.
Mechanisms of action — enamel and dentin
Self-etch adhesive systems are available in a range of acidities, from low pH (<1) through mild pH (≥2) variants. As with etch-and-rinse adhesive systems, the mechanism of adhesion is thought to be a combination of mechanical and/or chemical retention. Low-pH self-etch systems result in a hybrid layer that mimics the hybrid layer formed with etch-and-rinse adhesives, producing deep resin tags. Mild-pH self-etch adhesives have shallower resin tags — the hydroxyapatite is not completely demineralized — and it is believed that retention may be partly due to a chemical interaction between the monomer and the hydroxyapatite crystal.25

As the self-etch adhesives are moisture forgiving, they are particularly useful in difficult-to-isolate areas or with difficult patients. However, self-etch adhesives generally contain water in addition to monomers in their formulation. This implies that it is more critical to ensure that the drying of the adhesive after application is effectively completed. In addition, the presence of moisture in the formulation requires special attention to shelf stability on the part of the manufacturers, making the stability of some products less certain than etch-and-rinse systems.26 Since self-etch adhesive systems demineralize and penetrate the dentin at the same time, there is no concern over incomplete penetration and residual gaps within demineralized dentin. Due to the milder acidity of the self-etching adhesives, the removal of the smear layer is often less complete (Figure 10), so the dentinal tubules may not be as open as in the case of the etch-and-rinse systems. This is thought to reduce the risk of postoperative sensitivity, although the restorative technique is perhaps the key to reduced postoperative sensitivity.27

Figure 10. Self-etch and etch-and-rinse adhesives

The main disadvantage of self-etch adhesive systems is that the enamel must be instrumented to provide an effective etch. Self-etch adhesives typically do not provide as high an enamel bond compared to etch-and-rinse adhesives.28,29,30 In some cases, self-etch systems demonstrated a higher incidence of marginal staining on enamel margins, while the dentin margins were acceptable (e.g., posterior/more extensive preparations). Self-etch adhesives thus may be preferred over the etch-and-rinse adhesives if the remaining enamel has been instrumented and if the surface area to be bonded consists mainly of dentin. They may also be a better choice if sustained isolation from oral fluids is likely to be a problem.

Newer Adhesive Developments
In the last decade, most new developments in dental adhesives have been focused on simplifying the components required for the bonding systems and improving performance of the resulting self-etching adhesives. The true one-bottle self-etch systems have now evolved to only one material which is applied to the tooth, with no mixing required. Some of the newer systems have modified the self-etch ingredients so as to result in improvements in the products’ shelf lives, with diminished hydrolysis in the package. As noted above, while the quality of dentin adhesion with these self-etch systems is comparable to the etch-and-rinse adhesives, the enamel bonding of these systems still falls short of values for bond strengths achieved in the laboratory using a phosphoric acid etch system. The self-etch systems remain popular due to the lack of concern regarding the technique used with moist dentin. The moist bonding technique has been repeatedly shown to augment bond strengths of ethanol- and acetone-based

Techniques to maximize self-etch adhesive performance

1) Enamel, if present, should be beveled to improve retention.

2) The surfaces to be bonded should be clean and debris-free to prevent contamination of the adhesive, since there is no rinsing step that would remove any contaminants.

3) If using a multidose, single-bottle adhesive, the amount required should be dispersed immediately prior to use in order to reduce the risk of solvent loss, which could potentially result in phase separation of monomer and water. Using a unit-dose package helps to avoid this problem and also provides an appropriate amount of adhesive for use.

4) Apply the self-etch adhesive to the enamel first, followed by application to the dentin. Some products recommend agitation of the adhesive to enhance its penetration.

5) Do not use a separate etchant on the dentin prior to using self-etch adhesives. While it may be believed that this would improve the bond to dentin, self-etch adhesives are not designed to work on etched dentin. The result would be clinically undesirable and could potentially result in catastrophic failure of the restoration. If using a separate etchant on enamel, great care must be taken to avoid its contact with dentin and to thoroughly rinse it off prior to the use of self-etch adhesives.

6) If using a one-step self-etch adhesive, apply multiple applications to help ensure adequate coating and penetration.

7) Thoroughly dry the adhesive (with a gentle stream of air) once it has been placed, to ensure removal of any volatile solvent and prevent interference with polymerization.

8) Light-cure the adhesive prior to placing the composite.
etch-and-rinse adhesives, while low bond strengths have been associated with excessively air-dried dentin in the etch-and-rinse materials. The major reason for this is presumed to be the effect of collapsing the collagen network at the bonding interface. The collapsed collagen prevents complete infiltration of the resin monomers into the demineralized dentin, leading to gaps and voids within the adhesive interface.

As the first new etch-and-rinse adhesive system since 2000, XP Bond (Dentsply/Caulk) has shown promise, as it is relatively insensitive to the amount of residual dentin moisture. This characteristic can effectively widen the window of opportunity for bonding to demineralized dentin, and can generate a system with excellent dentin adhesion under a wide range of clinical conditions, with the reliability of an enamel bond generated through phosphoric acid conditioning.

This etch-and-rinse adhesive contains two resin-adhesion promoters: the phosphoric acid ester monomer dipentaerythritol pentacrylate-phosphoric acid (PENTA) and butan-1,2,3,4-tetracarboxylic acid, di-2-hydroxyethyl methacrylate ester (TCB), a monomer with two carboxylic acid groups. Recent Raman spectroscopy investigations have shown evidence of the formation of a covalent bond between the PENTA ester group and the calcium in dentin and enamel (Figure 11).

Figure 11. Covalent bond between PENTA ester group and calcium ions

In addition to the adhesive promoting monomers, it uses tertiary-butanol as the solvent carrier for the adhesive resin mixture. The chemical structure of this alcohol seems to impart unique properties to the adhesive formulation when applied to moist or dry dentin. Figures 12 and 13 represent, respectively, the scanning electron micrographs (SEMs) of the adhesive dentin interface of OptiBond Solo (an ethanol-based system) and XP Bond applied to moist dentin. A fully infiltrated dentin/mineral/resin hybrid layer is seen with both materials.

In Figure 14, OptiBond Solo was applied to overdried dentin. The hybrid layer is incompletely formed, with gaps and voids at the adhesive/dentin interface. Figure 15 shows XP Bond applied to overdried dentin, and the hybrid layer which results cannot be distinguished from that formed on moist dentin. Figure 16 shows a transmission electron micrograph of XP Bond applied to overdried dentin. The electron-dense band at the top of the hybrid layer represents the collapsed collagen layer. The XP Bond was able to completely infiltrate and demineralize the dentin below the collapsed layer of collagen. Numerous laboratory evaluations and early clinical results show great promise of the new etch-and-rinse XP Bond adhesive system.
Use of Resin Adhesives with Resin Cements

Use of resin adhesives is an important part of numerous clinical procedures when light-cured, self-cured, or dual-cured resin restorative or cements are employed. The indications include cementing posts; resin core build-ups; and cementing ceramic veneers, inlays, and onlays as well as certain full-crown ceramics. If exclusively light-cured materials are used, such as when cementing a ceramic veneer, the resin adhesive can be light cured alone if a light-cured-only resin cement base follows. However, there are known incompatibilities between some acid containing adhesives and self-cured and/or dual-cured resin cements or restoratives. It has been suggested that a small amount of residual acidic resin monomer can deactivate the tertiary amine that promotes the dark-cure polymerization of the resin cement or restorative. It is for this reason that it is suggested that, unless specifically designed for use with a dual and/or self-cure resin cement or restorative, self-etching adhesives should be avoided. In fact, even with etch-and-rinse adhesive systems, mixing different manufacturers’ materials should be avoided to prevent incompatibility issues between the interface of the adhesive and the dual and/or self-cure restorative or cement material.

Several manufacturers provide a self-curing activator to be mixed with their respective adhesive (etch-and-rinse or self-etch) to ensure full polymerization of a self- or dual-curing material. The primary function of these activators is not to promote the polymerization of the adhesive itself, but to provide a chemical environment at the interface between the adhesive and the self or dual-cured resin restorative material that promotes the curing of the interface, thus securely bonding the adhesive and restorative.

The new etch-and-rinse adhesive, when mixed with its specifically designed self-cure activator (SCA) in conjunction with Calibra cement, demonstrates some unique properties compared to other activated adhesives with their respective resin cements. When the self-cure-activated adhesive and the resin cement are light-cured (dual-cure mode for the Calibra), the enamel and dentin bond values are equal to or higher than those of other similar systems. However, even in the pure chemical self-cure mode (when no light is introduced), the self-cure-activated adhesive and self-cured cement form bond strengths to dentin that are higher than those achievable with similar dual-curing conventional systems.

Summary

Dental adhesives are used for a wide variety of applications. They are available as etch-and-rinse systems (also known as “total-etch” systems) and self-etch systems. Both systems result in etching of the tooth surface, and mechanical and/or chemical retention of the restoration or device upon curing of the adhesive. The adhesive system selected has implications for the technique used as well as for the quality of the bonding. Enamel bonding is superior with etch-and-rinse adhesive systems, while self-etch systems may be more suitable for restorations with large areas of dentin. Careful consideration of several factors is essential in making the selection of an adhesive system. Mixing different manufacturers’ materials (for example, adhesives and resin cements) should be avoided, as there are potential incompatibilities among the respective chemistries. Only adhesive systems specifically designed for the specific resin cement should be used. Recently, newer adhesives have been introduced that focus on simplifying and improving the performance of adhesive systems for bonding of both enamel and dentin.

References

6. Perdigão J, Geraldeli S, Hodges JS. Total-etch versus self-etch...
43 Suh BI, Feng L, Passley DH, Tay FR. Factors contributing to the incompatibility between simplified adhesives and chemically cured or dual-cured composites. Part III. Effect of acidic resin monomers.

Author Profile

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Mark A. Latta, DMD, MS is currently the Associate Dean for Research and Professor of General Dentistry at the Creighton University School of Dentistry. He is a graduate of the University of Pennsylvania School of Dental Medicine (D.M.D.) and the University of Maryland Baltimore College of Dental Surgery (M.S.). He has been awarded numerous research grants for evaluating the laboratory and clinical performance of modern dental materials. He has lectured extensively about new dental materials and techniques and has published over 40 manuscripts and 150 abstracts.

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The author of this course has been principal investigator on laboratory and clinical research projects funded by multiple manufacturers including the sponsors or the providers of the unrestricted educational grant for this course.

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Questions

1. _______ of the commonly performed tasks in dentistry have benefited from the development of dental adhesives.
   a. None
   b. A few
   c. Most
   d. All

2. Dental adhesives were originally developed as an extension of _______.
   a. industrial adhesives used to help paint and resin coatings bond to plastic
   b. industrial adhesives used to help paint and resin coatings bond to metal
   c. mining adhesives used to help fix explosives to coal seams
   d. none of the above

3. The first person to propose the application of adhesion technology in dentistry is widely considered to have been _______.
   a. Dr. Michael Buonocore
   b. Dr. Ian Fleming
   c. Dr. Michael Buenavista
   d. none of the above

4. By the 1990s, _______.
   a. multi-step adhesives were available
   b. single-step adhesives were available
   c. the concept of the “hybrid layer” was accepted
   d. all of the above

5. It is believed that dental adhesives _______ when used appropriately.
   a. may reduce postoperative sensitivity
   b. can reduce marginal staining and microleakage
   c. can reinforce weakened dentin or enamel
   d. all of the above

6. Both etch-and-rinse and self-etch adhesive systems result in a unique interface at the juncture of the _______.
   a. cementum surface and the etchant
   b. teeth surface and the etchant
   c. enamel surface and the etchant
   d. tooth surface and the adhesive

7. Etch-and-rinse adhesives are available as _______.
   a. one-, two- and three-step systems
   b. two- and three-step systems
   c. one- and three-step systems
   d. all of the above

8. Dental adhesives promote _______ of tooth structure.
   a. cortication
   b. conservation
   c. destruction
   d. none of the above

9. The basic mechanism for enamel and dentin bonding using etch-and-rinse systems consists of _______.
   a. demineralization of the surface by the acid
   b. curing of the adhesive monomers to form resin tags that macroscopically provide a mechanical bond
   c. penetration of the adhesive monomers into the microscopic spaces created by the etchant
   d. all of the above

10. Acid etching of enamel creates _______ that is available for resin penetration.
    a. a porous layer 5 μm to 15 μm in depth
    b. a porous layer 5 μm to 25 μm in depth
    c. a porous layer 5 μm to 40 μm in depth
    d. a porous layer 5 μm to 50 μm in depth

11. Self-etch adhesives generally demonstrate _______ adhesion to enamel than/as to dentin.
    a. poorer
    b. the same
    c. better
    d. none of the above

12. Acid etching of dentin bonding creates _______ that is available for adhesion.
    a. a demineralized surface 3 μm to 5 μm in depth
    b. a demineralized surface 5 μm to 15 μm in depth
    c. a demineralized surface 5 μm to 25 μm in depth
    d. a demineralized surface 10 μm to 15 μm in depth

13. Failure to remove the smear layer _______.
    a. encourages resin adhesion
    b. reduces dentin permeability
    c. is immaterial
    d. a and b

14. The primer in three-step etch-and-rinse systems is used to displace residual moisture, thus creating a surface to which the _______ bonding resin can adhere.
    a. Hydrophobic
    b. hydrophobic
    c. hydrophilic
    d. none of the above

15. One key factor that influences the performance of etch-and-rinse systems includes _______.
    a. the use of phosphoric acid of at least 40% concentration
    b. ensuring that the dentin is dry when applying primer and adhesive
    c. the thorough removal of the etchant prior to bonding
    d. all of the above

16. A recent study by _______ found no differences in postoperative sensitivity between patients treated with self-etch adhesives and those treated with etch-and-rinse adhesives.
    a. Bilbao et al.
    b. Persipany et al.
    c. Perdigio et al.
    d. none of the above

17. If the enamel to be etched comprises mostly intact or uninstrumented enamel, _______.
    a. the choice of a self-etch system is preferred
    b. the choice of an etch-and-rinse system is preferred
    c. both adhesive systems are equal
    d. none of the above

18. Self-etch adhesives are available as _______.
    a. one-step
    b. two-step
    c. three-step
    d. a and b

19. Self-etch adhesives _______.
    a. do not require a separate etching procedure
    b. are more tolerant of the presence of moisture on the preparation
    c. eliminate the potential for over-etching when treating dentin
    d. all of the above

20. Low-pH self-etch systems result in a _______ that mimics the first step of etch-and-rinse adhesives, producing deep resin tags.
    a. uniform layer
    b. segregated area
    c. hybrid layer
    d. none of the above

21. Mild-pH self-etch adhesives have _______ resin tags.
    a. shallower
    b. similar
    c. deeper
    d. none of the above

22. With self-etch adhesive systems, _______.
    a. the dental tubules may not be as open as they are with etch-and-rinse systems
    b. demineralization and penetration of the dentin occur at the same time
    c. the removal of the smear layer is often less complete
    d. all of the above

23. Self-etch adhesives typically provide _______ enamel bond compared to etch-and-rinse adhesives.
    a. lower
    b. similar
    c. higher
    d. none of the above

24. Use of a separate etchant on the dentin prior to use of self-etch adhesives may _______ the bond to dentin.
    a. decrease
    b. maintain
    c. improve
    d. none of the above

25. In the last decade, most new developments in dental adhesives have been focused on _______.
    a. increasing the concentration of etchant for faster etching
    b. simplifying the components required for the bonding systems
    c. improving performance of the resulting self-etching adhesives
    d. a and c

26. Low bond strengths have been associated with _______.
    a. air-dried
    b. excessively air-dried
    c. excessive preparation
    d. none of the above

27. The primary function of self-activators that are mixed with their respective adhesive is _______.
    a. provide a chemical environment at the interface between the adhesive and the self or dual-cured resin restorative material that promotes the curing of the interface
    b. provide a mechanical environment that secures the adhesive interface
    c. reduce curing at the interface of the adhesive and tooth
    d. none of the above

28. Mixing different manufacturers’ materials when using resin adhesives _______.
    a. is of no consequence
    b. should be done to promote compatibility between the interface of the adhesive and the dual and/or self-cure restorative or cement material
    c. excessive preparation
    d. none of the above

29. The self-etch systems _______ popular due to the lack of concern regarding the technique used with moist dentin.
    a. are no longer
    b. are more
    c. remain
    d. none of the above

30. The key to reduced postoperative sensitivity is perhaps the _______.
    a. preparation being maximized
    b. restorative technique
    c. pre-operative technique
    d. a and c
Clinical Perspectives on Current Dental Adhesives

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EDUCATIONAL OBJECTIVES

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COURSE EVALUATION

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

1. Were the individual course objectives met?  
   Objective #1: Yes  No  Objective #3: Yes  No

2. To what extent were the course objectives accomplished overall?  
   5  4  3  2  1  0

3. Please rate your personal mastery of the course objectives.  
   5  4  3  2  1  0

4. How would you rate the objectives and educational methods?  
   5  4  3  2  1  0

5. How do you rate the author’s grasp of the topic?  
   5  4  3  2  1  0

6. Please rate the instructor’s effectiveness.  
   5  4  3  2  1  0

7. Was the overall administration of the course effective?  
   5  4  3  2  1  0

8. Do you feel that the references were adequate?  
   Yes  No

9. Would you participate in a similar program on a different topic?  
   Yes  No

10. If any of the continuing education questions were unclear or ambiguous, please list them.

11. Was there any subject matter you found confusing? Please describe.

12. What additional continuing dental education topics would you like to see?

All participants scoring at least 70% on the examination will receive a verification form verifying 2 CE credits. The formal continuing education program of this sponsor maintains records of your successful completion of any exam. Please contact our offices for a copy of your continuing education credits report. This report, which will list all credits earned to date, will be generated and mailed to you within five business days of receipt.

Mail completed answer sheet to

Academy of Dental Therapeutics and Stomatology, A Division of PennWell Corp.
P.O. Box 116, Chesterland, OH 44026 or fax to: (440) 845-3447

For IMMEDIATE results, go to www.ineedce.com and click on the button “Take Tests Online.” Answer sheets can be faxed with credit card payment to (440) 845-3447, (216) 398-7922, or (216) 255-6619.

Payment of $49.00 is enclosed. (Checks and credit cards accepted.)

If paying by credit card, please complete the following:

   □ MC  □ Visa  □ AmEx  □ Discover

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Charges on your statement will show up as PennWell

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AGD Code 017

PLEASE PHOTOCOPY ANSWER SHEET FOR ADDITIONAL PARTICIPANTS.

Payment of $49.00 is enclosed. (Checks and credit cards accepted.)

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