Clinical Considerations for Aesthetic Laboratory-Fabricated Inlay/Onlay Restorations: A Review

Douglas A. Terry, DDS*
Bernard Touati, DDS, DSO†

The continued evolution of adhesive technology and materials has increased the application of composite materials for the direct and indirect restoration of posterior dentition. While these innovations cannot address every restorative challenge, such developments do allow clinicians to use conservative preparation designs and varying surface treatments in their efforts to achieve functional and aesthetic results. This discussion details the comprehensive clinical protocol required to use laboratory-fabricated resin systems for inlay/onlay restorations.

Key Words: indirect, resin, aesthetic, filler, polymerization

Aesthetic dentistry continues to evolve through innovations in bonding systems, restorative materials, function-based treatments, and conservative preparation designs. Such advances have increased the myriad of opportunities available to discriminating patients and have provided solutions to many of the aesthetic challenges faced by clinicians. Increased utilization of composite materials for the restoration of the posterior dentition has drawn attention to technological advances in the field. While direct composite resins offer excellent optical and mechanical properties, the use of these systems in posterior restorations should be limited to smaller restorations,[1-3] since polymerization shrinkage remains a concern in larger cavity preparations.[4-6] The difficulty encountered by clinicians in achieving proper bond strength may also result in a loss of adhesion at the tooth/restoration interface,[7] which increases the potential of microleakage, postoperative sensitivity,[8] and recurrent caries.

Indirect composite resin systems represent an aesthetic alternative for larger posterior restorations (Figure 1). These systems restore mechanical and biological function, while achieving optimal aesthetic results with minimal resin cement shrinkage and limited tooth reduction. Laboratory-fabricated composite resins (belleGlass, Kerr/Sybron, Orange, CA; Targis/Vectris, Ivoclar Williams, Amherst, NY; Sculpture/FiberKore, Jeneric/Pentron, Wallingford, CT; Cristobal, Dentsply/Ceramco, Burlington, NJ), also known as ceramic optimized polymers,[9] maintain a higher density of inorganic ceramic microfillers compared to the earlier systems.[10] These second-generation indirect systems have been noted to provide the advantages of composite resins and porcelain without being confined by their inherent limitations.[11]

Materials classified as "microhybrids" include a combination of inorganic particles (fillers) and an organic polymer (matrix) in a 2:1 ratio. The filler is the primary determinant of the clinical and physiochemical properties

Figure 1. Case 1. Preoperative occlusal view of defective amalgam restorations with recurrent decay.

**Clinical Assistant Professor, University of Texas Health Science Center, Houston, Texas; private practice, Houston, Texas.*

†Editor-in-Chief, Practical Procedures & Aesthetic Dentistry; *private practice, Paris, France.*

Douglas A. Terry, DDS
12050 Beamer
Houston, TX 77089

Tel: 281-481-3470
Fax: 281-484-0953
E-mail: dterry@dentalinstitute.com

of composite resin. These submicron-particle fillers provide surface characteristics such as polishability and wear resistance.[12] Wear is influenced by the filler size, shape, load, and matrix bonding.[13-15] In fact, a significant reduction in wear resistance has been observed when the size of the filler particle is decreased.[13,16]

More recent indirect composite formulations with increased filler volume and decreased particle size appear to exhibit improved wear resistance. A recent study at the University of Alabama reported the wear rate of such materials to be slightly more than one micron per year, which is comparable to that of natural tooth enamel.[17] Newer formulations in filler size, shape, composition, and concentration have significantly enhanced the mechanical characteristics of second-generation composite resins by reducing polymerization shrinkage, while increasing flexural and tensile strength, resistance to abrasion and fracture, and color stability.[18,19]

In addition, the various combinations of light, heat, pressure, and vacuum — as well as the use of nitrogen to enhance the degree of conversion through postcuring — continue to improve the physical properties of second-generation indirect resin systems. The curing process eliminates residual monomers and ensures a uniform cure with an optimum level of polymerization. The elimination of oxygen with pressure, vacuum, or nitrogen also removes the entrapped air pockets that contribute to the opacity of the restorative material. Therefore, these restorative materials exhibit optical properties with natural translucency, fluorescence, and opalescence.

Various methods of postcuring allow for secondary curing of the composite by increasing the conversion of the material from monomer to polymer.[18] This heightened degree of polymerization increases fracture toughness, flexural and diametral tensile strength, wear resistance, incisal edge strength,[20] and color stability.[21] Clinical benefits achieved from the indirect resin systems include tooth reinforcement, conservation of tooth structure, precise marginal integrity, and wear resistance similar to enamel. Indirect resin materials also provide wear compatibility with opposing natural dentition, longevity for the proximal contacts, and proper morphology and aesthetics.[22,23] Accepted clinical applications for these restorative polymers include single-tooth restorations (eg, metal-free crowns, veneers, inlays/onlays) and long-term provisional restorations.[19,23] Indirect resin systems can also be utilized with metal-reinforced implant-supported prosthodontics where the metal surface is prepared with macromechanical retentive features, such as microbeads, that are incorporated into the metal framework designed to mechanically interlock with the veneering material.

Figure 2. The indirect composite resin onlays represent an aesthetic restorative solution.

Figure 3. The onlay restorations were fabricated and layered in the laboratory.

Figure 4. Occlusal view of the indirect restorations during the laboratory sequence.

While many articles have examined the plethora of uses for indirect resin-reinforced systems, the following clinical review focuses solely on inlay/onlay restorations

Figure 5. Occlusal view of the built-up onlay restorations following application of the composite stain.

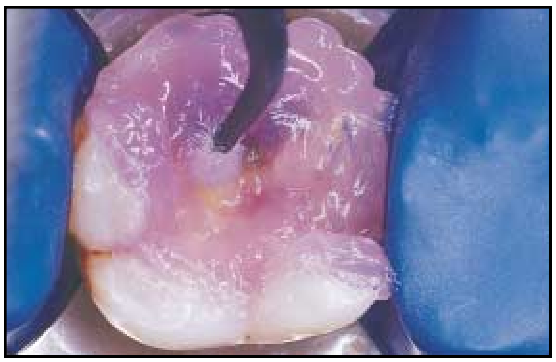

Figure 6. The preparation was etched for 15 seconds with 37.5% phosphoric acid semi-gel (Gel-Etchant, Kerr/Sybron, Orange, CA).

employing a heat-curing process in conjunction with nitrogen pressure. This discussion includes the proper preparation, design, adhesive, and finishing protocols required to achieve an optimal functional and aesthetic result.

System Components

An understanding of a specific indirect composite resin requires a discussion of the system's two components: the resin material and the curing mechanism. The belleGlass HP material (Kerr/Sybron, Orange, CA), for example, contains a combination of two different materials: an "artificial dentin" (base composite) and an "artificial enamel" (surface composite). The filler particles are silanated for improved adhesion to the organic matrix. The filler composition varies for the dentin and the enamel. The artificial dentin utilizes bariumaluminosilicate glass fillers of different sizes in the opacious dentin (86%/72% wt/vol) and dentin (78.7%/56% wt/vol), which provide durable mechanical properties with a low retraction coefficient. The artificial enamel incorporates borosilicate glass fillers (74%/63% wt/vol) of 0.4 μm to 0.6 μm particle size that provide wear resistance and natural optical properties by enhancing the translucency and opalescence of the composite.[11,18,24]

The matrices for the dentin and enamel also differ. The dentin matrix utilizes a regular BIS-GMA resin, while the enamel matrix is a combination of aliphatic and urethane dimethacrylate resins. The differing matrices determine the physical properties of the artificial dentin and enamel, mimicking the natural tooth layers and providing each with the necessary characteristics for optimal use. Since they differ, however, the incremental layering of the composite may require additional blending while shaping and light curing are performed.[18]

The polymerization process combines two different curing systems. The artificial dentin is initially polymerized with a conventional curing light, which stabilizes the restoration during buildup and preserves unreactive sites to enhance bonding. This layer has a lower conversion rate than the enamel, which allows it to bond with the resin cement. The enamel is then cured in a proprietary oven at 135°C and a pressure of 41.369 N/cm^2 in a nitrogen atmosphere. The elevated temperature and nitrogen gas increase the polymer conversion, and the pressure allows the oxygen to be purged out of the system in cycles. This is beneficial since oxygen limits the degree of polymerization by competing at the carbon double-bond sites. Therefore, replacing oxygen with nitrogen allows for a more complete cure since no air-inhibited layer remains uncured.[25] Results from a recent study indicate that an ideal conversion rate of 98.5% polymerization may be achieved with this material with a 20-minute curing period.[20,26] The enamel layer is designed to improve wear resistance through the heat/pressure

Figure 7. The adhesive agent (Nexus, Kerr/Sybron, Orange, CA) was applied and air-thinned.

polymerization process; the dentin layer has been improved to match the coefficient of expansion of a natural tooth and the flexural strength and modulus of natural dentin (ie, reduced polymerization shrinkage 9% by volume). The resulting composite material provides maximum strength and homogeneity, aesthetics, color stability, and enhanced resistance to wear and deformation.[22]

Preparation Design Requirements

Tooth preparation for indirect resin inlays/onlays differs from that required by conventional cast-metal materials. The preparation design is based on the mechanical properties of the indirect composite materials and the authors' clinical experiences. Since resistance and retention are determined primarily by adhesion to enamel and dentin, a more conservative preparation is achievable.[27-36] To attain optimal functional and aesthetic results, the following preparation guidelines should be considered:

- All enamel should be supported by sound, healthy dentin.
- All internal angles and edges should be rounded to avoid stress and facilitate the fabrication of the restoration.
- Isthmus width should be at least 2 mm with a minimum depth of 1.5 mm.
- All proximal walls should be flared or diverged 5 to 15 degrees (no undercuts).
- Gingival margins should be prepared to a 90-degree cavosurface line angle (butt joint).
- Sharp cavosurface margins should be maintained.
- Occlusal margins should not coincide with occlusal contact site.
- No feather-edge preparation.[11,18,22,27,28,37,38]

Fiber Reinforcement

A principal consideration in determining the long-term clinical success of laboratory-fabricated resin restoration is tooth reinforcement. To reinforce the composite resin, additional fibers are integrated into the resin matrix during fabrication and prior to the curing process.[28,38] The surface of these fibers has been treated to enhance adhesion to any synthetic restorative material. Although no long-term clinical trials are available to determine the clinical success of these materials, a recent short-term study on 60 single-crown restorations demonstrated

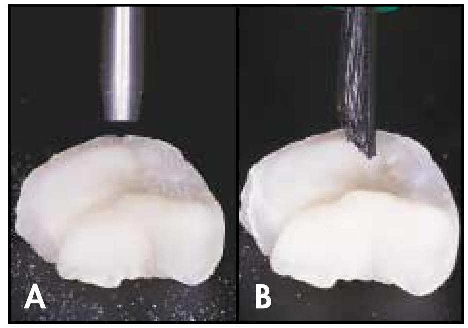

Figure 8A. The internal surfaces of the composite restorations were microetched. 8B. Silane was applied to the internal surfaces of the restoration.

Figure 9. The resin cement (Nexus, Kerr/Sybron, Orange, CA) was injected into the preparations.

Figure 10. The excess resin cement was removed from tooth #30(46) with a sable brush.

Figure 11. A sable brush was utilized to remove the remaining resin cement from tooth #31(47).

Figure 12. The occlusal anatomy was refined with #12 and #30 fluted egg-shaped burs.

Figure 13. Additional etching material was placed on the margins of the restoration.

Figure 14. The cavosurface margin was re-etched.

Figure 15. A composite surface sealant (OptiGuard, Kerr/Sybron, Orange, CA) was applied.

no breakage after 1 year.[11] Since the flexural strength of the restoration is increased by the addition of composite reinforced fibers,[11,39] the authors believe it is prudent to incorporate them to reduce fractures in regions of increased occlusal stress.

Adhesive Surface Preparation

Adhesive bonding of laboratory-processed composite resins increases their resistance to fracture.[40] A principal determinant in the long-term success of these restorations is the strength and durability of the interface between the resin cement and the bondable surface of the processed resin.[41] The surface of laboratory-processed composite resins is highly polymerized with minimal unreacted free-end radicals for bonding to the resin cement.

While microleakage has been reported to occur at this interface between the internal surface of the inlay/onlay and the resin cement in the absence of composite softening agents,[42] several surface treatments have been advocated to promote adhesion between the resin cement and the indirect restoration. Mechanical roughening of the internal surface of the inlay can be accomplished with diamond burs or microetching with either 50 μm aluminum oxide particles or 30 μm silanized silica-coated aluminum oxide particles, which creates a micromechanical retention bond at a microscopic level between the restorative material and the resin cement. In addition to mechanical roughening, an application of proprietary softening agents, wetting agents, or silane has been reported to enhance the bond strength between the restoration and the resin cement.[43]

Various precementation protocols have been recommended by the manufacturers of indirect resin systems. The authors' standard cementation protocol for laboratory-processed composite resins includes microetching with a silicate ceramic sand (CoJet-Sand, ESPE America, Norristown, PA) and subsequent application of silane to restore any coating on the original fillers that may have been removed by sandblasting. As a bifunctional molecule, the silane acts as a coupling agent between the filler particles on the indirect resin surface and the resin cement; newer formulations of silane that include a monomer (ie, unfilled resin) further simplify the bonding process. Microetching of aged composite resin with silica-coated aluminum oxide particles resulted in higher bond strengths compared to other surface treatments for intraoral repair of composites.[44] The mechanism of action allows the silicate particles to become embedded in the surface of the restoration during sandblasting, which then reacts with the silane to improve bond strengths.[45] Reports indicate, however, that etching or rinsing after such surface treatment significantly decreased shear bond strengths.[43,46]

Clinical Procedure

The following clinical protocol utilizes an indirect restorative technique that requires two appointments. At the first appointment, a shade selection and photograph comparison is performed prior to rubber dam placement, since dehydration of the teeth results in an elevated value that may cause the selection of an incorrect shade. Upon removal of the existing amalgam restoration and recurrent caries, the cavity is designed according to the aforementioned preparation guidelines. Following removal of the rubber dam, an additional photographic shade comparison of the underlying substrate is performed. An accurate polyvinylsiloxane impression (eg, Take 1, Kerr/Sybron, Orange, CA; Aquasil, Dentsply/Caulk, Milford, DE; Splash, Discus Dental, Culver City, CA) is made to define all cavosurface margins. A model of the opposing dentition and an interarch occlusal bite registration is conveyed with 35-mm photographs of the shade tab comparison. Digital photography provides another method for the instant transmission of information from the clinician to the laboratory via the Internet. A direct provisional restoration is placed, and the occlusion is inspected (Figures 2 through 5).

On the following visit, once anesthesia has been administered to the patient, the provisional restoration is removed with a spoon excavator. A throat pack of gauze is placed prior to removal of the provisional and during try-in of the restoration to protect the patient from swallowing the material.[37] The restoration is tried-in to permit the evaluation of color and marginal adaptation under 4.3× telescopic magnification. The proximal contacts are examined and equilibrated as necessary. The teeth are isolated with a rubber dam to protect against contamination and to achieve adequate field control.[47,48]

The preparation is subsequently cleaned with a 2% chlorhexidine solution (Consepsis, Ultradent Products, South Jordan, UT). Using the “total-etch” technique to minimize the potential of microleakage and enhance bond strength to dentin and enamel,[34,49,50] the preparation is etched for 15 seconds with 37.5% phosphoric acid (Gel-Etchant, Kerr/Sybron, Orange, CA), rinsed for 5 seconds, and then lightly air-dried to avoid dessication (Figure 6). A soft metal strip is placed interproximally to isolate the prepared tooth from the adjacent dentition. Once the dentin is lightly remoistened with water or a rewetting agent, a hydrophilic adhesive system is utilized. After the dentin primer and activator are applied

Figure 16. Final polishing was accomplished with rubber points and polishing paste.

Figure 17. Postoperative occlusal view of the definitive restorations. Note the harmonious integration of the composite resin with the existing tooth structure.

Figure 18. Case 2. Preoperative occlusal view of a defective amalgam restoration with recurrent decay.

Figure 19. Shade selection was performed prior to rubber dam placement.

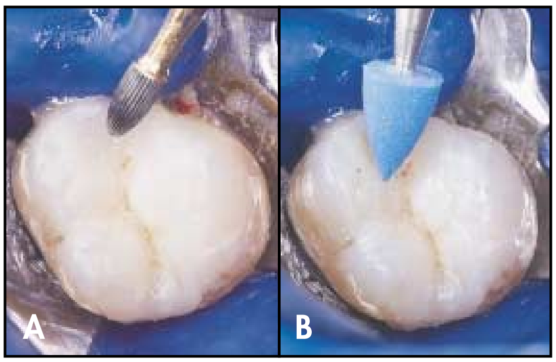

Figure 20A. Occlusal anatomy was refined with #12 and #30 fluted egg-shaped finishing burs. 20B. Final polishing with rubber points (FlexiPoints, Cosmedent, Chicago, IL).

Figure 21. Postoperative occlusal view of the definitive restoration. Notice the harmonious integration of the composite resin with the existing tooth structure.

separately and air-thinned, the adhesive agent (Nexus 1, Kerr/Sybron, Orange, CA) is applied in the same fashion (Figure 7).

Once the internal aspect of the onlay is treated according to the aforementioned surface preparation protocol (Figure 8), the restoration is cemented with a dual-cure composite cement (Nexus, Kerr/Sybron, Orange, CA). The cement is mixed and loaded into a needle tube syringe tip (Needle Tube, Centrix, Sheldon, CT) and injected into the entire preparation (Figure 9). A blunt-tipped instrument is used to seat the restoration firmly in place, and the excess resin cement is removed with a sable brush (Figure 10). It is imperative to leave some residual cement at the margins to prevent voids and to compensate for its polymerization shrinkage. The restoration is initially polymerized for 20 seconds while held in place with the blunt-tipped instrument. The residual cement is removed with a sable brush (Figure 11), and the interproximal aspects are flossed. This leaves only a small increment of cement at the margin to counteract any polymerization shrinkage. A thin application of glycerin is applied to all the margins to prevent the formation of an oxygen-inhibiting layer on the resin cement.[22] The restoration is subsequently polymerized from all aspects (eg, facial, occlusal, lingual, and proximal) for 60 seconds, respectively.

Once the resin cement is polymerized, the residual excess at the gingival margin is removed with a scalpel. The interproximal region is finished with #12 and #30 fluted needle-shaped finishing burs, and the occlusal anatomy is refined with #12 and #30 fluted egg-shaped finishing burs (Figure 12). The restoration and the adjacent enamel are then re-etched (Figures 13 and 14), and a composite surface sealant (OptiGuard, Kerr/Sybron, Orange, CA) is applied and cured to seal any cracks or microscopic porosities that may have formed during finishing (Figure 15). Finally, the restoration is polished with rubber points and cups and polishing paste (Figure 16). The rubber dam is removed, and the patient is asked to perform closure without force and then centric, protrusive, and lateral excursions. Any necessary equilibration is accomplished with #12 and #30 egg-shaped finishing burs, and the final polishing is repeated. The contact is tested with unwaxed floss, and the margins are inspected. The final result illustrates the harmonious integration of the laboratory-fabricated composite resin restoration with the existing tooth structure (Figure 17).

Conclusion

Although not a panacea to all restorative challenges, contemporary indirect resin systems offer the clinician alternative approaches to various clinical situations (Figures 18 through 21). Manufacturers' improvements in the physical and optical properties of restorative materials allow the clinician to utilize more conservative preparation designs to create function and aesthetic harmony. While innovative ideas and concepts continually flood the marketplace, one should not discount the power a new product may have on plan, design, or procedure. These developments promise to simplify the clinical application of aesthetic techniques and ultimately improve the level of healthcare provided for the contemporary dental patient.

Acknowledgment

The authors mention their gratitude to Vincent Devaud, CDT, for the fabrication of the restorations featured herein. They declare no financial interest in any of the products cited in this presentation.

References

1. Stangel I, Nathanson D. An overview of the use of the posterior composites in clinical practice. Compend Contin Educ Dent 1987;8(10):800-806.
2. Lacy AM. A critical look at posterior composite restorations. J Am Dent Assoc 1987;114(3):357-362.
3. Swift EJ Jr. Wear of composite resins in permanent posterior teeth. J Am Dent Assoc 1987;115(4):584-588.
4. Bausch JR, de Lange K, Davidson CL, et al. Clinical significance of polymerization shrinkage of composite resins. J Prosthet Dent 1982;48(1):59-67.
5. Jensen ME, Chan DCN. Polymerization shrinkage and microleakage. In: Vanherle G, Smith DC, eds. International Symposium on Posterior Composite Resin Dental Restorative Materials. St. Paul, MN: Minnesota Mining + Mfg Co; 1985: 243-272.
6. Bouschlicher MR, Vargas MA, Boyer DB. Effect of composite type, light intensity, configuration factor and laser polymerization on polymerization contraction forces. Am J Dent 1997; 10(2):88-96.
7. Davidson CL, de Gee AJ, Feilzer A. The competition between the composite-dentin bond strength and the polymerization contraction stress. J Dent Res 1984;63(12):1396-1399.
8. Nash RW, Radz GM. Single-appointment composite onlays. Compend Contin Educ Dent 1997;18(3):202-208.
9. Touati B. The evolution of aesthetic restorative materials for inlays and onlays: A review. Pract Periodont Aesthet Dent 1996; 8(7):657-666.
10. Douglas RD. Color stability of new-generation indirect resins for prosthodontic application. J Prosthet Dent 2000;83(2):166-170.
11. McLaren EA, Rifkin R, Devaud V. Considerations in the use of polymer and fiber-based indirect restorative materials. Pract Periodont Aesthet Dent 1999;11(4):423-432.
12. Soderholm KJM. Filler systems and resin interface. In: Vanherle G, Smith DC, eds. International Symposium on Posterior Composite Resin Dental Restorative Materials. St. Paul, MN: Minnesota Mining + Mfg Co; 1985:139-159.
13. Suzuki S, Leinfelder KF, Kawai K, Tsuchitani Y. Effect of particle variation on wear rates of posterior composites. Am J Dent 1995; 8(4):173-178.
14. Braem M, Finger W, Van Dooren VE, et al. Mechanical properties and filler fraction of dental composites. Dent Mater 1989; 5(5):346-348.
15. St. Germain H, Swartz ML, Phillips RW, et al. Properties of microfilled composite resins as influenced by filler content. J Dent Res 1985;64(2):155-160.
16. Bayne SC, Taylor DF, Heymann HO. Protection hypothesis for composite wear. Dent Mater 1992;8(5):305-309.
17. Givan DA, O'Neal SJ, Suzuki S. Eight-year clinical performance of heat- and pressure-cured indirect composite. J Dent Res 2000; 78[special issue]:1523.
18. Miara P. Aesthetic guidelines for second-generation indirect inlay and onlay composite restorations. Pract Periodont Aesthet Dent 1998;10(4):423-431.
19. Olk C. Esthetics in the composite resin veneer technique. Quint Dent Tech 2000;23:159-167.
20. Cook WD, Johannson M. The influence of postcuring on the fracture properties of photo-cured dimethacrylate based dental composite resin. J Biomed Mater Res 1987;21(8):979-989.
21. Bausch JR, de Lange C, Davidson CL. The influence of temperature on some physical properties of dental composites. J Oral Rehabil 1981;8(4):309-317.
22. Howard NY. Advanced use of an esthetic indirect posterior resin system. Compend Contin Educ Dent 1997;18(10):1044-1054.
23. Touati B, Aidan N. Second generation laboratory composite resins for indirect restorations. J Esthet Dent 1997;9(3):108-118.
24. Leinfelder KF. New developments in resin restorative systems. J Am Dent Assoc 1997;128(5):573-581.
25. Shellard E, Duke ES. Indirect composite resin materials for posterior applications. Compend Contin Educ Dent 1999;20(12): 1166-1171.
26. Bennett ME, Puckett AD, Parsell DE, Roberts SB. Conversion of a heat and pressure cured composite. J Dent Res 1996;75 [special issue]:291. Abstract 2188.
27. Robbins JW, Fasbinder DJ, Burgess JO. Posterior inlays and onlays. In: Fundamentals of Operative Dentistry: A Contemporary Approach. Carol Stream, IL: Quintessence Publishing; 1996: 229-249.
28. Dickerson WG, Rinaldi P. The fiber-reinforced inlay-supported indirect composite bridge. Pract Periodont Aesthet Dent 1996;8(suppl):1-4.
29. Wendt SL Jr. Microleakage and cusp fracture resistance of heat-treated composite resin inlays. Am J Dent 1991;4(1):10-14.
30. Fissore B, Nicholls JI, Yuodelis RA. Load fatigue of teeth restored by a dentin bonding agent and a posterior composite resin. J Prosthet Dent 1991;65(1):80-85.
31. Morin D, DeLong R, Douglas WH. Cusp reinforcement by the acid-etch technique. J Dent Res 1984;63(8):1075-1078.
32. McCullock AJ, Smith BG. In vitro studies of cusp reinforcement with adhesive restorative material. Br Dent J 1986;161(12): 450-452.
33. Lopes LM, Leitao JG, Douglas WH. Effect of a new resin inlay/onlay restorative material on cuspal reinforcement. Quint Int 1991;22(8):641-645.
34. Nakabayashi N, Nakamura M, Yasuda N. Hybrid layer as a dentin-bonding mechanism. J Esthet Dent 1991;3(4):133-138.
35. Elhabashy A, Swift EJ Jr, Boyer DB, Denehy GE. Effects of dentin permeability and hydration on the bond strengths of dentin bonding systems. Am J Dent 1993;6(3):123-126.
36. Pashley EL, Tao L, Matthews WG, Pashley DH. Bond strengths to superficial, intermediate and deep dentin in vivo with four dentin bonding systems. Dent Mater 1993;9(1):19-22.
37. Garber DA, Goldstein RE. Porcelain & Composite Inlays and Onlays. Aesthetic Posterior Restorations. Carol Stream, IL: Quintessence Publishing; 1994:117-131.
38. Touati B, Miara P, Nathanson D. Esthetic Dentistry and Ceramic Restorations. London, UK: Martin Dunitz; 1999:291.
39. Dyer SR, Sorensen JA. Flexural strength and fracture toughness of fixed prosthodontic resin composites. J Dent Res 1998;77 [special issue]:160. Abstract 434.
40. Rosenstiel SF, Gupta PK, Van der Sluys RA, Zimmerman MH. Strength of a dental glass-ceramic after surface coating. Dent Mater 1993;9(4):274-279.
41. Dietschi D, Magne P, Holz J. Recent trends in esthetic restorations for posterior teeth. Quint Int 1994;25(10):659-677.
42. Jordan RE. Esthetic Composite Bonding: Techniques and Materials. 2nd ed. St. Louis, MO: Mosby, 1993.
43. Sun R, Suansuwan N, Kilpatrick N, Swain M. Characterization of tribochemically assisted bonding of composite resin to porcelain and metal. J Dent 2000;28(6):441-445.
44. Bouchlicher MR, Cobb DS, Vargas MA. Effect of two abrasive systems on resin bonding to laboratory-processed indirect resin composite restorations. J Esthet Dent 1999;11(4):185-196.
45. Miller MB. Miscellaneous. In: Reality. 14th ed. Houston, TX: Reality Publishing; 2000:408.
46. Bouschlicher MR, Reinhardt JW, Vargas MA. Surface treatment techniques for resin composites repair. Am J Dent 1997;10(6): 279-283.
47. Liebenberg WH. General field isolation and the cementation of indirect restorations: Part I. J Dent Assoc S Afr 1994;49(7): 349-353.
48. Croll TP. Alternative methods for use of the rubber dam. Quint Int 1985;14(6):387-392.
49. Kanca J. Improving bond strength through acid etching of dentin and bonding to wet dentin surfaces. J Am Dent Assoc 1992; 123(9):35-43.
50. Kanca J. Resin bonding to a wet substrate. II. Bonding to enamel. Quint Int 1992;23(9):625-627.

Continuing Education (CE) Exercise No. 2

2 CONTINUING EDUCATION

To submit your CE Exercise answers, please use the answer sheet found within the CE Editorial Section of this issue and complete as follows: 1) Identify the article; 2) Place an X in the appropriate box for each question of each exercise; 3) Clip answer sheet from the page and mail it to the CE Department at Montage Media Corporation. For further instructions, please refer to the CE Editorial Section.

The 10 multiple-choice questions for this Continuing Education (CE) exercise are based on the article "Clinical considerations for aesthetic laboratory-fabricated inlay/onlay restorations: A review" by Douglas A. Terry, DDS, and Bernard Touati, DDS, DSO. This article is on Pages 51-58.

Learning Objectives:

This article details the comprehensive clinical protocol required for the placement of laboratory-fabricated resin inlay and onlay restorations. Upon reading this article and completing this exercise, the reader should:

- Understand the heat-curing process in conjunction with nitrogen pressure, as applied to indirect resin restorations.
- Be aware of various postcuring methods associated with composite resin restorations.

1. New generation indirect resins are also known as:

a. Matrices.
b. Misnomers.
c. Generation next.
d. Ceramic optimized polymers.

2. Indirect composite resin systems represent an alternative for larger posterior restorations. They restore mechanical and biological function with minimal resin cement shrinkage.

a. Both statements are true.
b. Both statements are false.
c. The first statement is true, the second is false.
d. The first statement is false, the second is true.

3. Microhybrids include a combination of:

a. Organic particles and an organic polymer.
b. Inorganic particles and an organic polymer.
c. Organic particles and an inorganic polymer.
d. Inorganic particles and an inorganic polymer.

4. The various methods of postcuring allow for secondary curing of the composite by increasing the conversion of the material from:

a. Polymer to isomer.
b. Isomer to monomer.
c. Monomer to polymer.
d. Polymer to monomer.

5. Accepted clinical applications for restorative polymers include:

a. Precision attachments.
b. Single-tooth restorations.
c. Progressive loading of implant-supported prostheses.
d. All of the above.

6. Clinical benefits achieved from the indirect resin systems include:

a. Color stability.
b. Wear resistance.
c. Both a and b.
d. Neither a nor b.

7. The two components of the indirect composite resin system include:

a. Filler and dentin.
b. Enamel and resin material.
c. Resin material and curing mechanism.
d. Curing mechanism and enamel.

8. Replacing oxygen with nitrogen during the polymerization process allows for:

a. A less complete cure.
b. No cure.
c. A more complete cure.
d. Suffocation.

9. To reinforce the composite resin, additional fibers are integrated into the resin matrix:

a. Never.
b. Only when needed.
c. During curing, prior to the fabrication process.
d. During fabrication, prior to the curing process.

10. Adhesive bonding of laboratory-processed composite resins increases their:

a. Resistance to fracture.
b. Resistance to adhesion.
c. Resistance to refraction.
d. Resistance to a complete cure.