Direct Composite Resin Restoration of Adolescent Class IV Tooth Fracture: A Case Report

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Anterior tooth fractures can be restored utilizing treatment modalities from various dental specialties. The combination of rising patient aesthetic expectations and the desire for conservative dentistry, however, has resulted in the development of intricate direct composite layering techniques. These procedures preserve the natural tooth structure while allowing light and color to be manipulated in the restored dentition. By highlighting the importance of light, color, and material selection, this case presentation documents the use of a direct composite resin technique for the fabrication of aesthetic anterior restorations.

Key Words: composite, anterior, adolescent, fracture, aesthetics, light, color

The frequency of permanent incisor fracture in children between 8 and 17 years old is reported to be as high as 16%.[1] Until recently, conventional methods for the treatment of coronal fractures of anterior teeth primarily included pin-retained composite resins, porcelain laminate veneers, or full-coverage crown restorations. Increased patient demand for optimal aesthetics with less invasive procedures, however, has resulted in the extensive utilization of freehand bonding in the anterior region. Advanced formulations of composite resins with high sculptability in an expanded range of shade selections allow the anterior teeth to be predictably restored in a manner that replicates the polychromatic characteristics of the natural dentition. This article demonstrates anatomic stratification and proper placement of tints and opaquers for the direct restoration of Class IV fractures. Utilized with an understanding of tooth morphology, restorative material selection, color options, and the physical properties of light, these techniques allow optimally aesthetic restorations to be predictably achieved.

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Light

Selecting proper tonalities of all restorative materials requires a basic understanding of natural tooth color.[2] In discussions of the optical properties of the teeth, light is often described in three dimensions: spatial, temporal, and color. Light is composed of electromagnetic oscillations that are differentiated by short or long wavelengths (ie, frequencies).[2] The retina is stimulated by electromagnetic radiation,[3] and the human eye allows such light stimulus to pass through the lens. The retina receives the light stimulus and transmits it to particular regions of the cerebral cortex via the optic nerve, where these stimuli are interpreted as color.[2] The light rays perceived by the human eye remain within the frequency of 380 nm and 760 nm. Light that becomes visible through the spectral color (ie, wavelengths) in the frequency range of 400 nm

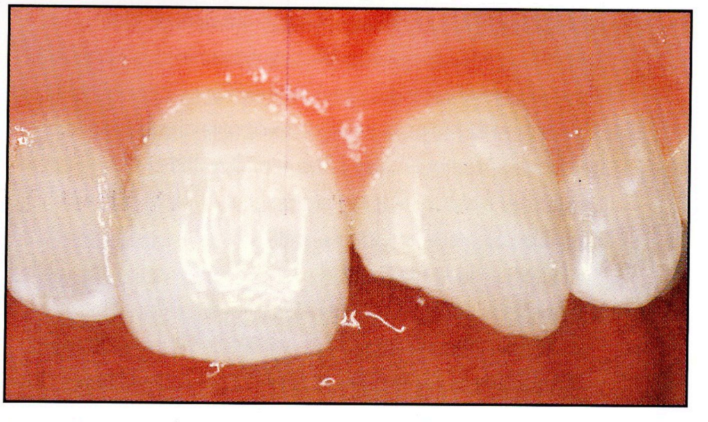

Figure 1. Retracted preoperative facial view. The replacement of a single anterior tooth is extremely difficult to perform utilizing porcelain or composite resin.

to 500 nm is perceived as violet-blue. Light rays that are perceived in frequency ranges greater than 600 nm are viewed as orange-red.[2]

Color

It is necessary for the clinician to have a clear understanding of color. The definition of color — as related to physics — does not possess the same measurable significance as when applied to an artist's paints since the compositional and emotional effects of color cannot be quantified by rational measurement.[4] The concepts of color, which evolved during the Renaissance and Middle Ages and culminated in the publication of Goethe's *Theory of Color,* have provided guidance to the future development and understanding of the principles of light and color. The Swiss painter Johannes Itten once wrote, "Whoever would become a master of color must see, feel, and experience each individual color and the endless number of their combination with all other colors. Colors are capable of spiritual-emotional expression."[2] The successful determination and transfer of color to an aesthetic reproduction of the natural dentition depends on the clinician's understanding of these concepts.[2]

In natural teeth, differing colors are distributed through the enamel and dentin; hence a "variation in hue, chroma, and value renders the tooth polychromatic."[2] This polychromatic effect is manifest in four dimensions: hue, chroma, value, and translucency; the relationships between these different dimensions and their role in the natural dentition must be properly interpreted in order to fabricate aesthetic restorations.[5] Hue, the "name of color," constitutes the first dimension of the polychromatic effect and corresponds to the wavelength of light reflected by the teeth.[6] As light passes through the natural tooth, it is reflected, refracted, absorbed, or transmitted by a multilayered complex tooth structure that varies according to the optical densities of the hydroxyapatite crystals, enamel rods, and dentin tubules.[3] The stimuli to the eye is determined by these reflected or refracted wavelengths, which are transformed in the cerebral cortex into perceptions of color or hue. The second dimension, chroma, can be defined as the intensity of a color or the degree of hue saturation. The chromatic dimension only compares colors of equal hue.[7] The "brightness" of color is represented by value, which comprises the third dimension of the polychromatic effect.[8] Value distinguishes light colors from dark. The final dimension — translucency — remains

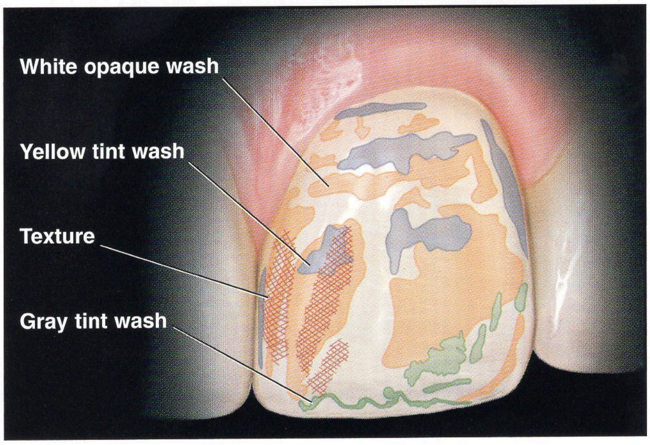

Figure 2. Diagram of preoperative color mapping.

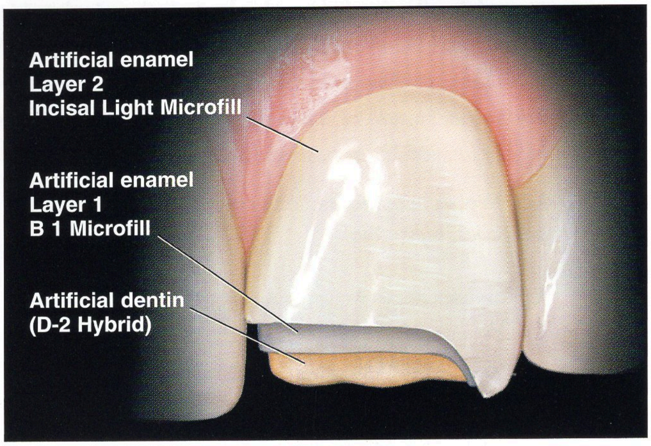

Figure 3. Illustration demonstrates the stratification technique that will be used to restore the tooth.

Figure 4. A cervical chamfer 0.3 mm in depth was placed supragingivally to follow the contour of the free gingival margin.

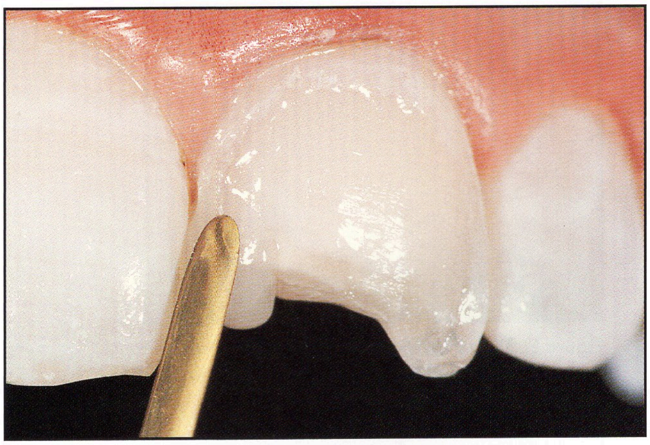

Figure 5. The artificial dentin body was applied and contoured with the appropriate shade of composite resin.

Figure 6. A second increment of hybrid composite resin was placed to form the dentin lobes.

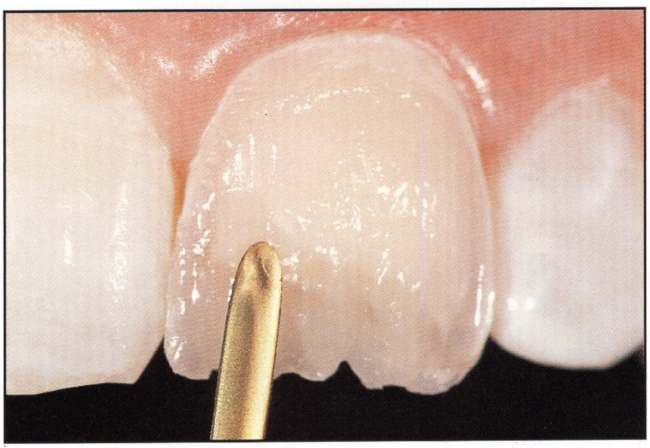

Figure 7. The first enamel layer of microfilled resin was applied to the incisal aspect and contoured.

one of the most difficult parameters to explain or quantify. The degree of translucency depends on the structure and the thickness of enamel and dentin. The translucency is determined by the amount of light that is able to penetrate the tooth or the restoration prior to being reflected.[9] Accordingly, the quality and quantity of the light reflected to a viewer's eyes is influenced by translucency.[9]

Composite Resins

In addition to light and color concepts, the re-creation of an aesthetically correct anatomic form requires a comprehensive understanding of composite resins and their properties. The interactions of the properties of different colors evident in the enamel and dentin, and the varied thicknesses distributed in dimensional orientation throughout the anatomic tooth structure, result in the polychromatic nuances of the natural dentition. The enamel layer — which has a white or gray appearance — remains thickest at the incisal edge of anterior teeth and thinnest at the cervical region. In adolescent dentition, the unabraded incisal edges of the anterior teeth often appear violet, blue, or gray, which denote the absence of the dentin substrate in these areas. The dentin contains varying distributions of yellow, orange, and red, and remains thickest at the gingival and middle thirds of the anterior teeth. Since composite resins are not available in all shades necessary to match natural dentin and enamel colors, the use of tints is required in the stratification process to adjust hue and chroma, to lower value, and to establish natural characteristics for a specific area of the tooth. The existing resins are generally translucent and are colored with either pigments or dyes to achieve the desired optical effect. In addition, the placement of tints over the dentin-colored composite and beneath the artificial enamel enhances the realistic distribution of color throughout the restoration. Complementary colors may be added to alter the chroma and lower the value as necessary. The addition of white, blue, or gray in the incisal region allows the color of the natural enamel to be created. Opaquers — designed to block the light with titanium dioxide and similar pigments — can either conceal underlying discolorations or duplicate areas that are difficult to match (eg, hypocalcification).

Due to the variety of colors and their orientation within natural teeth, the selection of appropriate composite shades remains difficult. Each composite — regardless of the manufacturer — is limited to the production of only one color. Since no single monochromatic composite resin can duplicate the complex orientation of the colors evident in the natural dentition, the ability to select a variety of appropriate composite resin shades must be acquired.[10] Arbitrary and subjective shade designations (eg, universal, yellow, or light) further complicate the process of shade selection. Since the majority of standard shade guides for composite resins correspond to unfilled methacrylates, they do not accurately represent the true shade, translucency, or opacity of the final polymerized restorative material.[9] In addition, several composite formulations are synchronized to porcelain shade guides rather than those designed for composite resins. Since virtually all shade guides must be further refined, the fabrication of custom shade tabs may be beneficial. During this process, a working knowledge of the optical properties of diffusion, refraction, reflection, and absorption of composite resins and the inherent differences from the natural dentition may be developed. For the clinician, this understanding is often of greater benefit than the memorization of procedures and formulas.

Preoperative Procedure

In fractures of adolescent teeth, the extent of trauma and pulpal injury must be assessed clinically and radiographically. If acute pathology is determined, all treatment plans must be altered to resolve the condition by any necessary action. The aesthetic restoration of a single anterior tooth is extremely difficult to perform using porcelain or composite resin (Figure 1). By using a previsualized mockup and knowledge of composite materials, the modifiers selected, and their shade and orientation (Figure 2), the definitive restoration can be visualized prior to completion. The transformation of this "vision" into an aesthetic creation that replicates natural variations constitutes the clinician's final challenge.[3] The following procedure — applied in the restoration of a fractured maxillary central incisor — demonstrates a stratification process that utilizes the previous accumulated data with appropriately selected composite resins (Figure 3).

Restorative Stage

To facilitate access to the cervical region of the tooth, the field was first isolated with a rubber dam using a modified technique. This process involved the creation of an elongated hole that allowed placement of the rubber dam over the retainers to achieve adequate field control.[11,12]

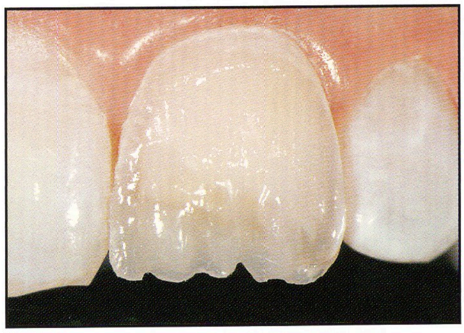

Figure 8. The microfilled resin was contoured with a long-bladed composite instrument and smoothed with a sable brush.

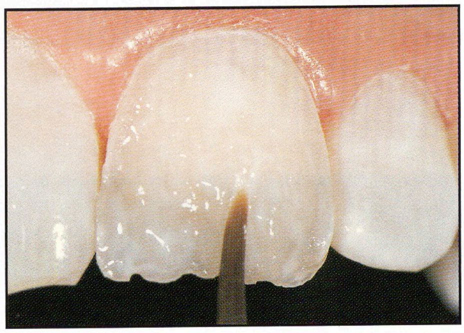

Figure 9. A white opaque modifier was applied as incremental wavelike grooves.

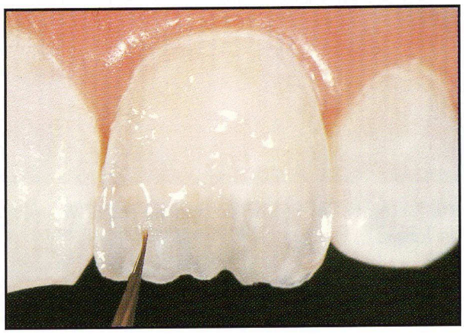

Figure 10. A gray tint was then thinned and applied vertically at the incisal edges between the projected dentin lobes.

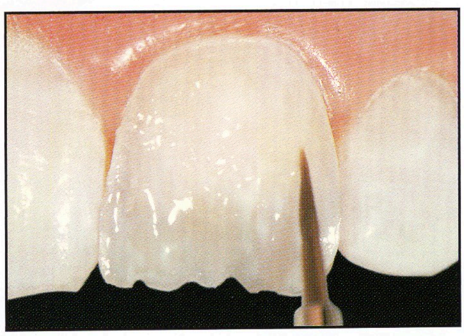

Figure 11. In order to replicate the natural color of the contralateral tooth, a thinned yellow tint was applied.

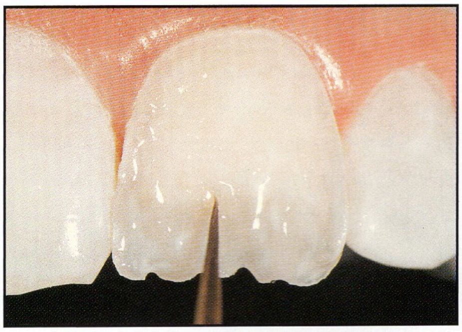

Figure 12. The yellow tint was thinned and applied in accordance to the reference established in the color map.

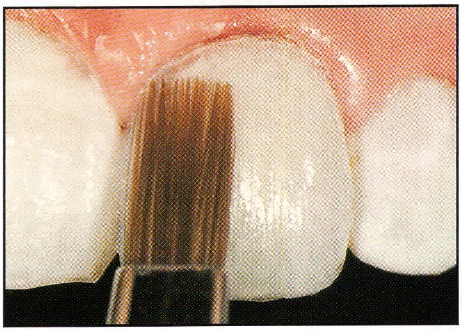

Figure 13. The final "artificial enamel" layer was sculpted, adapted, and smoothed with an artist's sable brush.

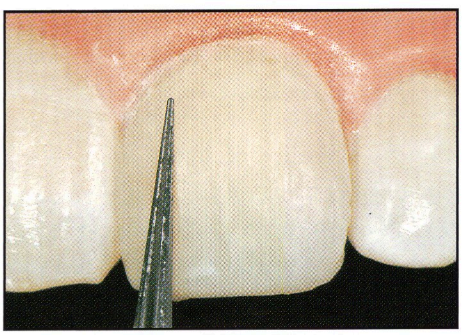

Figure 14. Facial contouring was performed with #8 and #16 fluted burs (ET-9, Brasseler USA, Savannah, GA).

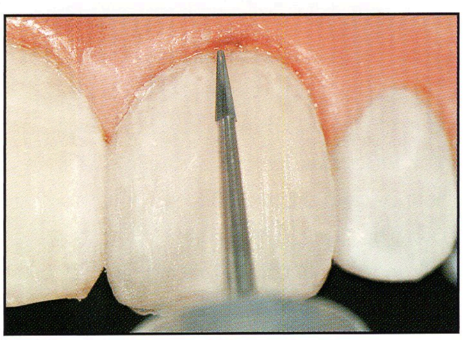

Figure 15. Gingival and interproximal contouring and finishing were completed with #8 and #16 fluted burs (ET-3, Brasseler USA, Savannah, GA).

Once the extent of the preparation was determined, a cervical chamfer 0.3 mm in depth was placed supragingivally with a long tapered diamond, following the free gingival margin. A scalloped bevel was developed in order to interrupt the straight line of the chamfer (Figure 4). The lingual aspect of the chamfer was extended 2 mm onto the lingual surface but not on the occlusal contact area.[13,14] The preparation was completed with finishing disks and polished with a rubber cup that contained a premixed slurry of pumice and 2% chlorhexidine (Concepsis, Ultradent Products, South Jordan, UT). The preparation was rinsed, lightly air-thinned, and isolated from the adjacent teeth with a soft metal strip placed interproximally. Due to its ability to minimize the potential of microleakage and enhance bond strength to dentin and enamel, the "total-etch" technique was utilized.[15-17] The preparation was etched for 15 seconds with 37.5% phosphoric acid gel, rinsed for 5 seconds, dried for 5 seconds, and lightly air thinned to avoid desiccation. Once the dentin and the enamel were remoistened with water on a cotton pellet, a hydrophilic adhesive agent (OptiBond Solo, Kerr/Sybron, Orange, CA) was applied. Any excess was removed with the applicator, and the agent was light cured for 20 seconds. Although a small quantity of excess adhesive could have been applied over the margin to improve sealing, this excess would have been removed during finishing procedures in order to avoid adverse periodontal sequellae.

The initial layer — the artificial dentin body — of dentin-shaded composite resin (XRV Herculite, Kerr/Sybron, Orange, CA) was applied and contoured with a long-bladed composite instrument (Figure 5) and smoothed with an artist's brush. Since surface irregularities could have interfered with placement of the tints for internal characterizations, this step was crucial. This process was repeated with a second increment of hybrid composite to form the dentin lobes (Figure 6). In order to prevent overbuilding of the artificial dentin layer, it was imperative to constantly monitor the composite material from the incisal aspect; such an overbuilding would not allow sufficient space for the final enamel layer of microfilled resin. Each increment was polymerized with a curing unit for 10 seconds, which allowed placement of subsequent increments without deforming the underlying composite layer. Dentin replacement materials were selected for strength and color, and the cores of these restorations were rendered with the hybrid and the

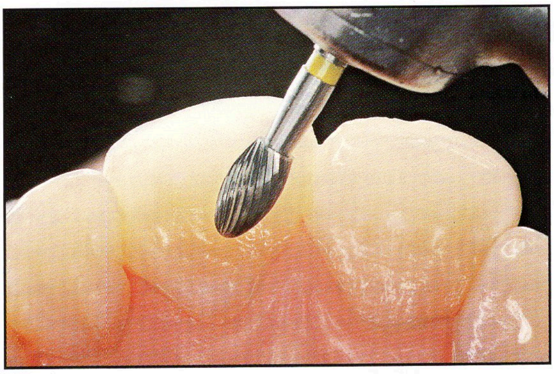

Figure 16. The contouring and finishing of the lingual aspects were accomplished using #8 and #16 fluted burs (OS1, Brasseler USA, Savannah, GA).

Figure 17. Postoperative retracted facial view of the restored central incisor reflected the harmonious integration of form and aesthetics.

microhybrid composites. Since these small-particle hybrids and microhybrids (eg, Enamel Plus HFO, Micerium, Avegno, Italy; Vitalescence, Ultradent Products, South Jordan, UT; Z100, 3M Dental, St. Paul, MN) have refractive properties and a variety of color selections that are similar to that of dentin, they imitate the natural tooth structure extremely well and often have sufficient resistance for use in stress-bearing anterior regions.

To establish more realistic depth of color, the "artificial enamel" was applied in two microfill layers that varied in thickness. The first enamel layer of B-1 shaded composite resin (Renamel, Cosmedent, Chicago, IL) was applied and contoured with a long-bladed composite instrument (Figures 7 and 8) and then smoothed with an artist's sable brush. Surface irregularities were carefully eliminated, and the increment was polymerized with a curing unit for 40 seconds. To re-create the natural surface appearance of young teeth, tints and modifiers (Creative Color, Cosmodent, Chicago, IL; Kolor+Plus/Opaker, Kerr/Sybron, Orange, CA) were applied at different regions of the tooth according to the schematic diagram. To reproduce the perikymata (ie, variations in structure and mineralization), a white opaque modifier was applied as incremental wavelike grooves (Figure 9). In order to replicate the translucent blue appearance of the incisal edge that is apparent in adolescent patients, a gray tint was thinned 30% with a clear liquid resin and applied in a very thin wash vertically at the incisal edges of the composite structures between the projected dentin lobes in accordance with the color mapping reference (Figure 10). A yellow tint was thinned 50% and applied in a very thin wash vertically between the lobes and at the mesial and distal line angles to mirror the image of the contralateral central incisor (Figures 11 and 12).

The final "artificial enamel" was restored with incisal light microfill composite resin (Renamel, Cosmedent, Chicago, IL) in a layer that displayed the underlying intricate distribution of color. The resin was rolled into a ball and placed on the cervical region of the tooth. Using short-bladed composite instruments, the composite material was sculpted, adapted, and then smoothed with an artist's brush to obtain an anatomically correct emergence profile that encased the underlying matrix cervicoincisally and mesiodistally (Figure 13). The microfilled resin was spread over the entire facial surface, and the final layer was slightly overcontoured to allow sufficient thickness for contouring and polishing.

Finishing and Polishing

In order to replicate natural form and texture, the initial contouring was performed with a series of finishing burs. The facial contouring was initiated with #8 and #16 fluted burs (ET-9, Brasseler USA, Savannah, GA) (Figure 14). The gingival and interproximal contouring and finishing were completed with #8 and #16 fluted burs (Figure 15). Contouring of the lingual surfaces was performed with #8 and #16 fluted burs as well (Figure 16).

Once preliminary contouring was completed, finishing strips (FlexiStrips, Cosmedent, Chicago, IL) were used to refine the interproximal regions; finishing on the proximal, facial, and incisal angles was performed with aluminum oxide disks and finishing strips. The polishing disks and strips were used sequentially according to the grit and ranged from coarse to extra fine. For characterization, finishing burs, diamonds, and rubber wheels and points were used to establish natural indentations, lobes, and ridges. The definitive result satisfied the aesthetic expectations of the patient and the clinician (Figure 17).

Conclusion

In the art and science of freehand bonding, the development of a universal tooth-colored direct restorative material remains an elusive objective. Nevertheless, considerable progress in adhesive technology and composite resin materials allows for the creation of aesthetic restorations that not only preserve, but also reinforce tooth structure. This case presentation demonstrates a methodical protocol for the incremental application of composite resins and modifiers to transform the complex Class IV fracture into a restoration with an aesthetic natural appearance. This learning process develops not only the clinician's chairside skills, but also the ability to communicate and interpret color to the laboratory technician and patient. Through an enhanced understanding of the three-dimensional concept of tooth morphology, color, and the optical properties of light as well as their relationship with the natural tooth structures, composite resin can be used to fabricate restorations that are virtually indistinguishable from the adjacent dentition.

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