Stress produced during polymerization of dental composite materials during light-curing is a leading cause of adhesive restoration failure, resulting in postoperative sensitivity, marginal staining, and recurrent caries. This polymerization contraction shrinkage creates stresses as high as 13 MPa between the composite material and tooth interface (1 MPa = 145 psi). This stress can exceed the tensile strength of the enamel and result in stress cracking and enamel fractures along the interface. When a composite resin is cured, the surrounding tooth structure deforms due to polymerization shrinkage. This deflection can range from 4 to 6 µm, depending on the filling technique used. It has been well established that the higher the intensity of the light source, the greater the contraction force at the composite-tooth interface, and use of intermittent or lower light intensities results in improved marginal integrity.

To achieve clinically successful posterior composite resin restorations, it is vital to maintain the integrity of the bond and the marginal adaptation to tooth enamel and dentin. Due to inherent shortcomings of the composite restorative material, it is imperative to evaluate the restorative protocol to minimize technique-related problems and thereby maximize long-term results. This article will discuss how the choice of bonding agent, the use of flowable liners, and the choice of composite material affect the long-term viability of a posterior com-
composite restoration by reducing polymerization stress.

**ETCHING OF TOOTH STRUCTURE**

The bonding of composite to tooth structure can be achieved with one of 4 different etching systems: total-etch 3 step, total-etch 2 step, self-etch 2 step, and self-etch 1 step. The self-etch adhesives have increased in popularity due to their simplified technique and lower incidence of postoperative sensitivity. However, the acidic nature and permeability of simplified, self-etch adhesives are characteristics that make them incompatible with self-cured and dual-cured composites. One-step adhesives have a lower bonding effectiveness; this is attributed in part to the dissolution of hydrophilic and hydrophobic monomers in a highly concentrated solvent, which jeopardizes bond durability. Tay has demonstrated that single-bottle adhesives, because of the lack of a more hydrophobic bonding resin layer, behave as permeable membranes after polymerization. They permit the continuous transudation of dentinal fluid and do not provide a hermetic seal for vital deep dentin. This may interfere with optimal polymerization of composites and resin cements in both direct and indirect restorations.

These findings preclude the use of self-etching adhesives if a self-cured composite is used for a posterior composite base. The shear bond strengths of self-etching primer/adhesive systems and total-etch, 1-bottle systems to enamel have been shown to be much lower than the other systems, resulting in increased leakage and staining at the enamel-composite interface. The bonding of these self-etching primers to enamel may depend on their specific composition (pH). The more acidic primers etch the enamel with a more distinct etch pattern, decreasing marginal staining and leakage.

The conventional, 3-step, etch-and-rinse adhesives still perform favorably and are the most reliable in the long-term. Multiple studies comparing contemporary adhesives reveal that these adhesives remain the gold standard in terms of durability; simplifying the clinical procedure results in loss of bonding effectiveness. Even though the 2-step total-etch systems exhibit slightly lower bond strengths than the 3-step systems after aging, the recent introduction of filled, 2-step total-etch systems shows promise. These filled adhesives provide better coverage of the dentinal substrate. When evaluating mic-
roleakage of packable composites, the filled adhesives were associat-
ed with a reduction in microleak-
age when compared to unfilled 
adhesives.15,16

According to Feilzer, et al17 restric-
tion of flow is affected by the 
configuration of the restora-
tion, known as the C-factor. The 
C-factor is the ratio of bonded 
(flow-inactive) to unbonded or 
free (flow-active) surfaces. An 
increase in the number of bond-
ed surfaces results in a higher 
C-factor and greater contraction 
stress on the adhesive bond.17 
When examining C-factor effects 
on microtensile bond strengths, 
Armstrong cited data suggest-
ing that the durability of the 
bonded joint is threatened by 
hydrolysis and that the most 
susceptible region is the bottom 
half of the hybrid layer. In low 
C-factor cavity designs, a more 
flexible, filled adhesive resin 
was more durable than unfilled 
adhesive resins.18

FLOWABLE COMPOSITES AS LINERS
The use of flowable composites as 
low-modulus cavity liners under 
large composite resin restorations, 
particularly in conjunction with 
packable and universal composite 
resins, has been extensively studi-
ed.19,20 Since these materials 
effectively wet the surfaces to 
which they are applied, they ex-
hibit excellent adaptation to the 
prepared walls of the cavity.5 The 
application of a thin layer of a 
flowable composite at the cervical 
margin as a liner underneath 
packable composites enhances the 
marginal adaptation of the res-
toration.21 When used in cavity 
preparations associated with re-
moval of occlusal enamel caries 
that results in undermined cusps, 
the flowable composites can be 
placed to buttress the undermined 
cusps, minimizing deflection.

In a study by Leevailoj and col-
leagues, three packable compos-
ites tested showed higher leakage 
than the microhybrid control. 
Flowable liners were not used.22 
When used in class II, light-cured 
composite resin restorations with 
margins below the cemento-
enamel junction, flowable com-
pose reduced marginal leakage 
and voids at the interface as well 
as the total number of voids in the 
restoration.23,24 In a study by Yaz-
ici, et al25 the combination of a 
flowable resin composite and a 
hybrid composite light-cured sep-
arately was associated with the 
least amount of microleakage.25

Other beneficial effects of the 
use of a flowable composite as a 
liner under resin-based composite 
restoratives are an increase in 
flexural strength26 and creation 
of a stress-absorbing layer that 
 Improves the integrity of the 
bonded interface area.27 However,
when the flowable resin composite is cured simultaneously with the adhesive, increased microleakage is the result.28

NEWER COMPOSITES
The cross-linking of resin monomers into polymers is associated with an unconstrained volume shrinkage of 2% to 5%.29 Newer posterior hybrid composites (eg, Aelite LS Posterior and Aelite LS Packable; Bisco) demonstrate greatly reduced shrinkage and offer a significant advantage by reducing the stress that polymerization contraction causes. Another posterior restorative technique, known as the directed contraction shrinkage technique, utilizes a self-cured base composite to the level of the dentoenamel junction. The self-cured reaction, being a slower set than what occurs with light-curing, places less stress on the bond-tooth interface.30 However, it must be remembered that some 1-bottle adhesives may not provide acceptable bonding to tooth structure when they are used with self-cure composites. Using self-cure composites, mean bond strengths to dentin ranged from zero for light-cured Prime and Bond NT (DENTSPLY/Caulk) to 21.4 MPa for One-Step (Bisco).31

APPLYING THE EVIDENCE-RESTORING POSTERIOR TEETH WITH COMPOSITE
Based on the supporting evidence cited previously, there are two viable approaches for composite restoration of the posterior dentition. One approach involves the use of a total-etch filled adhesive, which is compatible with all other composites, a flowable liner to reduce stress, a low-shrinkage, light-cured composite as the dentin replacement, a nanofil composite as the enamel replacement, and a sealing resin as the last step after finishing the restoration.33 The other approach is to use a total-etch filled adhesive; a self-cure, base posterior composite to replace the dentin; a nanofil composite to replace enamel; and a sealing resin to create a smooth surface after finishing.34,35

CLINICAL PROCEDURES — OPTION 1
Figure 1 shows an MO preparation of a maxillary right first molar with a wide lingual extension due to caries. The tooth has been isolated with a rubber dam. After placement of a standard ComposiTight Gold band (CLINICIAN’S CHOICE) with a standard G-ring to create separation and anatomic contour, the preparation is acid-etched for 15 seconds and rinsed, leaving a glossy wet surface (Fig. 2). The acid-etching step is accomplished after matrix placement to avoid inadvertently etching the adjacent tooth and to control the flow of gingival fluid. One-Step Plus (Bisco), a filled, single-bottle adhesive, is applied in two to three coats to moisten the dentin and enamel (Fig, 3). The solvent is gently evaporated with air to remove the acetone and then light-cured for 10 to 20 seconds. A dedicated, air-only syringe is recommended for use in all bonding procedures.

Aeliteflo LV (Bisco), a radiopaque, low flexural modulus (3.6 giga pascals), flowable composite, is placed in a thin layer on the pulpal floor, axial wall, and gingival floor (Fig. 4). After light-curing the flowable composite for 10 seconds, the dentin replacement material Aelite LS Packable (Bisco) is placed in 2-mm increments (Fig. 5), and each increment is cured for 20 seconds. This is continued until the buildup reflects the normal anatomic contour of the DEJ and includes the contact point (Fig. 6). The creation of the normal anatomic detail of the
enamel is achieved with Aelite Aesthetic Enamel (Bisco), a nanofil composite, and a Ronald E. Jordan (REJ) No. 22 (CLINICIAN’S CHOICE) burnishing instrument (Fig. 7). After light-curing, final anatomy and marginal finishing are accomplished with multi-fluted finishing burs (Fig. 8) to create verified centric stops. This is followed by re-etching the surface and application of BisCover (Bisco), an aesthetic sealant, and liquid polish that is light-cured for 30 seconds with a broadband light (Fig. 9). The result is a glossy finished surface. Further, any enamel cracks caused by polymerization contraction are sealed. The final restoration is shown in Figure 10.

CLINICAL PROCEDURES — OPTION 2
Figure 11 shows two premolars and a molar with failing amalgam restorations. The teeth have been isolated with a rubber dam. After removal of the existing restorations, caries, and weak tooth structure, Tofflemire matrix bands and retainers were placed with wedges to control the gingival floor and create separation prior to placement of the restoration. The use of a regular, Tofflemire-type band and retainer can translocate the contact point occlusally. This contact point is often lost when the marginal ridges are shaped to create both the correct height and the proper occlusal embrasure form. Therefore, it is critical to burnish a convex interproximal contour into the bands and ensure that the interproximal wedge is not placed too high in the occlusal direction.

Alternatively, a precontoured band such as the Dixieland Band (Getz), which has the correct pre-burnished height of contour, can be used.

After acid-etching for 15 seconds and gently rinsing for 5 to 15 seconds, excess water is evacuated, and the cavity preparations are gently air-dried for one or two seconds, leaving a glossy surface (Fig. 12). If the dentin surface has been dehydrated, apply Aqua Prep F (Bisco), a dentin/enamel wetting agent that functions as a desensitizer and contains hydroxyethylmethacrylate (HEMA), water, and fluoride. This solution will rehydrate the collagen and precoat the dentin with HEMA. One-Step Plus (Bisco) is applied in two to three coats to saturate the dentin and enamel fully. After 10 to 15 seconds (Fig. 13), the solvent is carefully evaporated without thinning the adhesive on the dentin and is cured for 10 seconds.

Since a self-cure composite does not place the same stress on the bond as a light-cured material, the placement of a flowable composite is optional here. Bisfil II (Bisco), a self-cure hybrid composite, is mixed and placed with a high viscosity tip to a point halfway through the contact point and across the pulpal floor to within 2mm of the occlusal surface (Fig. 14). Gently tap the material into place until it starts to gel, and then with gradually increasing pressure, condense into the proximal box, contact area, and across the pulpal floor, continuing until the material is fully solidified. Place Aelite Esthetic Enamel (Bisco) to fill the cavity preparation completely, and sculpt occlusal anatomy (Fig. 15).

After light-curing, finish with fine diamonds and multi-fluted fine finishing burs to remove excess and create final anatomy (Fig. 16). Next, check the occlusion and refine the final anatomy and interproximal contour (Fig. 17). After acid-etching, apply one layer of BisCover, thin with an air stream, and light-cure the entire restoration for 30 seconds. Figure 18 shows the final clinical restorations.

CONCLUSION
The polymerization stress produced by dental composite material during light-curing is a leading reason for bond failure of adhesive restorations. In order to achieve clinically successful posterior composite resin restorations, the clinician must maintain the integrity of the bond and the marginal adaptation of the composite to tooth enamel and dentin.

This article has discussed the materials and restorative protocol for minimizing technique sensitivity and improving long-term results when placing direct posterior composite resin restorations. OH

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