Point of Care

The Point of Care section answers everyday clinical questions by providing practical information that aims to be useful at the point of patient care. The responses reflect the opinions of the contributors and do not purport to set forth standards of care or clinical practice guidelines. Readers are encouraged to do more reading on the topics covered. If you would like to submit or answer a question, contact editor-in-chief Dr. John O'Keefe at jokeefe@cda-adc.ca.

Question 1

There is conflicting advice on how to place increments of composite in posterior restorations. Can you suggest a reliable technique?

A serious drawback associated with posterior resin composite restorations is related directly or indirectly to shrinkage during polymerization. Resin composites undergo volumetric shrinkage that is a direct function of the volume fraction of polymer matrix in the composite. The volumetric polymerization shrinkage of modern resin composites ranges from 1.8% to 4.42%.[1]

Polymerization shrinkage occurs regardless of the system used to initiate the setting reaction, chemical or light curing (with low-power, high-power or modulated light sources).[2]

However, there are differences of opinion regarding the direction of the force vectors and the stresses that develop in a composite restoration.[3] During the setting process, shrinkage stresses develop because the material is constrained by its adhesion to the cavity walls. These stresses at the tooth–composite interface may exceed the strength of the bond between the composite and the tooth structure, which can result in gaps.

The shrinkage problem can be partially overcome by technique. The most commonly used method is incremental addition and polymerization of thin layers of resin composite, which decreases the effect of setting contraction by reducing the bulk of resin cured at one time. Insertion of large amounts of composite or bulk placement tends to promote formation of a gap at the resin–dentin interface.[4] The difficulty of placing sticky resin composite in bulk and of perfectly adapting the material to the tooth structure, as well as the contraction due to polymerization of a large volume of composite, are probably responsible for these gaps. Also, the degree of curing of thick layers of composite is not as good as for thin layers.[5] In addition, incremental insertion reduces the ratio of bonded to unbonded surface area, which helps to relieve the stress that develops at the bonding interface between tooth and resin composite.

The use of a more flowable, low-viscosity resin composite, which would wet and adapt closely to the prepared tooth surface, thereby acting as a stress breaker, has been proposed. Researchers are still debating the advantages of this technique.[6,7]

One thing is certain: the ideal cervical margin of a Class II restoration is on enamel. Therefore, every effort should be made to preserve the enamel during tooth preparation.[8]

Research is still being conducted to develop a low-shrinkage or nonshrinking polymer matrix, but it is unclear if the methacrylate-base resin will permit such evolution.

Suggested Technique

Today's most accepted insertion technique is based on the incremental addition of thin layers of resin composite. The first increment is the most critical, so it is placed into the proximal box of the preparation and packed with a

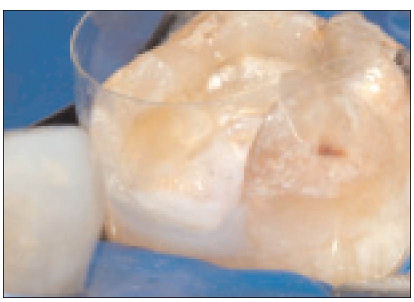

Figure 1: *The first increment is placed into the proximal box and packed so that it is adapted to the cervical margin and the floor of the preparation.*

Figure 2: *After light-curing of the first increment, subsequent additions are placed parallel to the cusp slopes by means of an oblique incremental technique.*

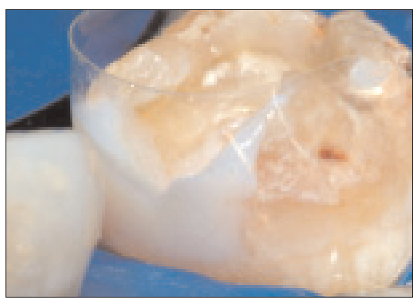

Figure 3: *The oblique incremental technique gradually reproduces the anatomic cusp incline.*

smooth-ended instrument to adapt the floor and the gingival margin of the preparation (**Fig. 1**). After light-curing of the first increment, subsequent layers are placed parallel to the cusp slopes by means of an oblique incremental technique, so as to gradually reproduce the anatomic cusp incline (**Figs. 2** and **3**). The advantages of these wedge-shaped increments become clear when the final occlusal adjustment is made; this approach reduces the effort and time required for finishing and polishing. ✧

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Question 2

What do we mean by “bonded amalgam,” and does it have any advantage over tried-and-true, less expensive procedures?

There are 2 types of bonding procedures for amalgam: self-cured bonding and light-cured bonding with adhesive dentin sealant.

Self-Cured Bonding

With self-cured bonding, amalgam is condensed into the prepared cavity lined with a mixture of adhesive and catalyst applied to primed dentin. The initially liquid adhesive becomes intermingled with the first layer of amalgam (**Fig. 1**). The bond between amalgam and resin is weaker than that between resin and dentin; however, there is evidence that this bond adds significantly to the adhesion of the amalgam and the strength of the restoration, in part because of the large surface area.[1,2] The primary indications for bonded amalgam are large, complex preparations and endodontically treated teeth that require amalgam cores. Amalgam bonding can be used as an alternative to pins during cusp replacement. This is one reason why the use of pins in operative dentistry is declining; the use of composite resin is another reason for this decline.

Copal resin degrades fairly rapidly within months of placement[3]; hence, there is a reliance on corrosion of the alloy at the alloy–dentin interface of conventionally placed amalgams to fill the resulting gap. However, modern high-copper alloys corrode less than their predecessors, and my colleagues and I believe that dentin bonding should (with emphasis on “should”) provide a better seal. However, evidence shows that conventional amalgam techniques can produce durable restorations lasting many years.[4]

Light-Cured Bonding with Adhesive Liners

At the College of Dentistry, University of Saskatchewan, and in my own professional practice we have been routinely bonding amalgam using light-cured adhesive liners for most amalgam preparations with ideal isolation (rubber dam and moisture control) for 8 years or so. Whether we are using fifth-generation one-bottle or syringe systems or fourth-generation multibottle systems (with separate primer and adhesive), the bonding system is applied to acid-etched, conditioned dentin and enamel and then light-cured before condensation of the amalgam. **Figures 2** to **5** illustrate the procedure in a simulation with extracted teeth and PermaQuik dentin bonding system (Ultradent Products Inc., South Jordan, Utah), with methylene blue incorporated into the bonding agent for visualization. The adhesive tends to pool in the retentive features of the preparation (**Fig. 3**), yet we have experienced few, if any, fractured or displaced restorations, presumably because of the bonding effect. Light-cured adhesive liners are used in an identical manner for the preparation of cavities for composite resin. Under the amalgam, such a liner should in theory provide a seal for the dentinal tubules and enamel tags that is superior to copal resin and other, less expensive dentin sealants. However, there is some evidence that postoperative sensitivity is not eliminated by this procedure.[5] An air-

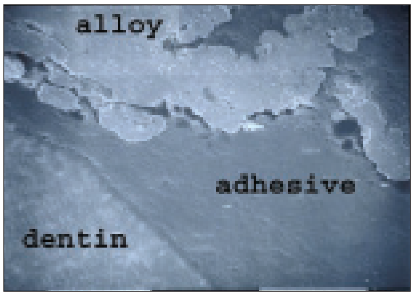


Figure 1: *Scanning electron micrograph of Valiant alloy condensed into 3M Scotch-Bond Multipurpose resin (3M ESPE Dental Products, St. Paul, Minn.), showing intermingling and "islands" of initially liquid resin within the alloy at the dentin surface.*

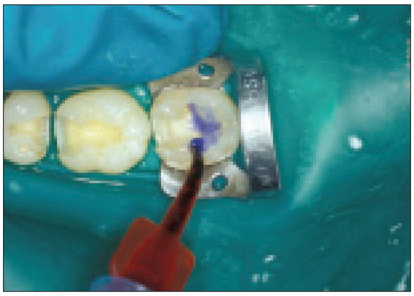


Figure 2: *Etching of enamel and dentin with the PermaQuik bonding system.*

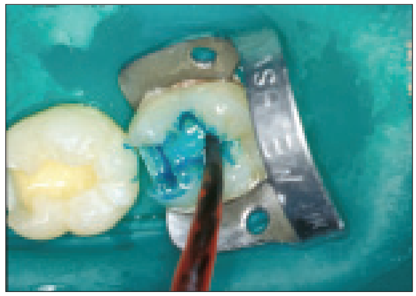


Figure 3: *Methylene blue is added to PermaQuik adhesive for visualization in laboratory studies.*

Figure 4: *Light-curing of the adhesive layer.*

Figure 5: *Low-power scanning electron micrograph of a cross-section of a tooth with a light-cured adhesive-bonded amalgam.*

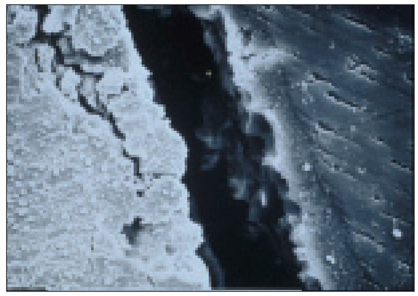
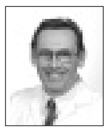


Figure 6: *Scanning electron micrograph showing a spherical alloy amalgam (Valiant; Ivoclar Vivadent Inc., Amherst, NY) "fingerprint" in the air-inhibited layer of the PermaQuik adhesive.*

inhibited layer forms, into which amalgam particles condense. There is intimate contact "fingerprint" between the particles of amalgam and the resin, which is revealed when the layers have become separated as an artifact of preparing the sample for microscopy (**Fig. 6**).

The cost of an adhesive liner is considerably more than the cost for copal resin. Obtaining reimbursement through insurance can be problematic, because some plans will not pay for use of a composite resin in molars if an amalgam would have been more economical; likewise, a bonded amalgam may be reimbursed as a conventional amalgam. I have never had a complaint about this issue, because I always explain that the procedure I am performing *should* provide an even more durable restoration than would have been the case with the previous generation of amalgams. However, whether this new generation of "super-amalgams" will prove even more durable than their predecessors remains to be shown. Evidence to verify any perceived advantages of light-cured adhesive liners is lacking, although evidence is now accumulating that bonded amalgams are effective alternative to pins during cusp replacement.[3] I can say that we have had few problems, in terms of either postoperative sensitivity or restoration failure. ◆



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Question 3

In the case of a porcelain fracture on a porcelain-fused-to-metal crown, what is the most reliable protocol for effecting a repair with composite, and is any repair method really reliable in these circumstances?

Any fracture, anterior or posterior, is alarming for the patient and requires prompt treatment. Fractured porcelain-fused-to-metal (PFM) crowns on posterior teeth may cause occlusal disturbances, masticatory discomfort, or lacerations of the tongue and oral mucosa, or they may jeopardize the affected restoration and the underlying natural tooth or implant abutment. With anterior teeth, the situation is exacerbated by poor esthetic appearance (**Fig. 1**). Although repair with composite resin is relatively simple, ascertaining the cause of the fracture is mandatory to avoid recurrence and to safeguard the longevity of the restoration, abutment and surrounding teeth. The cause of the fracture ultimately determines whether an abutment is salvageable (**Fig. 2**) and influences repair protocols.[1]

Causes

Because of its high modulus of elasticity, porcelain is inherently brittle and predisposed to fracture. A fracture can be initiated as the result of either trauma or incorrect clinical and laboratory procedures; in the latter situation, the fracture manifests as superficial or intaglio surface flaws. In the oral cavity, such flaws are compounded by occlusal stresses and the aqueous environment.

Repair

The method of repair depends on the location of the prosthesis in the mouth and the depth of the fracture lesion (**Fig. 3**). The literature suggests numerous repair techniques (direct and indirect), including overcasting restorations,[2] mechanical pin retention, laboratory-fabricated porcelain "patches," "reimplantation" of intact detached porcelain at the fracture site with a resin cement[3] and composite resin. It is important to emphasize that any repair should be regarded as ephemeral, with the survival period ranging from 1 week to 10 years.[4] The longevity of the repair depends on mastication, further trauma, marginal leakage (and subsequent staining), deterioration of the adhesive or the composite, and clinical technique.

The most expedient and rapid repair techniques are those performed at chairside with composite resins. For good survival of direct repairs, isolation with a rubber dam is mandatory, both to protect the soft tissues from hazardous chemicals (e.g., the caustic porcelain etchant) and to maintain an arid field for adhesive bonding. The process involves sequential application of various chemicals, culminating with a superficial layer of composite resin filling material. Salvaging fractured porcelain crowns involves 2 distinct processes: surface preparation and surface activation of the metallic substructure, porcelain and composite resin. The protocol for porcelain repair is as follows (**Fig. 4**).

1. Preparation of surface of exposed metal or fractured porcelain by one of the following methods:
   a. diamond bur[5]
   b. air abrasion with 50-µm aluminum oxide powder[6]
   c. etching with either 9.5% hydrofluoric acid or 1.23% acidulated phosphate fluoride

Figure 1: *Porcelain fracture at the cervical region of a porcelain-fused-to-metal crown on an implant-supported abutment. The fracture severely compromises the esthetic appearance.*

Figure 2: *Elucidating the cause of fracture determines the treatment protocol. In this case, a superficial porcelain fracture on a porcelain-fused-to-metal crown plus a horizontal fracture of the underlying abutment necessitates extraction.*

Figure 3: *Three failed post crowns showing various depths of porcelain fractures. The failure shown at left is superficial, the one shown in the middle is deeper but does not expose any metal, and the one shown at right has blatant exposure of the substructure (so-called "metal island" fracture).*

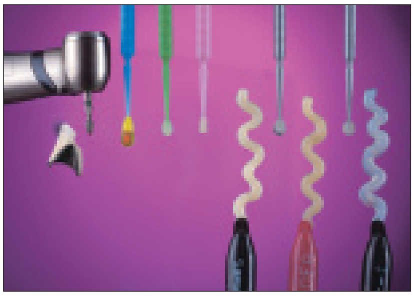

Figure 4: *Schematic representation of direct repair of a porcelain fracture on a porcelain-fused-to-metal crown with composite resin. From left to right, surface preparation with a diamond bur, porcelain etchant, silane, dentin bonding agent, condensable composite, composite connecting liquid, universal hybrid composite, composite connecting liquid and microfill composite.*

2. Surface activation:
   a. of porcelain with a silane coupling agent
   b. of metal with a dentin bonding agent containing 4-META (4-methacryloxyethyl trimellitate anhydride)
   c. of composite resin with the residual oxygen inhibition layer or a "composite connecting agent" such as CompoConnect Liquid (Heraeus Kulzer, Hanau, Germany), which not only activates the bonding surface but also reinstates the dispersion layer after modelling and curing of a composite, which allows subsequent incremental layers to "connect" during the buildup process.
3. Incremental composite layering to minimize polymerization shrinkage. The choice of composite depends on the depth of fracture. If metal is exposed, the first increment is a condensable composite, with a high filler content to mask the metal and emulate the porcelain opaque layer. This is followed by a universal hybrid, emulating the dentin porcelain.[7] Finally, a microfill is used as the superficial layer, with high polishability for superior esthetic appearance and to prevent accumulation of plaque.
4. Sealing of surface irregularities with a surface sealant such as Biscover (Bisco, Schaumburg, Ill.), which is devoid of an oxygen inhibition layer, after the finishing and polishing procedures.

The severity of the fracture will determine whether all 3 types of composites (condensable, hybrid and microfill) are necessary. If the fracture is limited to enamel porcelain in esthetically sensitive areas, a microfill alone is adequate. Conversely, deeper fractures on posterior crowns require condensable and hybrid composites for strength and resilience. ◆

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Question 4

What is the impact of nonvitality on acid etching of coronal enamel and dentin?

The answer to this question is rather simple, given that most bonding studies reported in the literature were performed on extracted teeth, which are in essence nonvital dental hard tissues. Within limits, we may comfortably apply what is known from these in vitro studies to the bonding of nonvital teeth in vivo. For example, studies on the application of the moist-bonding technique on extracted teeth have shown that it is possible to leave dentin in nonvital teeth visibly moist after acid-etching.

From a clinical perspective, the real source of concern should be the impact of *vitality* on acid etching of coronal enamel and dentin. By this, I mean the influence of the permeability of dental tissues on dentin bonding and the effect of the positive pulpal pressure that is present in nonanesthetized, vital teeth.

As far as enamel is concerned, some studies have shown a slow outward flow of fluid through the enamel of vital human teeth.[1] This can easily be demonstrated by taking an

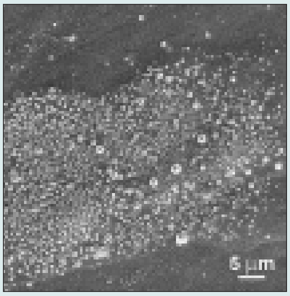

Figure 1: *Scanning electron micrograph of an epoxy resin replica of the surface of a vital central incisor of the author. Water droplets can be seen emanating from the enamel surface.*

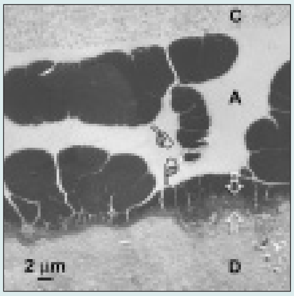

Figure 2: *Transmission electron micrograph of an undermineralized, silver-impregnated section of a single-bottle, one-step self-etching adhesive bonded to sound dentin. Extensive silver-filled water channels or water trees (pointers), caused by evaporative water flux, can be identified within the adhesive (A). Likewise, silver deposits are present within the entire hybrid layer (between the open arrows); these represent entrapment of water within the inter-fibrillar spaces of the collagen matrix. C = composite, D = sound dentin.*

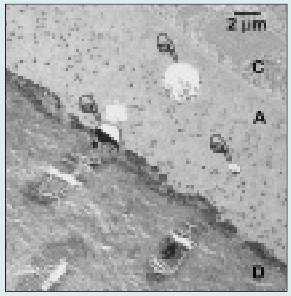

Figure 3: *Transmission electron micrograph of a section similar to that shown in **Fig. 2**, but in this case, a different single-bottle, one-step self-etching adhesive not containing HEMA is bonded to sound dentin. Water droplets emerging from the dentinal tubules (pointers) were caused by convective water fluxand were trapped by the adhesive (A).*

impression of one's own incisors using a slow-setting polyvinylsiloxane wash (**Fig. 1**). Although this phenomenon occurs more readily in young vital teeth, there have been no reports that this fluid flow adversely affects enamel bonding, even when hydrophobic resins such as pit-and-fissure sealants are used.

Vital dentin, in particular deep vital dentin, is highly permeable because of the presence of dentinal tubules and positive pulpal pressure. Two types of fluid movement may occur through the dentin: evaporative water flux and convective water flux. The former is induced by air blasts,[2,3] such as those that occur during air-drying of a crown preparation. Because nonvital dentin also contains water, evaporative water flux may occur irrespective of the tooth's vital status, even when smear plugs are retained within the dentinal tubules. The effect of evaporative water flux is usually not detectable clinically. Nonetheless, it may be an important issue in dentin bonding, particularly when simplified self-etch adhesives that lack hydrophobic resin coatings are applied to dentin. Although it is mandatory to remove solvents from these water-containing adhesives before light-curing, the same air-drying process induces outward evaporative water flux from the smear-layer-covered dentin. This may result in entrapment of the water vapour, which creates water-filled channels or water trees[4] within the polymerized adhesives (**Fig. 2**). These water channels permit rapid water sorption and leaching of incompletely polymerized resin components, which may in turn expedite the degradation of the resin–dentin bond. Evaporative water flux may be eliminated when bonding is performed on natural dentin tissues in which the dentinal tubules are heavily blocked by intratubular mineral deposits,[5] such as the transparent zone of caries-affected dentin or sclerotic dentin.

In the presence of smear plugs, only slow convective water flux occurs in vital dentin.[6] Even this slow convective water flux is adequate to permit the blebbing of dentinal fluid through simplified self-etching adhesives not containing 2-hydroxyethyl methacrylate (HEMA) (**Fig. 3**). Convective water flux is considerably more significant when smear plugs are removed by acid-etching. Many researchers have attempted to duplicate these convective water fluxes in vitro by bonding to dentin via perfusion at physiological pulpal pressure (pressure of about 15–20 cm water).

With simplified single-bottle adhesives, water movement by convective flux has been shown to occur both in vitro and in vivo during the polymerization of the adhesives (**Fig. 4**).[7–9] Water droplets trapped between the adhesive and the resin composite account for the apparent incompatibility that occurs when acidic versions of these adhesives are used with slow-setting, chemical-cured resin composites.[10] These water droplets act to increase stress,

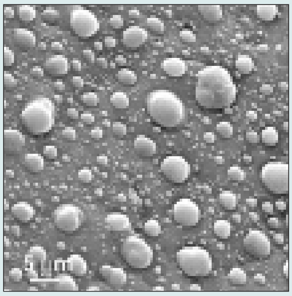

Figure 4: Scanning electron micrograph of an epoxy replica of the surface of vital deep dentin after use of a simplified single-bottle adhesive as a dentin desensitizer. Innumerable fluid droplets can be seen along the adhesive surface.

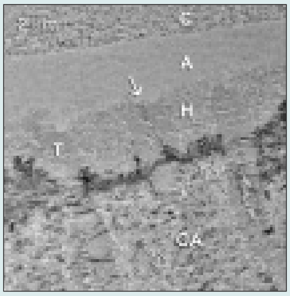

Figure 5: Transmission electron micrograph of a silver-impregnated section of caries-affected dentin (CA) bonded with a simplified one-step self-etching adhesive. Unlike **Figs. 2** and **3**, no evaporative or convective water flux was present to contribute to silver deposition within the adhesive (A) or hybrid layer (H). The latter was considerably thicker than the hybrid layer that is created in sound dentin because of the highly porous nature of the CA dentin, where silver deposits can be identified (pointers). The absence of water flux was due to the occlusion of the dentinal tubules (T) by intratubular mineral deposits and caries crystals (arrow).

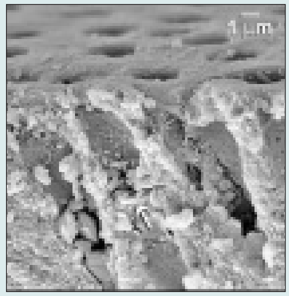

Figure 6: Application of potassium oxalate desensitizers to sound dentin after acid-etching. Calcium oxalate crystals have formed deep inside the dentinal tubules (arrow). Occlusion of the dentinal tubules by these crystals helps to reduce the adverse effects of dentin permeability during dentin bonding.

which may result in premature dislodging of the resin composites during function.

Clinically, convective water fluxes from vital dentin can be reduced by simulating what nature does for caries-affected dentin (**Fig. 5**) and sclerotic dentin: block the dentinal tubules before bonding. This may be achieved by applying oxalate desensitizers to acid-etched dentin.[11] The formation of calcium oxalates requires calcium ions. However, after acid-etching, the surface of dentin is completely devoid of calcium ions. When oxalate desensitizers are applied to acid-etched dentin, the oxalate ions must diffuse further down the dentinal tubules to seek calcium ions. The oxalate ions must diffuse further down the dentinal tubules to seek calcium ions. The dentinal tubules become blocked by calcium oxalate crystals, but the dentinal surface is free of crystals that might interfere with resin infiltration into the demineralized collagen matrices (**Fig. 6**). ◆

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