Enhanced Direct Composite Resin Restorations: An Advanced Pre-Etch and Seal Technique

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Educational objectives

Upon completion of this course, participants should be able to achieve the following:

• Understand the need for core build-ups in restorative dentistry.
• Understand the differences between self-etch and total-etch bonding.
• Be able to explain the clinical aspects of the core build-up procedure.
• Understand the reasons for a flowable composite liner in core build-ups.
• Understand the need for core build-ups in periodontal tissue management.

Introduction

Enamel and dentin are biologically and chemically different hard tissues, each responding differently to the etching process. Enamel, highly mineralized and uniform, is easily and predictably prepared for bonding with the application of 32-40 percent phosphoric acid, rinsing, and drying thoroughly. On the other hand, dentin bonding is more challenging due to several characteristics of dentin such as a variable tubular structure, a high organic content, and positive fluid flow. As well, the application of phosphoric acid leaves unsupported collagen.

A bonding strategy is presented that addresses uncut enamel and dentin individually, in which the benefits of each bonding strategy are optimized and their associated liabilities avoided. The results are enhanced restorations that are more durable, and more reliably bonded.
Phosphoric acid and enamel

Phosphoric acid etching, first described by Buonocore in 1955, is a familiar, routine clinical procedure used for decades to create a retentive surface that facilitates the bond between enamel and composite resin. The process involves formation of microporosities into which the resin can flow and following polymerization, will form a micro-mechanical bond to the enamel. This procedure almost completely eliminated microleakage at the tooth-restoration interface and has been shown to provide good adhesion to both ground and unground enamel.

The recommended etching time initially was 60 seconds, however subsequent studies have shown that a 15 second treatment produces similar surface morphology and bond strength values using a minimum concentration of 10 percent phosphoric acid.

Phosphoric Acid and Dentin

While phosphoric acid etching produces excellent, durable bond strength to enamel, its use on dentin has a less predictable result. First, it is important to understand that rotary instruments (burs) produce the smear layer: an acid-labile, tenacious layer of cellular debris that is burnished against the dentin surface that effectively occludes the dentinal tubules. The total-etch adhesives require this smear layer to be removed, hence the use of a phosphoric acid pre-treatment. In addition, this phosphoric acid decalcifies 3-5µm of peritubular and intertubular dentin and opens up the dentinal tubules, thereby increasing the dentin permeability to allow for the penetration of the primer and the resin.

The demineralization of the dentin using phosphoric acid leaves the collagen fiber network completely unsupported and in a fragile state, literally floating in the rinse water. If dried, these collagen fibrils collapse down onto the dentin substrate forming an impermeable organic barrier to the resin and so the hybrid zone cannot form. Where this phenomenon occurs, there is diminished bond strength to the dentin substrate, gap formation permitting bacterial infiltration, and recurrent caries, all contributing to post-operative sensitivity. Therefore, following the acid etching, the dentin must be allowed to remain “moist” in order to keep the collagen fibrils in an upright position until the primer can be applied; the primer helps support and re-expand the fibril network to allow full penetration of the resin.

As a practical matter, two potential problems exist. First, there is the difficulty in getting the adhesive resin to penetrate the decalcified zone fully and so microscopic voids can persist between the hybrid zone and the dentin surface, leading to factors that will promote additional post-operative discomfort. Secondly there is the technical difficulty is determining and creating the correct level of moisture on the dentin. Determining what is “too wet” and what is “too dry” is both a variable and a subjective evaluation, creating a very “technique sensitive” system by which the clinician must operate.

Total-etch dentin bonding therefore restricts the clinician to a narrow window because while excessively drying the etched substrate causes the collapse of the collagen fibrils and an unsatisfactory bonding surface, leaving too much water on the substrate prior to application of the primer will create clinical compromise as well. When there is too much moisture remaining, the excess water will diffuse into the organic solvents so fast that the adhesive monomers no longer remain dissolved in their solvents. They then undergo phase changes that lead to the creation of water blisters and resin globules between the dentin and the hybrid zone. These phase changes can cause poor resin tag formation, but also can create hydraulic pressure challenges with total etch dentin bonding

1. Difficulty in getting the adhesive resin to penetrate the decalcified zone fully.
2. Difficulty in determining and creating the correct level of moisture on the dentin.

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changes within the dentinal tubules under occlusal function. According to the Brannstrom hydrodynamic theory\(^1\), the current accepted theory of pain, such fluid movement within the tubules is the source of dentinal sensation.

### Self-Etch Dentin Bonding

In response to the technique sensitivity of the “total-etch” technique, researchers developed a new primer system for conditioning the dentin as a prerequisite for the formation of the hybrid zone. The newer method, called “self-etching” uses a highly acidic primer that is able to etch and prime the dentin simultaneously, avoiding the phosphoric acid pretreatment that removes the protective smear layer and decalcifies the cut dentin surface. It is not technique sensitive.

Since these products are meant to be used on dry dentin, the difficulty in determining what is “too wet” and what is “too dry” following the rinsing of the phosphoric acid pre-treatment of the total-etch systems is no longer a consideration. A uniformly dry dentin surface is easier to obtain clinically than a uniformly moist one, and so clinicians consistently obtain favorable results. With self-etching, the collagen fibrils cannot collapse during the drying of the dentin because they remain fully supported by the mineralized tissue during the entire bonding procedure. By avoiding the phosphoric acid dentin treatment, the smear plugs remain in the dentinal tubules, and intratubular fluid movement (with the resulting post-operative pain) is eliminated. Clinicians who routinely use self-etching adhesives report little or no post-operative sensitivity, even in deep restorations\(^1^4\).

While self-etching primers can be effective in creating a thin, strong dentin hybrid zone, they are less effective in etching uncut enamel as deeply as does phosphoric acid, potentially compromising the resin-enamel mechanical bond\(^1^5\). Therefore the bond strength to uncut or unetched enamel depends on chemical bonding with acidic monomers such as MDP or 4-META. Because the action of self-etching primers resulted in much less demineralization of intact enamel surfaces, enamel abrasion during cavity preparation can favor the formation of a defined etching pattern, which is what occurs clinically since teeth are prepared with carbide burs or diamonds prior to restoration. The effectiveness of self-etching adhesives on cut or prepared enamel are reliable and strong, although the effects of self-etching adhesives on unprepared enamel is still less than what are produced by phosphoric acid.

### An Advanced Strategy: Pre-Etch, Self-Etch and Seal the Margins

Combining the benefits of the phosphoric acid etching effect to uncut enamel with the self-etching adhesive’s conditioning of dentin is a technique that has been examined\(^1^6\).

Using phosphoric acid to pre-etch enamel prior to tooth preparation avoids the potential difficulties of the demineralized dentin substrate created by the phosphoric acid while still obtaining the advantages of the more aggressive etching of the unprepared enamel that phosphoric acid creates. Using the antibacterial, milder self-etching adhesive Clearfil Protect Bond on the cut dentin provides a dentin-resin hybrid zone that maintains the protective benefits of the smear layer by keeping the tubules occluded, and avoiding the technique sensitivity of maintaining the precise moisture levels on the dentin substrate.

After placing, contouring and rough finishing of a composite restoration, the use of a phosphoric acid etch followed by a fluoride releasing pit and fissure sealant

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**Challenges with self-etch dentin bonding**

1. Less effective in etching uncut enamel as deeply as does phosphoric acid.
2. Bond strength to uncut or unetched enamel depends on chemical bonding with acidic monomers.
3. Much less demineralization of intact enamel surfaces.
accomplishes three objectives. First, it seals and protects the interface between the restoration and the uncut enamel that might have been inadvertently damaged during the finishing procedure. Secondly it provides a surface glaze to the composite restorative material that flows into areas that might otherwise be inaccessible. Thirdly, the areas of the occlusal surface that are left unprepared can be effectively sealed with a material that has some filler content, hence more strength and better wear resistance.

Clinical Case:

Tooth #5 (Figure 1) exhibited signs of recurrent caries, and so the treatment plan was to remove the failed restoration and replace with an enhanced bonded composite.

Following satisfactory anesthesia using Citanest 1%, a rubber dam was applied only to the tooth being treated. The entire surface of the tooth and existing restoration was cleaned of plaque with coarse pumice (Figure 2) (Moyco) rinsed, and dried. Using a brush, 40 percent phosphoric acid was applied (Figure 3) over the entire occlusal surface (K-Etchant gel, Kuraray) for 15 seconds, then rinsed and dried (in order to visualize the frosted appearance of the enamel that would indicate a successful etch).

The old composite restoration was removed using a 330 carbide bur (Tri-Hawk) and the cut dentin was stained in order to check for caries (Caries Detector Solution, Kuraray Medical) (Figure 4). Any remaining decay was removed with a round bur #4 on the low speed handpiece under irrigation, and the cavity walls created with a tapered shoulder former diamond (F-82, Pollard Dental) so that they diverged occlusally similar to a cast inlay preparation (Figure 5).

Once the preparation was complete, a sectional matrix band (Composi-Tight Sectional Matrix, Garrison Dental Solutions) was inserted proximally using the special forceps such that the top of the matrix band extended above the marginal ridge of the adjacent tooth. A plastic wedge was selected from the kit that provided maximum separation of the teeth yet still was able to pass through to the lingual. Once in position, the wedge handle was twisted so that it separated, leaving the wedge in its proper position to separate the teeth and secure the sectional matrix. Then the ring was clamped into position (Figure 6) using the specialized clamp forceps, and the matrix burnished against the adjacent tooth using the multi-functional instrument (TN009, Garrison Dental Solutions).

With the matrix in its proper place, the dentin bonding process was ready to begin by applying the antibacterial self-etch primer (Clearfil Protect Bond, Kuraray) for the required 20 seconds to the cut dentin and also to the cut enamel (Figure 7). Following this conditioning process, the preparation was dried thoroughly so that no moisture remained on the dentin substrate. Then the microfilled resin was applied, lightly aired and then polymerized using a standard curing lamp.

Next, a heavily filled flowable composite (Clearfil Majesty Flow) was applied in a thin layer using a ball burnisher to the gingival seat of the proximal box, then cured for 20 seconds (Figure 8) followed by a thin layer application to the floor, then the walls of the cavity prep and cured again. Then, another small amount of
Flowable was deposited into the prep, immediately followed by an increment of an aesthetic nanohybrid composite (Clearfil Majesty Esthetic). The cavity was filled using small amounts of flowable followed by nanohybrid composite. The increments were placed at an angle to the vertical walls of the prep, using a composite carving instrument (TN009, Garrison Dental Solutions) to approximate the cuspal inclines and occlusal anatomy (Figure 9).

Once the material is fully cured within the cavity prep, the rubber dam was removed and the occlusion checked. Prematurities were removed using a shoulder former diamond (F-82, Pollard Dental) in order to maintain the cuspal inclines and occlusal anatomy. Coarse Soflex disks (3M) were then used to shape the proximal contours (Figure 10).

After the occlusion was correct, flash was removed with a scaler (Figure 11) and pumice was used on a rubber cup to remove the ink from the articulating paper and to provide a clean surface for the final seal. The pumice was rinsed, then the tooth isolated with cotton rolls. The tooth was re-etched using the same phosphoric acid, then rinsed and dried (Figures 12 & 13). Next, a pit and fissure sealant (Teethmate F-1, Kuraray) was applied to the entire surface of the restoration (Figure 14), contoured with a dry brush, then light-cured.

Discussion

Tooth enamel is a highly mineralized biologic substrate that is easily prepared for bonding with composite. By using a 15-second application of 32-40 percent phosphoric acid, rinsing, then drying, the clinician is able to create a strong, durable bond that is highly effective in preventing microleakage. Dentin, however, is a more complex and highly variable tissue where the use of a phosphoric acid treatment prior to dentin bonding (known as total-etch) will leave an unstable surface that if dried too little or too much will create a compromise in bond strength.

Self-etch adhesives were developed to address the “technique sensitivity” of total-etch systems by incorporating the smear layer into the hybrid zone, and maintaining the fully mineralized condition of the dentin during the entire bonding process. An improved self-etch adhesive was used that contained an antibacterial agent in the primer that disinfects the dentin substrate prior to bonding, a step that can contribute to lessening the chance for bacterial migration towards the pulp.

Self-etch primers will also create a favorable bonding surface on cut enamel, but less so on enamel that has not been prepared with rotary instruments. Therefore, a dentin bonding technique that incorporates the effective enamel etch of phosphoric acid with the biologic compatibility of a self-etching adhesive allows the clinician to create a more durable restoration without post-operative sensitivity.

The final use of the phosphoric acid followed by the application of a fluoride-releasing pit and fissure sealant will offer additional protection to the tooth-restoration interface from recurrent caries. Further, the sealant will correct any marginal defects that might have occurred during the finishing process as well as create a glass-like restoration surface without using a series of polishing abrasives. Accordingly, the final finish and seal becomes a “time neutral” procedure that can, in some circumstances, be delegated to auxiliaries.
Conclusions:

This “Advanced Pre-Etch and Seal” is a simple technique that maximizes the advantage of using phosphoric acid on the highly mineralized enamel without the technique sensitivity of using it on cut dentin. Similarly, the clinician accomplishes the dentin-bonding phase of treatment by taking advantage of the biologic compatibility of an antibacterial, self-etch adhesive without having potentially reduced bond strength to uncut enamel. Finally, the use a bonded fluoride-releasing pit and fissure sealant is a rapid procedure that protects the margins from breakdown and saves the operator chair time by imparting a high-gloss finish to the restoration.

Bibliography

Author’s Bio

Dr. Randall G. Cohen is in private practice of general, cosmetic and restorative dentistry in Bucks County, Pennsylvania, since his graduation from Temple University School of Dentistry in 1982. He has published papers in several journals and has lectured nationally on adhesive dentistry.

Disclosure: Dr. Cohen declares having received an honorarium from Kuraray America and Garrison Dental for this lecture.
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1. Dentin bonding is considered less predictable than enamel bonding because
   a. The application of phosphoric acid leaves unsupported collagen.
   b. Its tubular structure is highly variable.
   c. The pulp exerts a positive fluid flow.
   d. All of the above.

2. A phosphoric acid application to enamel
   a. Must remain undisturbed for 60 seconds.
   b. Requires a minimum concentration of 40 percent.
   c. Creates microporosities to accommodate resin.
   d. None of the above.

3. Self-etch primers:
   a. Eliminate the question of a “too wet” or “too dry” dentin substrate.
   b. Do not etch enamel as deeply as phosphoric acid does.
   c. Are not technique-sensitive.
   d. All of the above.

4. The smear layer
   a. Is removed by self-etch primers.
   b. Is acid resistant.
   c. Forms on the cut dentin surface following cutting with a bur or diamond.
   d. Becomes part of the hybrid zone when phosphoric acid is used.

5. Pre-etching a tooth prior to preparation
   a. Is not effective since preparation debris will contaminate the surface.
   b. Treats the uncut enamel without affecting the underlying dentin.
   c. Reduces bond strength of the resin-enamel bond.
   d. None of the above.

6. The use of phosphoric acid on enamel was first described by
   a. Buonocore
   b. Brannstrom
   c. Cox
   d. Pasley

7. The reason to etch the tooth prior to cavity preparation and follow with a selfetching adhesive on dentin is
   a. To maximize the benefits of phosphoric acid on dentin.
   b. To minimize the less desirable effects of phosphoric acid on uncut enamel.
   c. To maximize the benefits of the selfetching adhesives on cut dentin while improving the etching of uncut enamel.
   d. None of the above.

8. Etching the finished prep and then applying certain pit and fissure sealants accomplishes
   a. The creation of a glaze on the surface of the restoration.
   b. The sealing of the margins of the preparation with a fluoride-containing sealant that will aid in prevention of recurrent caries.
   c. The sealing of any pits and fissures not already included in the preparation.
   d. All of the above.

9. Which of these statements is false?
   a. Dentin is a highly variable bonding substrate.
   b. Enamel is a consistent bonding substrate.
   c. Enamel bonding is accomplished by creating a micromechanical bond.
   d. Self-etch adhesives are known as “technique sensitive” because they require a precise moisture content on the dentin bonding substrate.

10. The adhesion of self-etching products to intact enamel
    a. Relies upon chemical bonding.
    b. Creates microporosities.
    c. Etches more deeply than does phosphoric acid.
    d. None of the above.

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