Seventh Edition

Quality Resource Guide

Posterior Composites

Author Acknowledgements

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Educational Objectives

Following this unit of instruction, the learner should be able to:

1. Understand, describe, and discuss advantages and disadvantages, indications and contraindications of posterior composites in different clinical situations.
2. Distinguish the different types of composites available for use in the posterior composite technique.
3. List the basic components and the different phases of a composite material and understand how these components and phases affect a composite restoration.
4. Identify which composites are more suitable for use in posterior teeth.
5. Recognize the different types of adhesives available for use with posterior composites.
6. Understand how to perform a posterior composite restoration to achieve optimal results.
7. Describe proper methods of matrix selection and placement for posterior composites involving the proximal surfaces of teeth.
8. Recognize the advantages and disadvantages of incremental vs. bulk placement of posterior composites.
9. List methods for finishing, polishing, and occlusal adjustment to be applied in the posterior composite technique.
10. Understand how to maintain a posterior composite to maximize its longevity.

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The following commentary highlights fundamental and commonly accepted practices on the subject matter. The information is intended as a general overview and is for educational purposes only. This information does not constitute legal advice, which can only be provided by an attorney.

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The content of this Guide is subject to change as new scientific information becomes available.

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Introduction

Posterior composites are resin-based, tooth-colored materials used for the restoration of posterior teeth (molars and premolars). Posterior composites were first introduced in the early 1970's,[1-4] and have been increasingly used since then. Composite materials have evolved considerably since their introduction. Most currently commercially available composites can be used both for anterior and posterior restorations. There is nothing inherently different in terms of the material's composition that makes it suitable for anterior or posterior applications. As a definitive restorative material, composites offer advantages and disadvantages over dental amalgam when used in posterior teeth.

Advantages

Conservative Tooth Preparation, Minimal Intervention Dentistry

Composites can be placed in ultra-conservative preparations because they present minimal mechanical requirements relative to the material thickness, which is directly related to the tooth preparation design. This allows the clinician to limit the preparation to access and elimination of the diseased tooth structure and/or failed restoration, removal of grossly unsupported enamel, and establishment of a convenience form for the restoration. Consequently, the strength of the tooth is better preserved by reduced loss of sound tooth structure. Composites are also compatible with the concept of minimally intervention dentistry.[5,6]

Replacing Cuspal Stiffness/ Tooth Integrity/ Strength

The proper intracoronal use of a resin-based composite with an adhesive technique can replace some of the tooth strength lost due to caries, fracture, or tooth preparation.[7-9] This could be a factor in preventing tooth fracture.

Sealed Margins

Composites can be bonded to the tooth preparation virtually sealing the tooth-restoration interface against microleakage, resulting in less potential for secondary caries. In addition, the dentin-pulp complex is protected by virtue of this seal.

Esthetics

Composites are tooth-colored and can be almost imperceptible when properly placed. This advantage has great appeal to most patients, especially as the population grows more concerned with esthetics.

No Heavy Metals

Composites have evolved as an alternative to dental amalgam. Even though there is no indisputable evidence linking dental amalgam to health problems, emergent environmental concerns related to the use and disposal of dental amalgam are likely to influence and further regulate its use, which could elevate composites to the only viable direct restorative material for posterior teeth.

Although posterior composites present advantages and many positive properties, their current stage of development is still imperfect. Composite resin restorations are technique-sensitive, particularly in posterior areas of the mouth where access, visibility, and moisture control are more difficult.

Disadvantages

Critical Moisture Control

As with any bonded restoration, moisture control is more critical for posterior composites than for non-adhesive restorations. Even though studies suggest that some adhesives tolerate saliva contamination,[10-12] a clean, non-contaminated operating field is still considered critical when restoring posterior teeth with composites.

May Contain BPA

Although Bisphenol A (BPA) is rarely used as a formula ingredient in dental products, composites with bisphenol A glycidyl methacrylate (Bis-GMA) and/or bisphenol A dimethacrylate (Bis-DMA) may contain trace amounts of BPA as a byproduct of the manufacturing process. However, composites are far less likely to cause BPA exposure than other consumer goods such as plastic bottles and linings of metal cans.[13]

Increased Susceptibility to Secondary Caries

Because current composites lack the self-sealing properties of dental amalgam,[14] lack effective antibacterial and bioactive properties,[15] and tend to accumulate more plaque on their surface when compared to other materials,[16-18] it has been reported that composites may be more susceptible to secondary caries than other materials.

Despite these challenges, composites are gaining popularity as the restorative material of choice for intracoronal/direct restorations in posterior teeth.

Case Selection - Indications and Limitations

The inherent properties of contemporary composites have improved considerably since the introduction of Bis-GMA-based composites in the early 1960's. However, the clinical performance of posterior composites depends largely on proper case selection and operator proficiency. A thorough understanding of relatively complex factors, such as dentin physiology and polymerization kinetics, is often required from the clinician to succeed in placing posterior composite restorations consistently well. Substantial controversy about several aspects of the technique still exists in the scientific community, and the amount of inconclusive data abounds in the literature. However, with attention to a few important technical steps, the clinician can generate predictable, esthetic, durable, and functional posterior composite restorations.

Composites are the logical choice of material for the restoration of primary caries lesions in the occlusal and proximal surfaces of posterior teeth because they allow for the most conservative restorative approach. If one remembers that dental caries is still one of the most prevalent human diseases in both developed and developing countries, the relevance of the posterior composite technique becomes evident. Composites are also indicated for the replacement of small- to moderate-sized failed restorations. When the faciolingual extension of the occlusal aspect of a given defect exceeds 2/3 of the distance between a primary mesiodistal groove and the tip of the cusp, or when the facial and lingual extensions of the axial walls substantially undermine the facial and lingual cusps, composite use is compromised (**Figure 1**). The same is true for proximal defects/ preparations with gingival margins extending where no enamel is available for bonding. Moisture control is necessary for the appropriate placement of posterior composites, and is usually accomplished with rubber dam isolation. However, selective conservative composite restorations can be placed in compliant patients with alternative isolation methods, when the rubber dam cannot be used.

Esthetics is a commonly mentioned indication for composite use in posterior teeth, but it is only justifiable when the above-discussed limitations are carefully considered and respected. The American Dental Association accurately describes the indications and contraindications for the use of resin-based composites in posterior teeth:

Indications

- Pit-and-fissure sealants ("filled sealants")
- Preventive (conservative) resin restorations
- Classes I (occlusal) and II (occlusoproximal) restorations for both initial and moderate size lesions, using modified conservative tooth preparations (See **Figure 2**)
- Class V restorations
- Esthetically important areas
- Patients allergic or sensitive to metals

In addition, teeth presenting fracture lines can also benefit from the use of posterior composites. By restoring such teeth using an adhesive technique and composites, the propagation of the fracture line might be halted.

Contraindications

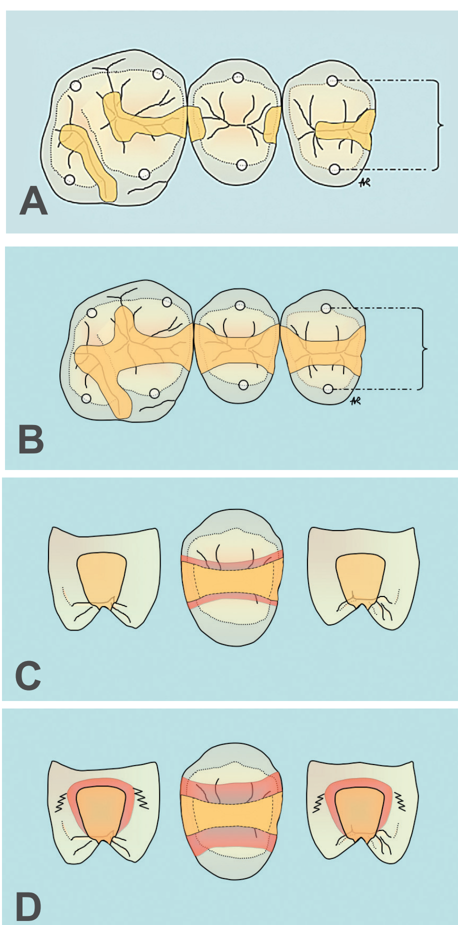
- Patients with heavy occlusal stress
- Sites that cannot be properly isolated
- Patients who are allergic or sensitive to resin-based composite materials

Heavy occlusal stresses can be present when the patient indicates parafunctional activities such as bruxing and/or clenching. More objectively, heavy occlusal stresses can be identified when the patient presents with multiple fractured posterior teeth, wear facets in several posterior and anterior teeth, and visibly worn occlusal and incisal surfaces. For these patients, posterior defects are more properly restored with indirect, laboratory-fabricated restorations due to their stronger physical and mechanical properties.

Composition and Classification

Dental composites comprise an organic phase and an inorganic phase. The organic phase is composed of polymerizable resin monomers, while the inorganic phase contains filler particles.

Figure 1



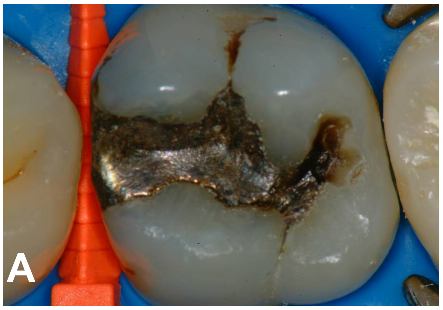
(A) Diagrammatic representation of a posterior segment with the outline of ideal posterior composite restorations. Note that the isthmus widths do not exceed 2/3 of the distance between the facial and lingual cusp tips. When proximal caries does not extend into the occlusal surface, box preparations can be used such as the ones illustrated in the second bicuspid.

(B) Diagrammatic representation of a posterior segment with the outline of acceptable posterior composite restorations. Note that the isthmus widths still do not exceed 2/3 of the distance between facial and lingual cusp tips.

(C) Diagrammatic representation of a bicuspid with the outline of a mesioocclusodistal (MOD) posterior composite restoration. Note that the occlusal isthmus width does not exceed 2/3 of the distance between the facial and lingual cusp tips. The red shaded area represents the facial and lingual extensions of the respective axial walls. These extensions have to be considered when evaluating the appropriateness of composite restorations (compare with Figure 1D).

(D) Diagrammatic representation of a bicuspid with the outline of a MOD posterior composite restoration. Note that the occlusal isthmus width still does not exceed 2/3 of the distance between facial and lingual cusp tips. However, the red shaded area representing the facial and lingual extensions of the respective axial walls extends considerably towards the facial and lingual surfaces. Note also that in this example the faciolingual extension of the gingival walls undermine the cusps, which can lead to potential cusp fracture. These extensions would be inappropriate for a posterior composite restoration.

Figure 2



Occlusal view of a compromised occluso-mesial amalgam restoration that will be replaced with a posterior composite restoration. Rubber dam has been installed, and an anatomical wedge has been secured.

Occlusal view after removal of the old amalgam restoration. Note that the wedge protects the rubber dam and the soft tissue mesially.

Occlusal view after the preparation is completed. An intraoral micro sandblaster device was applied to remove surface stains from adjacent areas, and all the remaining caries tissue is excavated.

The wedge is temporarily removed, a precontoured sectional metal matrix is inserted, and the wedge is re-inserted to secure the matrix in place. At this point, it is important to make sure that the gingival and axial margins of the proximal box are tight against the matrix.

A micro-hybrid composite is applied incrementally to the proximal aspect of the preparation. See **Figure 3** for an illustration of the incremental insertion technique used.

Most current resin-based composites are light-activated, and also contain initiators, coupling agents linking the resin and the fillers, color modifiers, and stabilizers.

The most clinically relevant phase in a composite is the inorganic phase, *i.e.*, the filler particles. Many physical and mechanical properties are related to the size, distribution, and concentration (or load) of filler particles in a given composite. Optical properties, such as the composite's translucency and polishability are also dependent upon the type and distribution of filler particles. Therefore, composites have been classified according to their average particle size. Excellent reviews on composite resin classification can be found elsewhere.[19,20]

Composites with large particles have been called macrofills, and composites with very small particles have been called microfills. Many modern composites use a mixture of particles with different sizes, and are called hybrid composites. Hybrid composites were considered the first universal composites, because they could (and many still can) be successfully used for the restoration of anterior and posterior teeth.

The newest category of composite materials has been referred to as nanocomposites because it contains nanometer-size particles. Built on nanotechnology principles, nanocomposites have an average particle size smaller than that of microfills, and are very good materials. The majority of nanocomposites in the market today are actually nanohybrid materials, *i.e.*, they contain nanosized particles and agglomerates, as well as a range of microfill and microhybrid particle sizes. Nanocomposites show excellent clinical performance.[21]

The organic phase or composite matrix provides cohesiveness to the filler particles. In addition, the matrix is directly related to the composite's polymerization shrinkage. Many different types of matrices are present in the different resin-based composites, such as Bis-GMA, Bis-DMA, UDMA, and TEGDMA. These are all organic polymers that can influence handling and shrinkage characteristics in any given resin-based composite material. A discussion on polymerization shrinkage is presented later in this review.

Table 1 illustrates some parameters of composites' classification, and indicates a few common examples and indications for each category.

Selection of Restorative Resins

Three categories of resin-based composites are currently used for the restoration of posterior preparations: conventional composites, flowable composites, and bulk-fill composites. They are summarized in **Table 1.**

Conventional Composites

This category includes traditional bimodal hybrid, microhybrid, nanohybrid, and nanofilled light-cured composites. These materials appear to be the most suitable composites for the restoration of posterior teeth. The average particle size, as well as filler load, vary according to the specific commercial product, but is typically between 0.4 and 1 micron, and some contain 5-10% of microfillers with approximately 0.04-micron particle size. Microhybrid composites have an overall blend of smaller particles than hybrid composites. Manufacturers have introduced nanocomposites as nanohybrid or nanofilled restorative composites. Nanocomposites present a very different inorganic structure when compared to traditional hybrid and microhybrid composites. Most nanocomposites are agglomerates of nanoclusters and nanomers which can be extremely small in size – on a nanoscale. However, despite a few marked differences relative to their inorganic phase, most available restorative composites are filler-loaded

Table 1

Composite Type	Average Particle Size	Characteristics	Indications
Macrofill	10 - 50 µm	**Advantages:** strength **Disadvantages:** wear resistance, polishability	- Non-stress bearing areas (Cl III, Cl, V) - Currently not used
Midifill	1 - 10 µm	**Advantages:** strength **Disadvantages:** wear resistance, polishability	- General use (anteriors & posterior restorations) - Limited use
Minifill	0.1 - 1 µm	**Advantages:** strength **Disadvantages:** stiffness	- General use (anterior & posterior restorations)
Microfill	0.01 - 0.1 µm	**Advantages:** polishability, translucency **Disadvantages:** tensile strength, stiffness	- Very esthetic areas - Facial surface of anterior restorations
Nanofill/ Nanohybrid	0.005 - 0.01µm	**Advantages:** polishability **Disadvantages:** limited clinical research	- Universal applications
Hybrid	1 mm + 0.04 µm	**Advantages:** wear-resistance, strength **Disadvantages:** limited polishability	- General use (anterior & posterior restorations)
Microhybrid	0.4 mm + 0.04 µm	**Advantages:** wear-resistance, strength, polishability **Disadvantages:** unknown	- General use (anterior & posterior restorations)
Packable[1]	Similar to hybrids and microhybrids	**Advantages:** wear-resistant, strength **Disadvantages:** polishability, no bulk cure, not condensable	- Posterior restorations (Cl I and II)
Flowable	Similar to hybrids and microhybrids	**Advantages:** handling, "injectable", flowability/wetability **Disadvantages:** high shrinkage, poor wear resistance, poor mechanical properties	- Limited applications as very small occlusal preparations and some Class V restorations, cavity liners
Bulk-fill	Similar to hybrids and microhybrids	**Advantages:** wear-resistant, strength, ability to be used in bulk-fill technique **Disadvantages:** color match, limited sculptability	- Posterior restorations (Cl I and II)

up to approximately 80% by weight and 70% by volume and have physical and mechanical properties that suit them to be utilized in the posterior region.

Flowable Composites

Flowable composites are composites with a high matrix/filler ratio. These low-viscosity, low-modulus resins have been indicated as (1) the main restorative material for very conservative or preventive composite restorations, (2) an intermediate "stress-absorbing" layer between the adhesive and the restorative resin, and (3) a restorative material for cervical non-carious abfraction lesions. As an intermediate layer, flowable composites facilitate the contact between the restorative resin and the tooth preparation coated by the adhesive and partially compensate for the stresses generated upon composite polymerization.

The use of flowable composites has not been fully accepted. Due to their high matrix/ filler ratio, flowable composites have poor mechanical properties and shrink substantially upon curing. The performance of the restorative composite might be negatively affected by the properties of the base or adhesive material, but it is not clear if this would be a legitimate concern regarding the use of flowable composites as an intermediate layer. Regardless, if flowable composites are used as an intermediate layer before the insertion of the main restorative composite, its thickness should be kept to a minimum (up to 1-mm), and the material should not extend to the preparations' margins.

Bulk-fil Composites

"Bulk-fill composites" are available as *flowable base bulk-fill composites* and *full-body bulk-fill composites*.[22] Flowable base bulk-fill composites are used for dentin replacement only and require a conventional composite as the occlusal increment, while full-body bulk-fill composites can replace dentin and enamel in a single increment. Bulk-fill composites can expedite the restorative procedure as increments of up to 4 mm in thickness are often suggested.[23] Although in vitro studies have raised concerns about a possible compromised internal adaptation and increased wear when these techniques are used,[24,25] a recent and very thorough systematic review and meta-analysis demonstrated that bulk-fill and conventional composites had similar clinical performance over a follow-up period of 12 to 72 months.[26] While this technique may present advantages, namely more expediency during composite placement, bulk-fill composites should be used with caution due to the lack of long-term clinical performance information at this time.[27] Bulk-filling may also limit the operator's ability to carve the occlusal anatomy of the restoration before light-activation, and are typically highly translucent to facilitate curing – which can result in "grayish" restorations.

Longevity of Posterior Composites

Posterior composites can last many years when properly placed.[28-31] Several studies report the clinical performance of posterior composites overtime. Opdam, *et al.*, published a retrospective study on the longevity of 1,955 posterior composites placed in a private-practice setting.[32] Life tables calculated from the data reveal a survival rate of 92% at 5 years and 82% at 10 years. There was a significant effect of the mass of a restored surface on the survival of the restoration, *i.e.,* the more conservative the restoration the longer it survived. Similar results linking the location and size of the restoration with clinical performance and durability were reported in a recent study by Montagner and colleagues.[33] A number of other studies report success rates ranging from 70% to 100% for posterior composites.[34-38] These results were similar to those of a meta- analysis of studies conducted during the 1990's.[39] Very few clinical studies with evaluation periods longer than 10 years are available. A study by Wilder *et al.*, reported a 76% success rate for 85 UV-cured posterior composites after 17 years,[40] while da Rosa Rodolpho *et al.,* reported a 65% success rate for 282 hybrid VL-cured composites after 17 years.[41] The relatively low success rate reported in the later study was attributed by the authors to the high number of large restorations placed. More recently, Kiremitci *et al.*, reported on the clinical performance of a packable composite material, noting no clinical failures at the six year evaluation visit.[42] A more recent publication by da Rosa Rodolpho *et al.,* reported good clinical performance over 22 years with annual failure rate ranging from 1.5% to 2.2% depending on the specific material.[43] Pallesen and van Dijken reported results from a randomized controlled study of three conventional resin composites in Class II restorations;[44] 25 subjects (75 restorations) were evaluated at 30 years post-insertion, with an annual failure rate of 1.1%. The most common causes of failure were caries (39% of failures) and fracture (36% of failures); the authors also noted that 2/3 of the caries failures occurred in patients with high caries risk.

Most clinical performance studies show that, in general, there is a linear correlation between size of restoration and observation period, and number of failures,[30,33,45,46] which supports the recommendation that posterior composites should be used in conservative cases.

Causes of Failure

The most commonly cited reasons for failure in clinical studies of posterior composites are secondary caries, fracture, marginal deficiencies and wear. It should be noted that these reasons vary greatly depending on the type of study (randomized clinical trial vs. private-practice setting), type of composite used (UV-cured, hybrid VL-cured, etc.), period of observation and other aspects of study design.[14]

Although clinical studies do cite reasons for restoration failure, only a few studies discuss predictive factors for future failure. In one such study, Hayashi and Wilson demonstrated that marginal deterioration is a good predictor of failure.[47] By studying the data from a 5-year clinical trial, they noted that restorations with marginal deterioration were over 5 times more likely to have failed by 5 years than restorations with no marginal deterioration, and that restorations with marginal discoloration at 3 years were 3.8 times more likely to have failed by 5 years than restorations with no marginal discoloration at 3 years. Moreover, restorations with both marginal deterioration and marginal discoloration at 3 years failed 8.7 times more frequently than restorations with sound margin at 3 years. In another report based on results from the same study, the authors conclude that restorations with post-operative sensitivity in large cavities were more likely to have failed by five years than restorations in small cavities.[48]

In a study of 51 posterior composite restorations where a 30% failure rate was reported at 5 years, Köhler, *et al.,* demonstrated that almost 2/3 of the failures (69%) occurred due to secondary caries and marginal defects in patients with high counts of *S. mutans* at baseline, suggesting that patient factors such as caries activity and/or risk can influence the longevity of posterior composite restorations.[35] Patient risk factors, principally caries risk, were shown to be a relevant factor in the survival of posterior composite restorations in other studies.[49,50]

Resistance to wear has improved markedly in modern composites. While early studies showed clinically important wear rates,[51,52] studies published more recently in general show clinically acceptable wear rates when posterior composites are used in conservative and moderately-sized restorations.[53,54] It is believed that the improvement in wear resistance is due in great part to improvements in the material itself, but certainly a better understanding of the posterior composite technique, along with improved light- curing techniques, has also helped. Willems et al. reported occlusal contact wear values of 110 to 149 microns after 3 years,[54] while Wilder, *et al.,* reported wear values of 197, 235, 264 microns after 5, 10, and 17 years, respectively.[40] Given that the occlusal contact wear for enamel has been reported to be 15 microns/year for pre-molars and 29 microns/year for molars,[55] it appears that the yearly wear reported for posterior composites is in line with the reported enamel wear. However, wear may still be an important mode of failure for bruxers and clenchers, especially in large restorations.[56]

Dental Adhesives - Current Trends and Rationale for Use

Enamel bonding is still the most predictable and proven way to provide a seal against microleakage. Therefore, the most predictable results with posterior composites are achieved when enamel is present in all margins of the tooth preparation. At their present form, restorative composites do not bond to the tooth preparation without bonding. **Table 2** illustrates the current adhesive strategies applied to most direct composite restorations, including posterior composites. Adhesive resins are used primarily to seal the pulp dentin complex, and bond the composite to the tooth structure. Adhesion provides retention, tooth strengthening, and resistance against microleakage. Dentin/ enamel bonding is a very technique-sensitive procedure. With posterior composite restorations, the adhesive of choice, be it an etch-and-rinse system, self-etching system, or universal system, should be applied in as much dentin and enamel available as possible on the prepared (internal) surfaces. The application of a liner or base should be restricted to very deep areas in the preparation, when the remaining dentin thickness between the preparation floor and the pulp is estimated to be less than 0.5 mm. Calcium hydroxide bases are seldom utilized under composites due to their poor mechanical properties, and their use should be limited to direct pulp-capping procedures. MTA and tricalcium silicate/calcium chloride formulations are also successfully used as a pulp-capping medicament. When used, pulp-capping medicaments should be protected from the acid/ adhesive with a thin layer of a resin-modified glass ionomer liner, to avoid dissolution by the adhesive system component(s).

Some authors recommend resin-modified glass-ionomer (RMGI) cements as an integral part of the posterior composite technique. RMGI materials are easier to manipulate and have improved physical and mechanical properties when compared with conventional glass-ionomer materials. There is no consensus on whether RMGI should be used in every posterior composite as a liner or base, but their use do not compromise the technique.

A strategy that has been proposed to minimize post-operative sensitivity when applying posterior composites with the etch-and-rinse technique is the use of a desensitizing solution as a rewetting agent. This product, typically an aqueous solution of glutaraldehyde and/ or HEMA (*e.g.*, Gluma Desensitizer, Kulzer, Armonk, NY; G5, Clinician's Choice, New Milford, CT), should be used as an intermediate priming step after acid etching and before application of the adhesive. Research shows that water-based desensitizers such as these can be used prior to self-etching adhesives (UNC unpublished data).

Currently, it is generally accepted that the hybridization of the prepared tooth substrates with an adhesive system is the optimal treatment to seal the preparation and protect the pulp-dentin complex under composite restorations. Simplified adhesives, also referred to as self-etching, have been proposed and used recently. Although sparse clinical reports indicate that simplified adhesives tend to reduce the incidence of postoperative sensitivity when placing posterior composites, clinical research has failed to confirm such assertions.

Light-Curing Technology and Polymerization Shrinkage

Advances in light-curing technology parallel the evolution of the posterior composite technique. Most, if not all, posterior composites available today are light-activated. Although it is not the purpose of this review to elaborate on light-curing, a brief commentary is included because this is an important aspect of the technique.

Light-activated composites afford the operator total control over working and setting time. They were introduced in the early 1970's as ultraviolet-cured composites, and have evolved into modern methods of light-activation that include halogen lamps, lasers, plasma lights, and light-emitting diodes (LEDs).

In light-activated composites, the polymerization or setting reaction initiates when the composite is exposed to light at a specific wavelength (typically 474 nm, blue light). This light will excite a photoinitiator in the composite, usually camphoroquinone.

Table 2

Adhesive Type	Bonding Strategy (required actions)
Etch-and-rinse, multi-bottle	**Step 1:** etch enamel and dentin with phosphoric acid; rinse and dry **Step 2:** prime dentin with dentin primer; dry **Step 3:** coat etched enamel and primed dentin with resin adhesive; light-cure
Etch-and-rinse, one-bottle	**Step 1:** etch enamel and dentin with phosphoric acid; rinse and blot-dry. (The degree of moisture present in the etched dentin might affect the infiltration of these adhesives. Dentin should not be dried after rinsing the etch. If dentin is dried, a rewetting agent should be used before the adhesive is applied) **Step 2:** coat etched enamel and dentin with resin adhesive; light-cure
Self-etch, 2-step	**Step 1:** coat enamel and dentin with acidic primer; dry **Step 2:** coat enamel and dentin with resin adhesive; light-cure
Self-etch, 1-step	**Step 1:** coat enamel and dentin with acidic adhesive; light cure
Universal	**Can be used as either etch-and-rinse or as self-etch**

Still today, not all composites can be cured with all light-curing units, which results in considerable confusion when it comes to matching a composite with a curing light. From all available light-curing methods, the current generation of improved LEDs has been preferred, because these units seem to be effective with virtually all available composites. The composite's manufacturer (not the light-curing unit manufacturer) should indicate the most appropriate light-curing method(s) and required energy output for a specific composite.

Light-activated composites can only cure well when exposed to enough energy or light in the correct wavelength. The physical and mechanical properties of all composites are directly related to how well they are cured. Therefore, unless a proven bulk-fill composite is being used, it has been recommended that any given increment of composite is no more than 2 mm thick, to enable all polymerizable monomers in that increment to be reached by the curing light. Dark (or opaque) composite shades, the distance from the curing tip to the composite, and curing through the tooth affect the reach of the curing light, so the operator should pay attention to these factors as well.

One of the most significant drawbacks of light-activated composites is polymerization shrinkage. As of today, all composites undergo approximately 3% of volumetric shrinkage upon curing, regardless of the curing method. Consequently, a significant amount of stress can develop at the tooth- restoration interface when the composite is light-cured and soon thereafter, until the polymerization process is completed. It is estimated that 17-21 MPa of bond strengths are required to counteract the stress generated by polymerization shrinkage. Problems such as post-operative sensitivity, marginal enamel fractures, premature marginal breakdown and staining, can result from the polymerization shrinkage stress. The polymerization shrinkage and the resultant stress can be affected by (1) the total volume of the composite material, (2) the type of composite, (3) the polymerization speed, and (4) the ratio of bonded/unbonded surfaces or the configuration of the tooth preparation (C-factor). Today, it is not possible to totally avoid polymerization shrinkage, but a careful insertion and curing technique, as discussed in this Guide, can minimize the stresses resulting from this phenomenon. As new research successfully result in the introduction of non-shrinking composites, which might happen in the near future, polymerization shrinkage concerns might became irrelevant.

Clinical Technique

Initial Clinical Procedures

Assuming a thorough clinical and radiographical examination including pulp status diagnosis has been carried out beforehand, plaque/biofilm removal, shade selection and occlusal analysis are important initial clinical procedures that should be accomplished before starting the tooth preparation.

Plaque/biofilm Removal: Plaque/biofilm removal should be done prior to initiation of restorative procedures if the patient presents with plaque build-up. Ideally, caries and plaque control should be addressed before initiating the restorative phase of a patient's treatment.

Shade Selection: While shade selection is not as important in the posterior area as it is with anterior restorations, contemporary composite systems offer several shade options, making it possible to closely match the shade of the adjacent natural teeth. The composite shade might play an important role in the success of the restoration of maxillary premolars, because these are often visible particularly when the mesiofacial aspect of the tooth is involved in the preparation. Shade selection should be accomplished before isolation of the teeth, due to dehydration and shade shift after isolation.

Occlusal Analysis: The analysis of the interocclusal relationship between the tooth to be restored and the adjacent teeth can guide the sculpture of the occlusal aspect of the restoration. Pre-operative occlusal analysis minimizes post-operative occlusal adjustments substantially. Sharp and mal-aligned opposing cusps that relate to the tooth to be prepared should ideally be identified before the area is isolated and the preparation is initiated. Centric stops and eccentric contacts should be registered before initiating the tooth preparation, and maintained in tooth structure, if possible, or reproduced on the finished restoration when indicated.

Tooth Preparation

In general, the more conservative the preparation the better the long-term prognosis. The tooth preparation for a composite restoration is usually limited to access, removal of the failed restoration and/or caries excavation and development of a convenience form to facilitate placement of the matrix system and the restorative material. The extension of the preparation is usually dictated by the extension of the defect or failed restoration, because it is not necessary to reduce sound tooth structure to provide “bulk for strength,” or to provide conventional retention and resistance forms. Small initial caries lesions in pit-and-fissures of posterior teeth are conservatively restored with composites without the need for extension into the dentin enamel junction or extension for prevention to non-affected fissures. In these restorations, called conservative or preventive resin restorations the carious pit is excavated, the preparation is restored with composite, and the adjacent non-carious pits are sealed with a pit-and-fissure sealant for prevention.

Regardless of the posterior composite preparation size, the preparation outline should be well defined to facilitate insertion of composite and finishing of margins. All friable enamel present at margins should be conservatively removed. Marginal enamel is the most effective barrier against microleakage. Bevels are typically not indicated for posterior composite restorations. Originally designed to increase the surface area for etching and retention, bevels increase the restoration size by extending the margins onto the occlusal and proximal surfaces. Additionally, beveling of gingival margins may compromise the enamel available for bonding in that critical area.

When the preparation involves the proximal aspect of the tooth, pre-preparation wedging may be useful. Pre-wedging protects the interproximal rubber dam and the papillae, prevents bleeding that could jeopardize bonding procedures, and promotes slight teeth separation favoring matrix application and achievement of adequate proximal contacts. Anatomical wooden wedges are most appropriate, but plastic WedgeGuards® (Ultradent Products, Inc. South Jordan, UT) or FenderWedges® (Garrison Dental Solutions, Spring Lake, MI) are appropriate as well and provide additional protection of the adjacent tooth surface while cutting the adjacent proximal box.

Matrix Application (for Occlusoproximal Preparations)

Matrices are often needed to restore proximal surfaces of posterior preparations. Matrix selection and placement is critical when restoring with composite, which is a non-rigid, non-condensable material. Individual, thin precontoured metallic matrices are very suitable to obtain good contour and effective interproximal contacts without composite overhangs in most situations. Care should be taken to avoid collapse of the matrix in the preparation, which would generate inappropriate contour.

Various excellent sectional matrix systems are available (*e.g.,* V3 Triodent System, Ultradent, South Jordan, UT; Composi-Tight 3D, Garrison Dental Solutions, Spring Lake, MI; Palodent Plus, Dentsply Sirona, Charlotte, NC) and include a metallic ring to stabilize the matrix system and promote additional tooth separation. Such rings should be used only when (1) there is no remaining proximal contact between the tooth being restored and the adjacent tooth, (2) they do not interfere with the matrix contour, (3) the remaining tooth structure is strong enough to support the ring, and (4) they can be placed securely not interfering with the wedge.

Matrix application techniques vary depending on the proximal box faciolingual extension. In conservative preparations where the faciolingual extension does not break contact with the adjacent tooth, a conventional metallic matrix can be used. For these cases these bands are easier to apply than sectional matrices. In larger preparations where the faciolingual extension does break contact with the adjacent tooth, sectional, precontoured matrices are recommended. However, very wide faciolingual preparations should be restored with composite infrequently as discussed in previous sections.

Regardless of the type of matrix used, the clinician should always stabilize the matrix with an anatomic wooden or plastic wedge. The wedge should be positioned gingival to the preparation’s gingival margin, as not to interfere with the restoration’s contour. After the matrix is secured with a wedge, it should be burnished internally against the adjacent surface to provide for appropriate contour and proximal contact. Because light-cured composites are plastic, non-rigid materials, matrix installation and modeling prior to insertion of composite is essential in order to obtain a proper restoration.

Application of Dental Adhesive

Regardless of the type of adhesive used, it should be applied and polymerized after matrix application and wedging, which prevents etching and bonding of adjacent surfaces/teeth. Care should be taken to avoid adhesive pooling in areas adjacent to the matrix and on internal angles on the preparation.

As discussed previously, the use of liners and bases under posterior composites is controversial. It is generally accepted that hybridization of the prepared tooth substrates with an adhesive system is the optimal treatment to seal the preparation and protect the pulp-dentin complex under composite restorations. Liners and/or bases are recommended only when the preparation is deemed deep. In small, non-contaminated, non-hemorrhagic mechanical pulp exposures, the pulp and immediate surrounding dentin should be covered with a thin layer of hard-set calcium hydroxide cement or an MTA medicament.

Then, a 1-2 mm thick layer of a resin modified glass-ionomer cement (RMGI) should be placed to protect the pulp dressing material. In deep, non-exposed preparations the RMGI can also be used as the initial increment of the restoration. Liners and/or bases, if used, should in general not be exposed at the restoration's margins.

Composite Placement and Polymerization Technique

Techniques for insertion and polymerization of posterior composites have been extensively researched. Horizontal, oblique, vertical, bulk, and incremental techniques have all been recommended. Microleakage assessments comparing different insertion and polymerization techniques are not conclusive, and no single technique has been universally accepted.

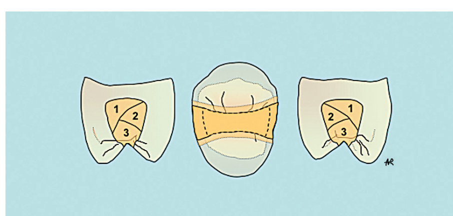
Several manufacturers claim that a more profound depth of cure can be achieved with some composites, but this assertion has been disputed. Incompletely cured composites can cause adverse pulp reactions when in direct contact with vital dentin, through leakage of unreacted monomers via dentinal tubules. In addition, the material's properties and bond strengths are substantially compromised when the composite is not fully cured. High-intensity curing lights and new curing technologies are promising in providing faster and more thorough composite polymerization, as was discussed earlier. However, initial research on high-intensity curing lights demonstrate that the high energy output per unit of time might lead to more shrinkage stress than when conventional curing techniques are used. Polymerization-derived stresses can disrupt the composite-preparation bond, and/or diffuse stresses to the tooth structure, compromising the integrity of the tooth-restoration unit.

The incremental insertion and polymerization technique provides enhanced control over application and polymerization of individual increments of composite. The incremental technique also allows for (1) orientation of the light beam according to the position of each increment of composite, enhancing the curing potential, (2) intrinsic restoration characterization with darker or pigmented composites, and (3) sculpture of the restoration occlusal stratum with a more translucent material simulating the natural enamel.

Tight proximal contacts can also be better achieved when composite is applied in increments. The matrix can be held in close contact with the adjacent proximal surface while the contact- related increment of composite is cured. A hand instrument with a large surface area (*e.g.*, a small football- or round-shaped burnisher) is well suited for that purpose. Once this increment is cured, the proximal contact is established and remaining increments can be inserted and polymerized.

Research has indicated that efficient light curing requires a curing device with a minimum energy output of 300 mW/cm2.[57] The energy output of any curing device should be monitored regularly with a curing radiometer. Even though composite increments of up to 2 mm can be appropriately cured with modern curing lights, this can be affected by (1) the composite's shade and opacity, (2) the composite's distance from the light source, and (3) the power of the light source. The number and distribution of increments varies with the preparation's geometric shape and size. **Figure 3** illustrates the recommended incremental insertion and polymerization technique that should be used to restore proximal boxes. Once the proximal box(es) is(are) restored, the occlusal box can be approached as a Class I preparation.

Figure 3



Diagrammatic representation of recommended incremental insertion and polymerization technique for posterior composite restorations.

In the technique illustrated in **Figure 4** and used to complete the restorations illustrated in **Figure 2**, the composite application is guided by dental anatomy. Shaping the entire anatomy, or most of it, during insertion of the composite minimizes the need for burs during the finishing phase, eliminating complications associated with this procedure. The occlusal sculpture is guided by the remaining cusp inclines, similarly to the technique used for sculpting amalgam restorations. Uncured composite can be effectively carved, shaped, and smoothed with a variety of instruments and brushes to establish contour and surface smoothness.

In the cases that illustrate this review, a composite with low value (darker overall shade) was used to restore the dentin aspect of the preparation. This stage is typically completed using two increments of composite, cured individually for 40s. (It is important to thoroughly cure these increments due to their distance from the light source and to their relatively dark shade.) The final occlusal stratum of the restoration is built in segments, with a more translucent and/or high-value shade. In the technique described, each increment of the enamel stratum is cured initially for 5s; after all occlusal elements have been developed, a thorough 40s light-curing cycle is performed with a layer of glycerin gel covering the surface of the restoration to avoid formation of an oxygen-inhibited resin layer. The most efficient and predictable result is obtained when each cusp area is restored independently, as illustrated in **Figures 4K** and **4L**. Because this technique respects the anatomical elements present in the unprepared tooth structure, a physiological contour is "naturally" reproduced in the restoration, minimizing occlusal adjustments.

As noted earlier, bulk-fill composites have gained considerable attention recently. While the clinical research on these composites is not abundant, preliminary laboratory and short-term clinical studies indicate that when correctly used (meaning correct case selection, tooth preparation, insertion and adequate light-curing) bulk-fill composites can be successful. Bulk-filling will make it more difficult to develop the occlusal anatomy than when an incremental technique is used as described previously but will be expeditious in that all (or most) of the composite is inserted and cured in one single increment. A skilled operator can develop effective occlusal anatomy using a bulk-fill composite approach.

No more than two or three hand instruments are needed in the posterior composite armamentarium. One thin, round-ended composite spatula, and one double-sided composite condenser, both metallic, are enough for inserting and shaping posterior composites. The sharp end of an explorer tine can be used to sculpt primary and secondary grooves on the composite before it is cured. Contemporary posterior composites have much better handling properties when compared to earlier composites. Still, some composites might feel “sticky” and difficult to handle. The best technique to avoid having the composite stick to the instrument and not to the tooth is to use a clean, dry instrument. The instrument can be wiped with a piece of dry gauze often during the procedure. Lubricating the composite spatula or condenser with bonding agent will compromise the restoration by imbedding fluid resin in it, and alcohol should also be avoided.

Finishing, Polishing and Occlusal Adjustment

Ideally, composite restorations should not have to be finished. The use of cutting instruments on the polymerized resin can induce flaws on the tooth-restoration interface and on the restoration surface, compromising its performance. When the described stratified incremental technique is utilized, and an anatomical matrix is used when a proximal box is involved, the need for finishing with hand or rotary instruments is minimized because the restoration will have the required morphology upon curing.

However, it is virtually impossible to insert the composite to the exact desired final contour with available materials and instruments, particularly when a proximal surface is restored. As necessary, flashes of composite can be trimmed with a surgical blade or reciprocating diamond blades. Sequential aluminum oxide-impregnated finishing discs are good instruments to contour and polish the accessible facial and lingual embrasures and marginal ridges of posterior composites. If necessary, the anatomy of the restoration can be refined with medium, fine and super-fine diamonds applied intermittently with a high-speed handpiece running at reduced RPM. These instruments should be used in a dry field to facilitate visualization and avoid inadvertent cutting of marginal enamel.

Posterior composites are difficult to polish to a high gloss, as with microfill composites. However, good results can be achieved with extra-fine polishing pastes applied with nylon brushes and/or silicone points and cups at slow speed. Aluminum-oxide impregnated polishing brushes are available and produce a very good surface finish on occlusal surfaces. The finishing and polishing potential of resin-based composites has been shown to be product-specific. It is important, therefore, to follow the manufacturers’ recommendations for finishing and polishing.

Occlusal adjustments are made after removal of the rubber dam, if used. The same diamonds used for occlusal finishing described above should be utilized to adjust newly placed composite restorations in centric and eccentric positions. In the described technique, occlusal adjustments are minimal, and usually restricted to a small area. When excessive corrections have to be made, the occlusal analysis was incorrectly done. If occlusal adjustment is done, it is necessary to polish the restoration’s selectively adjusted area(s) and apply a surface sealant to “seal” the restoration surface and margins. No surface sealant is necessary if the restoration surface is not instrumented or adjusted.

Maintenance of Posterior Composite Restorations

As indicated in a previous section of this Guide, failure of posterior composite restorations can occur due to a number of factors. Research has indicated that the most common cause of failure of restorations in general is secondary caries. Secondary caries is defined as caries occurring at margins of or adjacent to an existing restoration. The etiological factors are the same for secondary caries and primary caries: dental plaque, fermentable carbohydrates, host (tooth). Research also shows that most failed posterior composite restorations occur in patients with high caries risk.[35] Therefore, posterior composite restorations, and for that matter any restoration, will be better maintained (and will last longer) in patients with low caries activity.

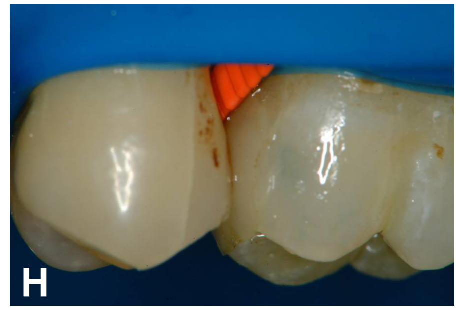
Every single step in the placement technique has the potential to influence the longevity of the restoration. Complete excavation of existing carious tissues, proper pulp protection and adhesive placement, adequate insertion and curing techniques, and good finishing and polishing techniques will likely produce a restoration that has the best chances of survivability. In general, the more conservative (the smaller) the restoration, the longer it will last.[19] A conservative posterior composite restoration placed according to the guidelines presented in this Guide can be expected to last an average of 5 years, but in many situations this time will be considerably greater.

Posterior composites might present localized chipping or staining at margins with time, and typically require more maintenance than amalgam restorations.[33] If the restoration is deemed otherwise sound, and if the tooth is not compromised with additional caries lesions and/or fractures, the chipped/stained area can be easily corrected. If the chipped/stained margin can be corrected without composite addition, simply re-finish and re-polish the margin using the finishing/polishing instruments described, being careful not to damage adjacent enamel. If new composite has to be added due to any deficiency in the contour, prepare the existing composite with a small #329 or 330 diamond bur, slightly roughen the marginal enamel, and proceed with the restorative technique described. Chairside air-particle abrasion or microetcher devices can also be used to prepare or roughen the surface of the “old” composite to be repaired. Consider this repair as if it were a conservative composite restoration. The best results will be obtained if the repair is made with the same composite present as the restoration, though that is not critical.

Figure 4

Each individual increment is light-cured for 20 seconds with a visible light curing unit. The proximal segment is restored to the height of the matrix, and fully light-cured.

At this point, the matrix is removed and the occlusoproximal preparation is converted into an occlusal preparation.



Facial view of the restoration after the matrix has been removed. Note the excellent adaptation of the restorative composite to the facial wall of the preparation. Minimal excess composite is present.

To restore the occlusal segment, the dentin stratum of the preparation is initially restored incrementally.

Each increment should not exceed 2 mm in thickness, and ideally should not contact more than two internal walls in the preparation.

To restore the enamel stratum of the preparation, the cusps are restored one at a time. These small increments can be initially individually light-cured for 5 seconds. This picture shows the mesiolingual increment being shaped.

Occlusal view of the restoration after all the composite increments were light-cured, immediately before finishing and polishing.

The facial and lingual proximal embrasures can be finished and polished with aluminum-oxide flexible finishing discs (Sof-Lex, 3M, St. Paul, MN).

The occlusal aspect of the restoration can be polished with aluminum-oxide impregnated elastomer brushes (Sof-Lex, 3M, St. Paul, MN).

Occlusal view of the restoration after all the composite increments were light-cured, immediately before finishing and polishing.

Conclusion

Composite resins are extensively used for the restoration of defects in posterior teeth. As the understanding of their properties, characteristics, and intraoral behavior increases, it can be expected that the posterior composite technique will soon be applied with even more predictability. Careful attention to case selection and placement technique is critical for optimal success with posterior composites.

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POST-TEST

Internet Users: This page is intended to assist you in fast and accurate testing when completing the "Online Exam." We suggest reviewing the questions and then circling your answers on this page prior to completing the online exam.

(2.0 CE Credit Contact Hour) Please circle the correct answer. 70% equals passing grade.

1. Which of the following is a LIMITATION of posterior composites?
a. Posterior composites can be bonded to enamel and dentin.
b. Posterior composites are very sensitive to moisture contamination from saliva and gingival fluids during placement.
c. Posterior composites can be placed in very conservative preparations.
d. Posterior composites are tooth-colored.

2. Which of the following is an ADVANTAGE of bulk-fill composites?
a. Do not require a dental adhesive.
b. Do not need to be light-cured.
c. Facilitate development of occlusal anatomy.
d. Can be placed and cured in 4-mm single-increments.

3. Posterior composites were introduced in the early 1970's. Which of the following is NOT an indication for posterior composites?
a. Small- to moderate- sized posterior defects.
b. Posterior defects where esthetics is an important consideration.
c. Replacement of small to moderate failed amalgam restorations.
d. Large reconstructions involving cusp replacements.

4. Posterior composites have several advantages over amalgam. Which of the following is NOT a posterior composite advantage?
a. Allows for more conservative tooth preparation than amalgam.
b. Can be bonded to the tooth more effectively than amalgam.
c. Is less technique sensitive than amalgam.
d. Is more esthetic than amalgam.

5. Regarding initial clinical procedures for posterior composite restorations, which statement is NOT true?
a. Shade selection should be made only after the preparation is completed.
b. Occlusal analysis is made to anticipate occlusal elements of the restoration.
c. Shade selection is accomplished before isolation.
d. In occlusoproximal restorations, it is convenient to have a preoperative radiograph to evaluate the extension of the defect.

6. Research shows that the longevity of posterior composite is affected by:
a. Type of composite.
b. Patient's caries risk.
c. Operator geographical location.
d. Number of composite increments used.

7. Composites with large particles are called:
a. Macrofills
b. Microfills
c. Hybrids
d. Nanofills

8. Posterior composite restorations are typically inserted incrementally. Which of the following is NOT an advantage of the incremental insertion and polymerization technique?
a. Orientation of the light beam according to the position of each increment, enhancing the curing potential.
b. Intrinsic characterization of the restoration with darker or pigmented composites.
c. Sculpture of the occlusal stratum of the restoration with a more translucent material.
d. Speed.

9. The use of a dental adhesive is an integral part of the posterior composite technique. Regarding dental adhesive application in a Class II preparation, which is CORRECT?
a. The adhesive should be applied before the installation of the matrix.
b. The adhesive should be applied after the installation of the matrix.
c. The adhesive should not be light cured before the insertion of the composite.
d. Use of a dental adhesive is not necessary when placing posterior composites.

10. A composite's physical and mechanical properties are mostly influenced by its:
a. Coupling agents
b. Filler particles
c. Organic matrix
d. Pigments

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Preferred Dentist Program ID Number: ____________________ ☐ Check Box If Not A PDP Member

AGD Mastership: ☐ Yes ☐ No

AGD Fellowship: ☐ Yes ☐ No Date: ________

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Evaluation - Posterior Compositities 7th Edition

Providing dentists with the opportunity for continuing dental education is an essential part of MetLife's commitment to helping dentists improve the oral health of their patients through education. You can help in this effort by providing feedback regarding the continuing education offering you have just completed.

Please respond to the statements below by checking the appropriate box, using the scale on the right.

1 = POOR 5 = Excellent

	1	2	3	4	5	
1. How well did this course meet its stated educational objectives?	☐	☐	☐	☐	☐	
2. How would you rate the quality of the content?	☐	☐	☐	☐	☐	
3. Please rate the effectiveness of the author.	☐	☐	☐	☐	☐	
4. Please rate the written materials and visual aids used.	☐	☐	☐	☐	☐	
5. The use of evidence-based dentistry on the topic when applicable.	☐	☐	☐	☐	☐	☐ N/A
6. How relevant was the course material to your practice?	☐	☐	☐	☐	☐	
7. The extent to which the course enhanced your current knowledge or skill?	☐	☐	☐	☐	☐	
8. The level to which your personal objectives were satisfied.	☐	☐	☐	☐	☐	
9. Please rate the administrative arrangements for this course.	☐	☐	☐	☐	☐	

10. How likely are you to recommend MetLife's CE program to a friend or colleague? *(please circle one number below:)*

10 **9** **8** **7** **6** **5** **4** **3** **2** **1** **0**

extremely likely — neutral — not likely at all

What is the primary reason for your 0-10 recommendation rating above?

11. Please identify future topics that you would like to see:

Thank you for your time and feedback.

MetLife

To complete the program traditionally, please mail your post test and registration/evaluation form to:
MetLife Dental Quality Initiatives Program | 501 US Highway 22 | Bridgewater, NJ 08807