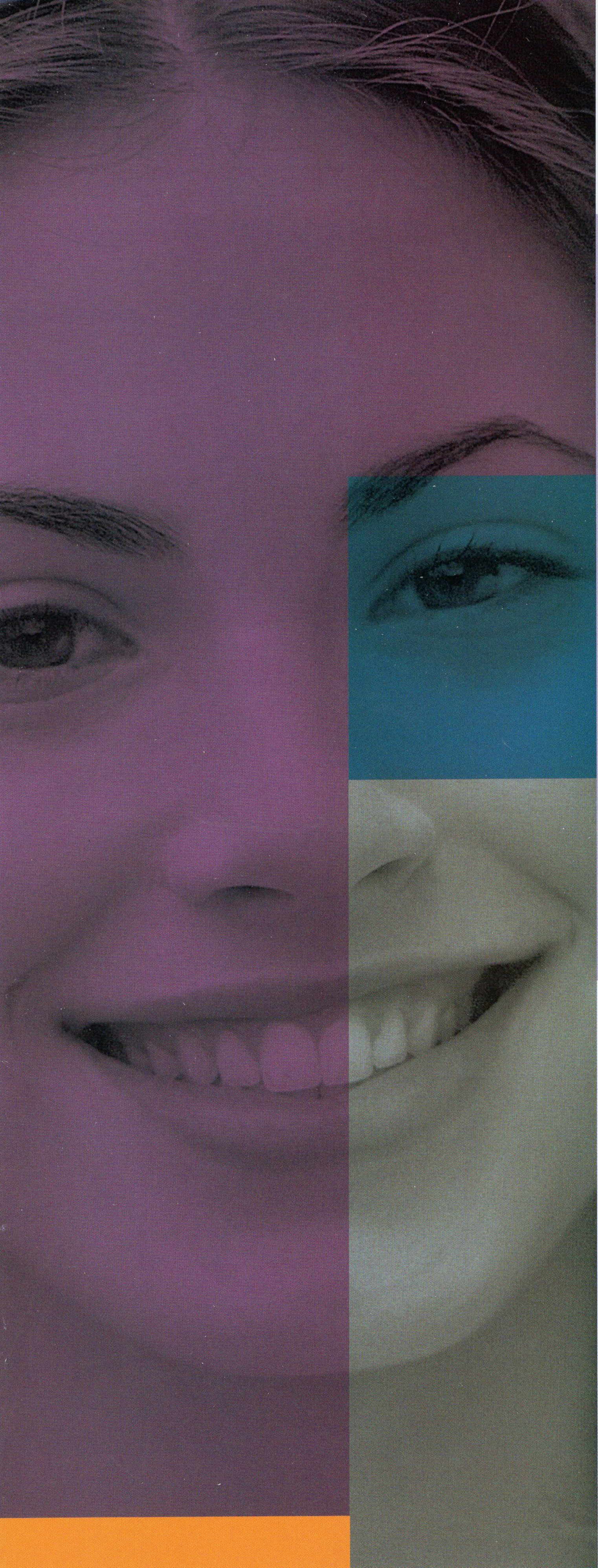

VOLUME 1

Direct Restorations: A Restorative Solution

- Utilization of a Small-Particle Composite Resin for Anterior and Posterior Restorations
  Douglas A. Terry, DDS

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Utilization of a Small-Particle Composite Resin for Anterior and Posterior Restorations

Douglas A. Terry, DDS*

The ability to acid etch enamel dramatically affected the practice of dentistry and initiated the interest in adhesive procedures.[1] The development and commercial introduction of the first composite resin followed shortly thereafter,[2] as did the definition of a composite as a "three-dimensional combination of at least two chemically different materials with a distinct interface separating the components."[3] The applications for composite resin now vary from restoration of cavities, to reconstruction of anterior teeth, core preparation for crowns, correction of stains and erosion, placement of orthodontic brackets, and cementation of dental prostheses.[4]

This article reviews the composition of these materials, describes the mechanical and physical significance of composite resins, and clarifies the manner in which the knowledge has been utilized by the researcher, manufacturer, and clinician to develop a smaller particle composite. These practical clinical observations and research will assist the practitioner in attaining predictable aesthetic results.

The Foundation of Composite Resins

Three phases comprise the foundation of composite resins — the organic phase (matrix), the dispersed phase (filler), and the interfacial phase (coupling agent).[5] Bis-GMA (bisphenol A-glycidyl methacrylate) is a high molecular weight monomer that comprises 80% to 90% of most commercial dental composites.[6] Other matrix components include an initiator (eg, benzoyl peroxide for chemical activation and camphoroquinone for visible light activation), co-initiators, polymerization inhibitors (to extend working time and storage stability), and various pigments.[7-10]

The mineral component of a composite, which is a filler, is termed "the dispersed phase" and has been noticeably improved with the addition of small particles or fillers.[11] In dental composites, fillers provide strength and reinforcement to the matrix.[12-18] Fillers include ground quartz, alumina silicate, pyrolytic silica, lithium aluminum silicates, borosilicate glass, and other types of glass that may contain oxides of heavy metals (eg, barium, strontium, zinc, aluminum, or zirconium) for radiopaque characteristics.[19,20] Produced by milling or grinding, precipitation,

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Figure 1. Case 1. Preoperative facial view of a horizontal fracture in the maxillary right central incisor.

or through condensation, these fillers vary in particle size depending on the manufacturing process.[4] The interfacial phase or coupling agent, the third basic component of composite resins, includes either a bipolar coupling that connects the resin matrix and the inorganic filler, or a copolymeric or homopolymeric bond between the organic matrix and the partially organic filler.[4,21]

Alteration of the filler component remains the most significant development in the evolution of composite resins.[11] In general, mechanical and physical properties of composite materials improve in proportion to the volume of filler added. Numerous mechanical properties — including compression strength and/or hardness, flexural strength, the elastic modulus, coefficient of thermal expansion, water absorption, and wear resistance — depend on this filler phase.

Since the filler particle size, distribution, and the quantity incorporated dramatically affects the mechanical properties and clinical success of composite resins,[22] several classification systems have been based on these characteristics. Subsequent modifications in classification systems reflect the evolution in the mean particle sizes of the non-microfilled composites and reduction of larger particles from the previous composite formulations. Though traditional terms (eg, hybrid, microfill, and fine particle) remain applicable to all these systems, their description varies in each system.[23]

Composite materials are often subdivided into two categories: hybrids and microfills. The successful restoration of a patient's condition often requires the use of both these materials. Hybrid composites consist of several types of filler particles — a glass in the 1 μm to 3 μm range that contains radiopaque oxides (eg, strontium, barium, or zirconium) and silica, which generally have a size of 0.04 μm. Though noted for their strength and polishability, the initial luster attained on these composites diminishes over extended function. Hybrids provide ease of use, natural refractive indices (that allow light to blend into the tooth), and enhanced physical properties.[24] The hybrid composite resins exhibit superior tensile strength and improved abrasion resistance as well as reduced polymerization shrinkage, coefficient of thermal expansion, and water sorption[22]; they also exhibit greater fracture resistance as a result of the inclusion of heavy inorganic fillers.[25] Consequently, these materials are

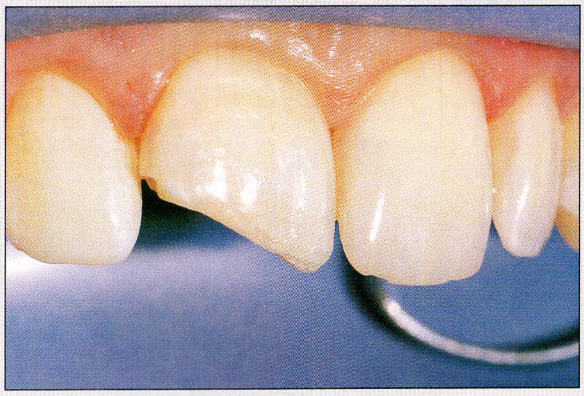

Figure 2. A chamfer 0.3 mm in depth and 2 mm in length was placed around the entire margin.

Figure 3. Once the tooth was acid etched, the dentin layer was built up with shaded (A2) composite resin (Point 4, Kerr/Sybron, Orange, CA).

clinically indicated for Class I, Class II, substructure and incisal regions of Class IV restorations, diastema closures, and direct veneers.

Microfills are composed of submicroscopic silica particles that average approximately 0.04 μm in size. The production of a homogeneous, nonadherent composite paste requires increased volume of filler particles in the composite. This agglomeration occurs through the wetting of the fillers with resins, which are then polymerized together. As a result of the difficulty in wetting these small particles, the filler concentration is strictly limited (35% by weight).[22] Consequently, inhomogeneous materials that allow a higher proportion of filler to be incorporated (45% to 80% by weight) have been developed; this type of microfill composite is often used as a restorative material. This resin-rich environment results in excellent polishability and allows

Figure 4. A second layer of composite resin (shade A2) was added and contoured to form the dentin lobes.

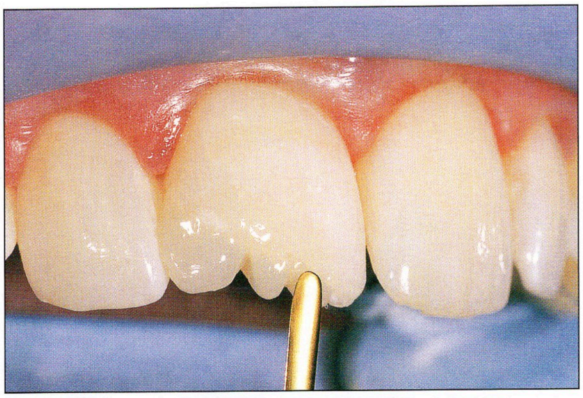

Figure 5. The composite resin was contoured with a long-bladed instrument and smoothed with an artist's brush.

the restoration to retain a surface smoothness over function.[26] The limitations of microfilled composites include high water sorption, lack of radiopacity, the tendency to have lower compressive strengths, fracture resistance, fatigue strength, and hardness. Accordingly, these materials are generally contraindicated for high stress-bearing restorations (eg, Class IV, large Class I, and Class II restorations in occlusal contact with opposing cusps). These composites are indicated for direct veneers and the replacement of enamel in Class III, IV, and V restorations.

Particle size thus represents crucial information in the determination of how best to utilize composite materials. Until recently, the standard method for measuring particle size has been limited to sedigraphs that determine the specific gravity of the rate at which a particle falls. Unfortunately, the measurement is limited to 0.4 μm, and its accuracy drops significantly below 1 μm. The continual development of new technology, however, will improve the ability of scientists, manufacturers, and clinicians to measure more effectively, and to create a more ideal composite. Improved data collection and advanced laser and optic technology allow the "actual size and shape" of hybrids and microfills to be ascertained. The recent introduction of an optimized particle composite with an average "true size" of 0.4 μm (with 90% of the particles below 0.8 μm) represents the profession's continual research and development for the ideal composite material. Prior to the introduction of this small-particle composite resin, it was often necessary to combine hybrid and microfilled composites to achieve proper aesthetics (eg, luster, color) and mechanical stability (ie, strength, wear resistance, fracture resistance) in adhesive restorations. The small-particle composite resin, however, appears to incorporate these properties into a single restorative material. While polychromatic stratification techniques are still necessary with this revised composite formulation, they are used only to attain natural aesthetics and color rather than physical requisites. The following clinical presentations describe the utilization of this smaller particle composite in the restoration of anterior and posterior regions.

Restoration of an Anterior Fracture

A 24-year-old male patient presented with a horizontal fracture of a pre-existing Class IV composite resin restoration on the maxillary right central incisor (Figure 1). The tooth had already been prepared twice since the initial fracture and repair had failed due to inadequate tooth preparation. The proper shade of composite was selected prior to rubber dam placement to prevent improper shade matching due to tooth dehydration. Once anesthesia had been administered to the patient, the teeth were isolated with a rubber dam using a modified technique. This process involved the fabrication of an elongated hole that allowed placement of the rubber dam over the retainers to achieve adequate field control.[27,28]

A chamfer 0.3 mm in depth and 2 mm in length was placed around the entire margin to increase the enamel-adhesive surface and to allow for a sufficient bulk of material at the margins.[29] Using a long tapered diamond, a scalloped bevel was placed to break up the straight chamfer line. Since the margin was located entirely on enamel, a 0.5 mm bevel was placed on the gingival margin to reduce the potential for microleakage (Figure 2).[26] The lingual aspect of the chamfer was extended 2 mm onto the lingual surface, but not onto the occlusal contact area.[26] The preparation was completed with a finishing disk and polished with rubber cups that contained a premixed slurry of pumice and an aqueous 2% chlorhexidine solution (Consepsis, Ultradent Products, South Jordan, UT) to remove potential contaminants.[24] The preparation was rinsed and lightly air dried, and a soft metal strip was placed interproximally to isolate the prepared tooth from the adjacent dentition. The "total-etch" technique was performed to minimize the potential of microleakage and enhance bond strength to dentin and enamel.[30-32] The preparation was etched for 15 seconds with 37.5% phosphoric acid (Gel-Etchant, Kerr/Sybron, Orange, CA), rinsed for 5 seconds, and lightly air thinned to avoid desiccation of the tooth. An adhesive agent (OptiBond Solo Plus, Kerr/Sybron, Orange, CA) was subsequently applied for 20 seconds with a disposable applicator using continuous motion. Excess adhesive was removed with the applicator, and the agent was light cured for 20 seconds.

The first layer — the artificial dentin body (shade A2) — of composite resin (Point 4, Kerr/Sybron, Orange, CA) was then applied (Figure 3) and contoured with a long-bladed composite instrument and smoothed out with an artist's sable brush (Figure 4) to prevent surface irregularities that could have interfered with placement of internal characterizations. This increment was polymerized with a curing unit (Optilux 501, Demetron, Danbury, CT) for 10 seconds, which allowed placement of subsequent increments without deforming the underlying composite layer.

This process was repeated with a second layer of composite resin to form the dentin lobes (Figure 5). In order to prevent overbuilding of the artificial dentin layer, the composite was monitored from the incisal aspect to ensure that adequate space was provided for the final "artificial enamel layer." A white tint (Kolor+Plus, Kerr/Sybron, Orange, CA) was applied vertically between the projected dentin lobes to accent their presence (Figure 6). The areas underlying the mesial and distofacial line angles were highlighted with a diluted white tint,

Figure 6. A white tint was applied vertically between the projected dentin lobes to accent their presence.

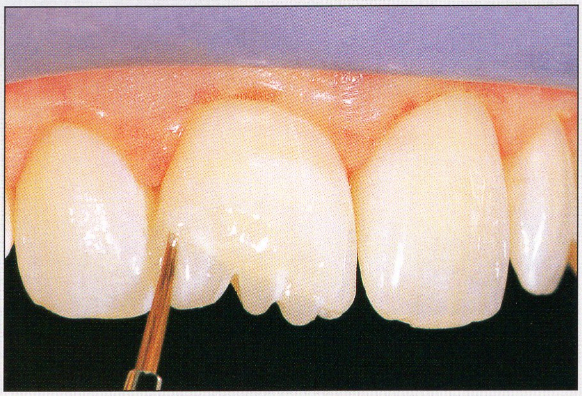

Figure 7. The areas underlying the mesial and distofacial line angles were highlighted with a diluted white tint and overlaid with increments of composite (XL-1, Point 4, Kerr/Sybron, Orange, CA).

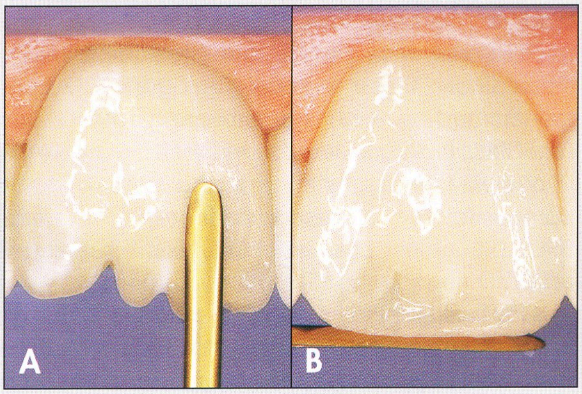

Figure 8A. The enamel layer was applied and contoured with the composite instrument. 8B. This process allowed the natural translucency to be achieved.

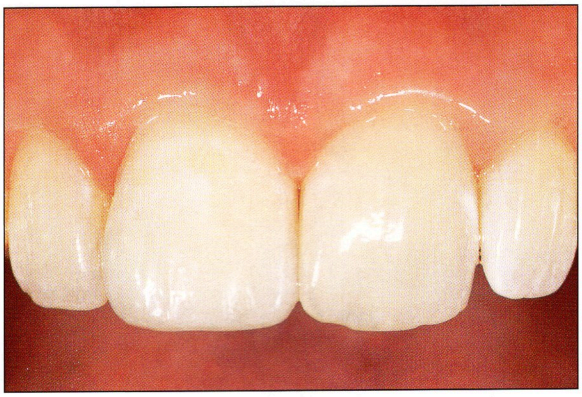

Figure 9. Postoperative facial view of completed restoration. Note the natural characterization achieved with the direct technique.

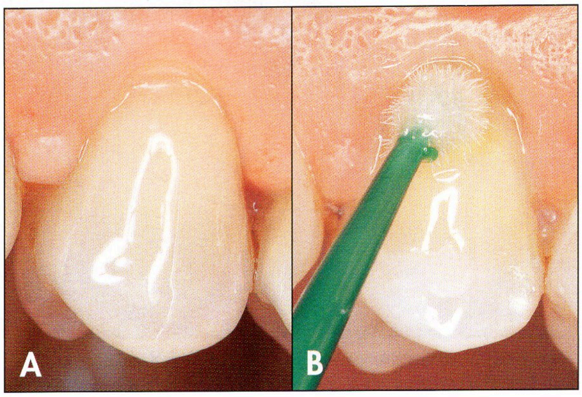

Figure 10A. Case 2. Preoperative view of lesion caused by deflective occlusal contacts. 10B. The adhesive agent (OptiBond Solo Plus, Kerr/Sybron, Orange, CA) was applied for 20 seconds.

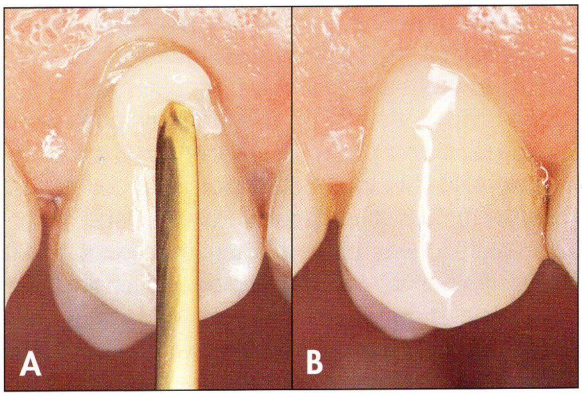

Figure 11A. A single layer of shaded (A3) composite resin (Point 4, Kerr/Sybron, Orange, CA) was applied and contoured. 11B. The completed restoration was harmonious with the surrounding tissues.

cured for 40 seconds, and overlaid with additional increments of composite resin (shade XL-1) that were also light cured for 40 seconds (Figure 7). These techniques utilized color variation to emphasize the tooth form and instill the definitive restoration with a three-dimensional effect. To re-create the natural translucency of the enamel, the final enamel layer (shade T-1) of composite resin (Point 4, Kerr/Sybron, Orange, CA) was applied and contoured with a long-bladed composite instrument and smoothed with an artist's brush (Figure 8). This layer was cured from the facial and the lingual aspects for 40-second intervals, respectively.

The initial contouring was performed with a series of finishing burs in order to replicate natural form and texture.[33] The facial and lingual aspects of the restoration were contoured with #12 and #30 fluted needle-shaped and football-shaped burs, respectively. Finishing of the proximal, facial, and incisal angles was performed with aluminum oxide disks and finishing strips, which were used sequentially according to grit and ranged from coarse to extra fine. For innate characterization, finishing burs, diamonds, and rubber wheels and points were used to create indentations, lobes, and ridges. To impart a high luster while maintaining the existing texture and surface anatomy, a soft white goat-hair brush was used with composite paste to polish the restoration. The completed case demonstrates how a restoration can be sculpted with direct techniques to the desired morphology and color to achieve a sound and aesthetic result (Figure 9).

Restoration of a Class V Lesion

A 45-year-old female patient presented with a noncarious lesion caused from deflective occlusal contacts (Figure 10A).[34-38] Once the clinical examination was completed, a treatment plan that required direct restoration of the lesion was formulated. A nonmedicated retraction cord was placed subgingivally along the free gingival margin to expose the gingival extent of the lesion. A bevel was placed on all enamel margins to prevent microleakage. Although mechanical retention was unnecessary, a slow-speed bur was used to roughen the dentin surface to enhance resin penetration through the dentin into the tubules.[30] In order to achieve proper bond strength, the dentin was kept moist. Once the preparation was scrubbed with a slurry mixture of disinfectant and pumice, it was etched and rinsed for 15 and 5 seconds, respectively. Using a light continuous scrubbing motion, a single-component adhesive was applied with a disposable applicator for 20 seconds (Figure 10B). The adhesive was gently air thinned for 5 seconds and light cured for 20 seconds.

A single layer of composite resin (Point 4, Kerr/Sybron, Orange, CA) was applied and contoured with a long-bladed composite instrument and an artist's sable brush (Figure 11A). Shaping and contouring were performed dry with a series of finishing burs, in order to replicate natural form and texture.[39] It was important not to overheat the resin by using excessive pressure or to damage the cementum at the gingival margin. Any excess resin was removed with a #12 scalpel and the retraction cord removed to permit the inspection of overhangs. Polishing was completed with finishing disks, cups, and points. The restoration and all margins were re-etched for 15 seconds and rinsed for 5 seconds; a layer of composite surface sealant (OptiGuard, Kerr/Sybron, Orange CA) was applied over the margins and the restoration to reduce the potential for leakage and seal any microfractures in the material caused from the finishing procedures. The completed restoration was harmoniously integrated with the surrounding tissues and eliminated the sensitivity for the patient (Figure 11B).

Replacement of a Defective Composite With a Class II Direct Restoration

A 52-year old female patient presented with a fractured distal marginal ridge of the mandibular second premolar that had been previously treated with occlusal composite (Figure 12). Once anesthesia had been administered, the tooth was isolated with a rubber dam to protect against contamination and facilitate moisture control. The preexisting restoration and caries were removed with a rounded tapered diamond that produced rounded line angles. The outline form was as conservative as possible and removed tooth structure only when dictated by caries; the occlusal and gingival margins were butt joints, rather than bevels. The preparation was scrubbed with a mixed slurry of disinfectant and pumice and rinsed. A contoured sectional matrix was placed, wedged, and secured with a G-ring (Composi-Tight, Garrison Dental Solutions, Springlake, MI) to compress the matrix against the beveled proximal line angles. The

Figure 12. Case 3. Preoperative occlusal view of a fractured distal marginal ridge on the mandibular second premolar with pre-existing composite restoration.

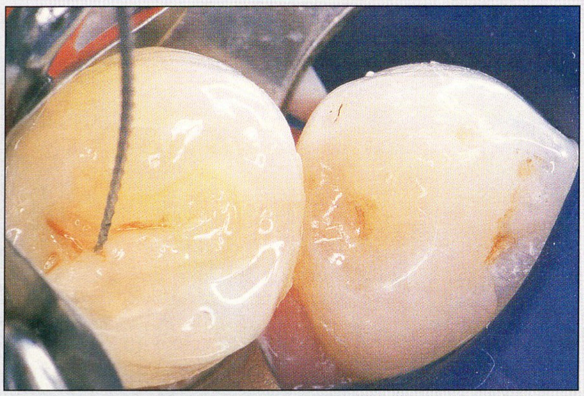

Figure 13. A diluted brown tint (Kolor+Plus, Kerr/Sybron, Orange, CA) was placed with an endodontic file into the invagination of the first increment.

preparation was etched with a 37.5% phosphoric acid gel for 15 seconds and subsequently rinsed for 5 seconds and the dentin kept moist, for higher bond strengths. The gingival margin of the proximal box was coronal to the cementoenamel junction (CEJ). An adhesive agent was applied with a disposable applicator for 20 seconds with continuous motion and was lightly air thinned for 5 seconds. The adhesive was light cured for 20 seconds. The initial increment of composite (Point 4, Kerr/Sybron, Orange, CA) was placed against the buccal wall and followed the cuspal inclines to ensure that the preparation was not crossed buccolingually. A diluted brown tint was placed with an endodontic file into an invagination of the first increment and then cured for 40 seconds (Figure 13). The final layer of shaded (T-1) composite resin was placed to slightly overfill the cavity preparation.

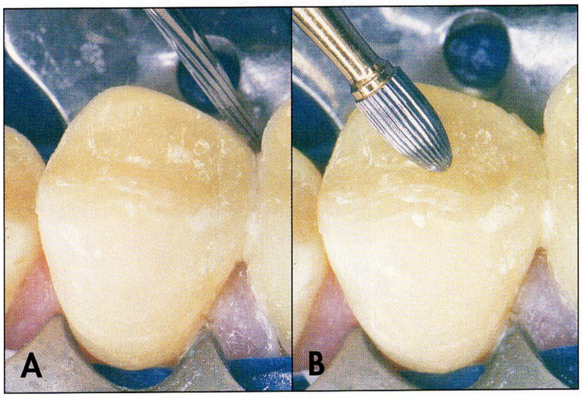

Figure 14A. Interproximal contouring was performed with #12 and #30 fluted needle-shaped finishing burs. 14B. Occlusal anatomy was refined with #12 and #30 fluted egg-shaped finishing burs.

Figure 15. Postoperative occlusal view demonstrated an optimal aesthetic result achieved through proper application of composite resin.

This independent vertical increment minimized polymerization shrinkage and contraction of the cusps, which could have resulted in postoperative sensitivity.

The matrix was removed, the interproximal region was finished with #12 and #30 fluted needle-shaped finishing burs (Figure 14), and the occlusal anatomy was refined. The contact was tested with unwaxed floss prior to removal of the rubber dam. The occlusion was evaluated and adjusted as necessary, and final polishing was completed with rubber points and cups. The proximal surfaces were cleaned and smoothed with polishing paste that was carried into the interproximal region with floss.[40] Once the restoration and the adjacent enamel were re-etched, a composite surface sealant was applied and cured to seal any cracks that may have formed during finishing procedures.

Through proper application of composite resin (Figure 15), the preoperative goals of the patient and clinician were readily achieved.

Discussion

Despite recent evolution in adhesive preparation and design, definitive bevels remain controversial. One in vivo study noted no difference in performance between composite resins placed in beveled or butt joint cavities. Other studies have demonstrated that bevels prove valuable with sealed enamel margins. While the proximal margins should be beveled, they should not be used on the occlusal aspect. The gingival margins, when located substantially coronal to the CEJ, can have a minimal bevel, that may control leakage in this area. Bevels at or apical to the CEJ are contraindicated, however, since enamel or cementum of poor quality is often present at the gingival margins of Class II preparations; beveling will not reduce the microleakage that is common at this location. In addition, aggressive wedging of the matrix can compress the band onto the bevel, which prevents the covering of that bevel with composite resin and creates an undercontoured margin.[24]

Conclusion

The ultimate goal of continuous material research and development is to enhance the practice of dentistry. By understanding how particle size, distribution, and volume affect the mechanical properties of composite resins, the clinician can accurately diagnose and treat a patient's condition. Through further advancement in clinical and laboratory funding and research, refinements in material formulations will continue to improve. In the cases presented, a small-particle composite resin with revised mechanical and physical properties enabled the clinician to deliver restorations that replicated the natural dentition. Although the long-term benefits of this material remain to be determined, the utilization of a small-particle composite in the aforementioned patients demonstrated enhanced sculptability, the polishability of a microfill, the strength of a hybrid, and the ability to simulate the optical properties of the natural tooth.

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