Antibacterial Self-etch Immediate Dentin Sealing

by Dr. Randall G. Cohen
Private Practice
Langhorne, Pennsylvania

Educational objectives
Upon completion of this course, participants should be able to achieve the following:
• Understand factors relating to dentin permeability.
• Understand self-etch vs. total-etch bonding.
• Understand how bacteria affects successful restorative dentistry.
• Understand the benefits of immediate dentin sealing.
• Be able to integrate the immediate dentin sealing procedure effectively into routine crown and bridge procedures.

Introduction
The use of adhesive resins to seal the dentin of crown preparations in order to protect the pulp has important clinical applications. In this article, the author discusses dentin permeability, bonding, and the role that bacteria plays in restorative dentistry. This background leads to a rationale for sealing of the dentin and a clinical technique by which to accomplish it.
Dentin Permeability

There are two aspects to dentin permeability. One is tubular permeability, which is the diffusion of substances and fluids through the dentinal tubules to and from the dental pulp. The second is intratubular permeability, the dentin's property that is responsible for the diffusion of adhesive monomers between the tubules.\(^1\) Intact enamel and cementum prevent the outward movement of fluid through the dentinal tubules, but once the dentin is exposed, then the tubules become a fluid-filled pathway from the oral cavity to the pulp, allowing for the movement of fluids and dissolved substances toward and away from the dental pulp.\(^2\)

As the tubules approach the pulp, they converge, becoming wider at the expense of the intratubular dentin. In the shallow dentin near the dentino enamel junction (DEJ), the openings of the tubules occupy only approximately one percent of the surface area, whereas in deep dentin, they take up 22 percent of the surface area.\(^2\) The tubules themselves are about 1µm in diameter at the DEJ and 3mm (3,000µm) long.\(^2\) This long diffusion distance helps to dissipate the concentration of noxious substances and tends to prevent the initiation of inflammatory reactions to bacterial products. As dentin is made thinner by cavity preparations or abrasion, the diffusion distances are shortened, and the dentin becomes more permeable.\(^3\)

The “hydrodynamic theory” of fluid flow within the tubules is a well-known model currently considered to be the primary mechanism by which pain impulses are transmitted.\(^4\)

The dentin has a natural resistance to fluid flow within the tubules. The three components and relative amounts of dentin resistance were described by Pashley, et. al. as listed to the left.

Dentin Bonding

The smear layer that develops following tooth preparation, occludes the dentinal tubules and reduces permeability. Accordingly, dentin bonding agents can work if either the smear layer is completely removed, thus exposing the dentinal tubules to the bonding resins, or, if an adhesive is able to diffuse into the smear layer, using it to create the hybrid zone.\(^5\)

In the first type of dentin bonding, a phosphoric acid etch pre-treatment is used to remove the smear layer, demineralizing the dentin to a depth of between 5.0µm and 7.5µm. The surface is left slightly moist, then a primer is applied in multiple coats and then air dried, followed by a bonding agent. Adhesives that work in this way etch both enamel and dentin and are called “total-etch systems.”

The effect of the acid on the dentin is dramatic in that it opens the dentinal tubules, and removes the mineralized component from the dentin surface. Accordingly, the protein (organic) portion of the dentin, the collagen fiber network, is left completely unsupported, literally floating in the rinse water. If the surface is air-dried, the soft demineralized surface collapses and forms an impermeable organic film that effectively prevents resin uptake. Therefore, total-etch systems require the surface to be left moist until the primer can support and re-expand the collagen fibrils prior to bonding.\(^6\) The difficulty arises because the primer does not always penetrate to the full extent of the demineralized zone, leaving voids within the hybrid layer.

The other difficulty with total-etch systems is the question, “how wet is wet?” Too much water left on the dentin surface cause the monomers to separate from their solvents, forming resin globules and water blisters, thus lowering bond strength. Too much air-drying creates the aforementioned collapse of the unsupported collagen fiber network, also greatly lowering the bond strength. A recent study measured bond strength, fluid movement, and nanoleakage of different

---

**Three Components & Relative Amounts of Dentin Resistance**

1. Pulpal resistance, coming from odonoblasts and their processes within the tubules, accounting for 7.5 percent of the total dentin resistance.

2. Intratubular resistance, coming from the presence of collagen, accounting for 6.3 percent of the total dentin resistance.

3. Surface resistance, coming from an intact smear layer, or well-hybridized resin tags in bonded dentin, accounting for the large bulk (86 percent) of the total dentin resistance to fluid flow.\(^2\)
bonding groups when the surface was either left too wet or too dry. The results showed conclusively that unless the operator utilized meticulous evaporation technique, then the restorations showed high nanoleakage and lowered bond strength.  

The second means of dentin bonding is called “self etching” because the primers are acidic enough to penetrate, but not remove the smear layer without an additional phosphoric acid step. The primer is left on for 20 seconds and dried without rinsing. These primers are meant to be used on dry dentin, a clinical condition that is easier to establish than “moist” but not too “wet.” Since there is no decalcification, the protein portion of the dentin surface remains fully supported throughout the entire procedure, thus avoiding the organic barrier that can occur from too dry a surface, as well as the phase changes that occur in too wet a surface.

**Bacteria and Restorative Dentistry**

The dentinal tubules allow for the diffusion of inflammatory stimuli such as bacterial toxins, enzymes, antigens, chemotoxins, organic acids, and tissue degradation products into the pulp. Similarly, diffusion occurs in the other direction, as plasma proteins, immunoglobulin and complement proteins have been recovered from the dentinal tubules as a response to these inflammatory stimuli.

Brannstrom’s team concluded in early research that bacteria was the cause of pulpal damage under the restorative materials that were prevalent at the time. The team’s conclusions were that tooth surfaces needed to be disinfected prior to restoration. Later work by Bergenholtz showed that bacteriocidal restorative materials resulted in the least amount of post-operative sensitivity, and that bacteria were found in the histologic sections of mice teeth where pain was present. Cox, et. al., similarly implicated bacterial microleakage as the prime factor causing pulpal inflammation and necrosis.

Feuerstein’s team acknowledged the increased risk of recurrent caries from an infected smear layer, and tested a number of self etching products (Adhes by Ivoclar Vivadent, Clearfil Protect Bond by Kuraray, Adper Prompt L-pop by 3M ESPE and Xeno III by Dentsply) for their antibacterial effect. While all of the adhesives tested showed some immediate antibacterial activity against S. mutans, Clearfil Protect Bond showed the longest duration (14 days) and the largest zone of inhibition on the agar diffusion test.

**Immediate Dentin Sealing (IDS)**

This procedure refers to the application of a dentin bonding agent (DBA) onto the cut dentin immediate following preparation. In this way, the clinician creates a hybrid zone and resin layer on the external surface of the preparation, thus effectively reducing dentin permeability.

There are four reasons cited by Magne that the clinician should routinely do IDS, the first being that freshly cut dentin is the ideal bonding substrate. As the only way that freshly cut dentin exists is at the preparation visit, reason dictates that this is a better time than after the dentin has been contaminated by provisional cements and bacteria. The second reason given is that curing the bonding resin prior to application of the overlying composite resin material results in better bond strength. In many cases, this “pre-curing” of the DBA at the time of cementation of the casting will interfere with the proper seating of the casting, so this problem is
eliminated by applying the DBA prior to impression making. The third reason is that complete bond strength of resins has been shown to take a week to develop. Applying the DBA at the time of cementation of the casting means that the weaker initial bond must compete with the contraction force of the overlying composite resin cement. Whereas the application of the DBA immediately following the preparation gives the dentin-resin bond a chance to cure fully before it is challenged by the contraction force of the composite resin cement. Lastly, IDS protects the cut dentin against bacteria during the provisionalization phase of treatment.

Clinical Techniques for Antibacterial Self-etch Immediate Dentin Sealing

There are two different clinical techniques for IDS, both of which will be discussed. The DBA chosen for either procedure is Clearfil Protect Bond because of its self-etching nature and antibacterial components.

Following the casting preparation, the preparations are cleaned with a loose slurry of coarse pumice, [Fig. 1] rinsed thoroughly, then isolated with cotton rolls and parotid pads. Then, the Protect Bond primer is applied to the preparations, [Fig. 2] left in place for at least 20 seconds, then thoroughly air-dried. Next, the second agent, the bonding resin is applied to the preparations, [Fig. 3] lightly air-dried, then cured with the halogen lamp.

In a technique described in earlier work, the preparations are then covered with a clear glycerin gel to block air from the surface, then light cured a second time. The preparations are then scrubbed with ethyl alcohol, to remove any unset bonding resin. Following a thorough rinse, the case is ready for impression making.

In the second technique, the operator applies a flowable composite resin immediately following the light cure of the DBA. This flowable composite shown (Majesty Flow, Kuraray America) is dispensed through a special brush tip (Prototype device, Kuraray America) that allows for the controlled application of a very thin layer [Fig. 4]. This flowable composite layer is light cured, scrubbed down with ethyl alcohol [Fig. 5] in a similar fashion as illustrated in the first technique, using a brush tip/syringe combination for convenience [prototype device, Kuraray America]. Lastly, the margins are inspected, and polished if necessary, with a white rubber point (White Midget, Dedeco Corp) to eliminate any excess resin that may have accumulated on the margins [Fig. 6].

This thin layer of flowable composite exerts minimal contraction force during its polymerization due to its low volume, yet its highly filled composition affords excellent strength and additional pulpal protection. In this author’s experience, this method results in a more comfortable patient experience than the DBA alone.

Provisionalization and Cementation

The clinician is cautioned to apply ample lubricant (Isolit, Degussa Dental) to the preparations before creating direct provisional restorations since acrylics and composite provisional materials will bond to the DBA-treated surface, creating great clinical difficulty. Larger cases are best accomplished using an indirect method. The case is temporarily cemented with a strong, non-eugenol containing cement such as Durelon®.

For the permanent cementation, clinicians are cautioned to avoid zinc phosphate cement. The flowable composite, or the bonding resin alone fills in the
tiny scratches on the external surface of the preparation thus drastically reducing any available mechanical retention. A resin-bonded cement is the cement of choice for final cementation since it will bond chemically to the composite surface of the IDS treated substrate rather than engage any undercuts or surface roughness. Further, the resin cements exhibit low solubility leading to less leakage over time. Recently, many composite cements utilize an automix system, greatly simplifying the mixing procedure.

Conclusions

The application of a self etching, antibacterial dentin bonding agent onto the external surface of a crown preparation can improve the outcome of the case in several important ways. The mechanical benefits such as better bond strength in the final casting and the dramatic reduction in post-operative sensitivity justify the short time that the procedure takes to accomplish.

Bibliography


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, Inc. for this course.

This CE activity is supported by an unrestricted grant from Kuraray America, Inc.
1. Dentinal tubules:
   a. converge as they approach the dental pulp.
   b. facilitate the transmission of substances to and from the dental pulp.
   c. contain smear plugs following preparation.
   d. all of the above.

2. The dentin surface that is etched with phosphoric acid:
   a. retains the smear layer.
   b. becomes less permeable.
   c. has its organic portion left unsupported.
   d. none of the above.

3. Self-etch adhesives differ from total etch adhesives in that:
   a. they retain the smear layer.
   b. they open the dentinal tubules.
   c. their primers need to be rinsed thoroughly.
   d. the timing of the primer step is critical.

4. The effect on the dentin of self-etch immediate dentin sealing is:
   a. the smear plugs are removed.
   b. the collagen fiber network is floating in the rinse water and might collapse if air-dried.
   c. the tubules are left open following the etch step.
   d. the permeability of the dentin is reduced.

5. Which is not a reason for Immediate Dentin Sealing?
   a. To protect the pulp from bacteria and their by-products.
   b. To build up deficient areas in the prep prior to impression making.
   c. To allow the dentin bonding agent to achieve maximum bond strength.
   d. To facilitate pre-curing of the dentin bonding agent.

6. Most of the cut dentin’s resistance to fluid movement comes from:
   a. odontoblasts and their processes.
   b. collagen and mineral constrictions within the tubules.
   c. intact smear layer or presence of well hybridized resin tags.
   d. positive pressure of tubular fluid.

7. According to Cox, et. al., what is the prime causative factor for pulp inflammation and necrosis?
   a. Acidic nature of restorative materials
   b. Bacteria and bacterial by products
   c. Frictional heat created by rotary instruments
   d. Occlusal trauma

8. Self-etching primers:
   a. work well on dry dentin.
   b. are rinsed prior to bonding resin application.
   c. leave the organic portion of dentin floating in rinse water.
   d. increase dentin permeability.

9. Immediate dentin sealing is effective clinically because:
   a. it lowers the permeability of dentin.
   b. it improves the dentin-resin bond strength.
   c. freshly cut dentin is the best bonding substrate.
   d. all of the above.

10. Castings should not be cemented with zinc phosphate cement following IDS because:
    a. the acidic pH will dissolve the bonding resin.
    b. the compressive strength of zinc phosphate is insufficient.
    c. the composite resin coating fills in the tiny scratches in the prep thus interfering with mechanical retention.
    d. none of the above.
    e. all of the above.
Fill out this sheet ONLY if you wish to submit your test by mail or fax. A $35 processing fee applies.

Instructions: To receive credit, complete the answer sheet and mail it, along with a check or credit card payment to: Dentaltown.com, Inc., 10850 S. 48th Street, Phoenix, AZ 85044. You may also fax this form to 480-598-3450. You will need a minimum score of 70% to receive your credits.

Please print clearly. Deadline for submission of answers is 24 months after the publication date.

Antibacterial Self-etch Immediate Dentin Sealing by Dr. Randall G. Cohen

License Number ____ ____ ____ ____ ____ ____ ____ ____ ____ ____

AGD#___________________________________________________________________________________

Name___________________________________________________________________________________

Address_________________________________________________________________________________

City ___________________________________________ State _________ ZIP ______________________

Daytime phone __________________________________________________________________________

☐ Check (payable to Dentaltown.com, Inc.)

☐ Credit Card (please complete the information below and sign)

Card Number ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

Expiration Date – Month / Year ____ ____ / ____ ____ ____ ______________

Signature ___________________________________________________ Date_____________________

CE Post-test
Please circle your answers.

1. a b c d
2. a b c d
3. a b c d
4. a b c d
5. a b c d
6. a b c d
7. a b c d
8. a b c d
9. a b c d
10. a b c d e

Program Evaluation
Please evaluate this program by circling the corresponding numbers: (3 = Excellent to 1 = Poor)

1. Course objectives were consistent with the course as advertised 3 2 1
2. Course material was up-to-date, well-organized and presented in sufficient depth 3 2 1
3. Instructor demonstrated a comprehensive knowledge of the subject 3 2 1
4. Overall, I would rate this course 3 2 1
5. Overall, I would rate this instructor 3 2 1

For any questions, please contact Rita Zakher, DMD, MBA, director of continuing education at rita@dentaltown.com