The Role of Colors and Tints in Composite Restorations

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Abstract

Creating lifelike restorations that harmoniously complement existing dentition is every dentist's goal. To achieve this seamless emulation of nature, clinicians not only must have a solid understanding of the current generation of materials and techniques, but also must possess a comprehensive knowledge to better understand the teeth from a biologic perspective. Considering the major role composite restorations play in clinicians' daily practice, mastering this technique is vital. However, simply using the resin is not enough—it also is essential to characterize the restoration through the artful application of additional colors or tints. This article illustrates how the skillful, subtle, and judicious incorporation of colors/tints and related effect materials to composite restorations can aid in creating restorations that successfully mimic nature to produce realistic and esthetically pleasing results that meet patients' needs and desires.

Key Words: colors, tints, effects, fluorescence, opalescence, opaquers, composite, optical properties, polychromatic

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Introduction

Composite is one of the most versatile restorative materials, affording clinicians a wealth of artistic chairside possibilities and creative control during the restorative process. Through its bonding process, it also offers an ultra-conservative method of tooth preparation.[1] Ever since Dr. Rafael Bowen's revolutionary research in the development of resin composites,[2] dentists have striven to use composite restorations to recreate nature—in physical appearance as well as biological properties—to achieve results that meet patients' esthetic and emotional needs and desires.

Creating a three-dimensional composite restoration with realistic depth of color requires an understanding of the optical properties of the tooth structure and its anatomy, as well as mastery of layering techniques. Artful layering includes not only using the correct shade of composite, but also judicious use of tints and opaquers to create the illusion of different translucencies and opacities visible in the natural tooth structure.[1]

Discussion of how to best recreate these visual effects most often revolves around selecting the correct shade to match the adjacent tooth. However, as essential as shade matching is, replicating the anatomy and optical effects is equally important, requiring paying close attention to incisal effects and light reflections.

Optical Properties of the Tooth

Internal and External Tooth Structure

Before starting the restorative process, clinicians must fully understand the optical properties of the particular tooth needing restoration. A tooth's color is determined by the combined effects of internal (i.e., pulp, dentinal tubules, and hydroxyapatite crystals) and external tooth structure (i.e., size, shape, and surface texture).[3,4] Intrinsic tooth color is associated with the light scattering and absorption properties of enamel and dentin.[5] Research by Dozic and colleagues indicated that the combined effect of all internal tooth structures causes light to be reflected at the surface and absorbed within the tooth structure, thereby making a tooth's color visible.[6] As demonstrated in the cross section of tooth shown in **Figure 1**, the incisal edge, which is primarily enamel, is responsible for the opalescent effect. The middle and cervical third of enamel are less intensely shaded and more translucent than the dentin, thereby allowing the dentin to shine through. The dentin, more opaque and intensely shaded than enamel, is responsible for the tooth's basic shade. Correctly determining and recreating the proper opacity level significantly increases the likelihood of the final restoration's esthetic success.

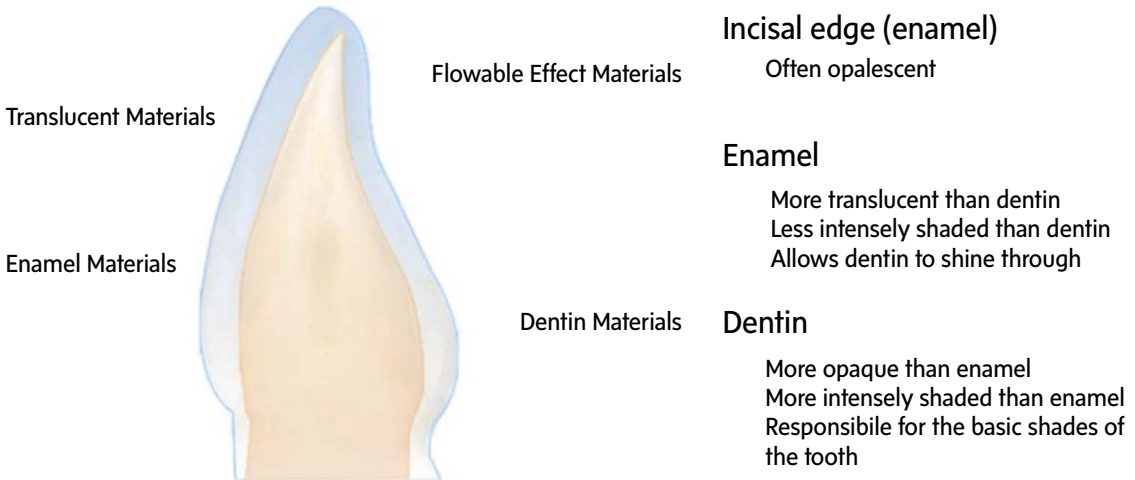

Figure 1: Drawing detailing a tooth's optical properties.

Fluorescence and Opalescence

Fluorescence and opalescence are also crucial components that must be considered for natural-looking restorations. *Fluorescence* is the absorption of light by a material and the spontaneous emission of light in a longer wavelength.[7] *Opalescence* is the property that makes the tooth appear bluish in incident light and orangish-brown in transmitted light.[8] Dentin exhibits more intense fluorescence than enamel because the former has a greater amount of ultraviolet (UV) photosensitive organic pigment than the latter.[8] When selecting a composite, clinicians must carefully consider the tooth structure's natural fluorescence and opalescence so they can best simulate these in the final restoration. There are several effect composites available on the market that can help to recreate the opalescent effect. Clinicians also must be guided by the specific characteristics demonstrated by the different teeth themselves. For instance, a blue shade in the central incisors might appear stronger, whereas in the lateral incisors, it might appear softer or subtler. The canines, on the other hand, will demonstrate higher chroma and stronger color when compared to the laterals and the centrals.[9] All of these differences are caused by various thicknesses and opacities of enamel and dentin.[10]

Figure 2: Various colors for composite restorations.

Indications for Colors/Tints

Highly esthetic tooth-colored restorations were introduced to dentistry in 1940 with acrylic resins and silicate cements.[11] The development and introduction of direct composite restorations in the 1960s gave dentists even greater creative freedom to conceive and execute esthetic restorations.[12] Thanks to advances in composites, clinicians now have myriad shades, tints, and opaquers at their artistic disposal. However, these advances have also brought a new challenge: being able to masterfully manipulate these colors and tints to maximum effect.

Polychromatic Approach

To emulate the complex beauty of natural teeth under various light sources, clinicians must master a polychromatic approach to create subtle, nuanced, and three-dimensional effects. To do so, they need to understand how its background influences a composite color. When light falls on a natural tooth, four associated phenomena can be described:

- transmission of light through the tooth
- specular reflection from a tooth's outer surface
- diffuse reflection of light from the buccal surface
- absorption and scattering of light in the dental tissue.[13]

Features such as surface texture, enamel thickness, dominant dentinal color, and light source may further complicate the visual perception of the various nuances of the entire tooth.[14]

A tint's primary indication is to match natural tooth structure's polychromicity and maverick colors[15] **(Fig 2)**. Initially, tints were introduced to characterize ceramic restorations. Later, tints were also developed to incorporate characterizations into direct and laboratory-fabricated composite resin restorations. A tint's effect on color is mainly to lower the value. It can be used individually or can be mixed to tone down the intensity and to create a unique, desired shade. Tints, strong and intense colors, should be used judiciously; they tend to disappear during layering and reappear during polishing.[16]

Producing the opposite of a transparency effect, opaquers determine the degree to which light is prevented from passing through the color. Opaquers' primary indication is to block out any size, shape, and unwanted degree of darkness within a tooth.[15] Opaquers should be applied in a thin layer.

The Chemistry of Colors

Composite tints can be applied for direct and indirect composite restorations. Tints for direct composite resin restorations are mostly composed of the following:

- monomer matrix of bis-GMA (bisphenol A-glycidyl methacrylate), urethane dimethacrylate, and triethylene glycol dimethacrylate
- filler consisting of highly dispersed silanized silicon dioxide
- additional components such as stabilizers, initiators, and pigments.

Tints for indirect composite restorations are composed of the following:

- color paste (multifunctional monomer, methacrylate monomer, silica powder, pigment, photo initiator, and others)
- clear liquid (multifunctional monomer, methacrylate monomer, photo initiator, and others).

Light-curing composite tints differ in composition from tints used for characterization in laboratory-fabricated porcelain restorations. Tints for porcelain restorations are composed of alkali aluminosilicate glass, which requires subsequent glazing.

Table 1. Colors and Their Effects

White	• imitate enamel stains • simulate halo effects • accentuate cusps and ridges • accent presence of dentin lobes • increase the value • simulate craze lines and enamel hypocalcification • mask yellow stains
Honey-yellow **Ochre** **Orange**	• raise chroma of the cervical third of the restoration • emphasize the dentin core • highlight fissures • imitate individual enamel characteristics
Blue **Violet** **Gray**	• simulate translucent enamel areas • imitate opalescent areas • reduce the value (brightness)
Red **Pink**	• simulate gingival tones • enhance vitality • neutralize blue tetracycline stains
Yellow **Yellow-brown**	• create illusion of narrowness (along proximal surfaces) • used in cervical third of the tooth
Brown	• imitate discolored fissures, pits, and enamel cracks • mimic craze lines in enamel
Opaquers	• mask dark tooth during placement of direct veneers • neutralize (or elevate) the low value of selected area of the tooth • mask tooth-restorative interface • raise the value

Effects of Placement and Light Source on Colors/Tints

Clinical application of tints will vary depending on the color of the natural dentition they are meant to mirror. This makes it especially critical to know each tint's final outcome before use **(Table 1)**.[15,16] Extensive study of color distribution along the tooth surface has concluded that teeth are polychromatic.[17-19] In the 1990s, opalescence was incorporated into the fabrication of dental porcelains to mimic natural teeth's "opal effect."[20] The "opal effect" is a light-scattering phenomenon in translucent materials that produces a blue effect in reflected light and orange-brown in transmitted light. This light-scattering effect is due primarily to the particle size and crystalline orientation of enamel prism.[21] While this iridescent phenomenon may occur across the entire labial surface, it is more evident in the incisal third, where there is no dentinal interference.[22]

Opalescence creates a natural halo by reflection of white, natural, and bluish hue light. Opalescent materials are placed in the spaces between the dentinal lobes incisally, and if required, are extended into mesial and distal proximal spaces.[23-25] In posterior teeth, these characteristics are exemplified on cusp tips and marginal ridges.[26] The more translucent a tooth, the more opal effect it displays; the more opaque a tooth, the less opalescence it exhibits.[27] Numerous opal effect materials are available. As shown in this example of a light-curing flowable nanohybrid composite (IPS Empress Direct Effect, Trans Opal, Ivoclar Vivadent; Schaan, Liechtenstein), opal effect materials will produce unique opal effects when viewed under different light sources **(Figs 3-5)**.

Figure 3: Opal effect material exhibiting bluish appearance under reflected light.

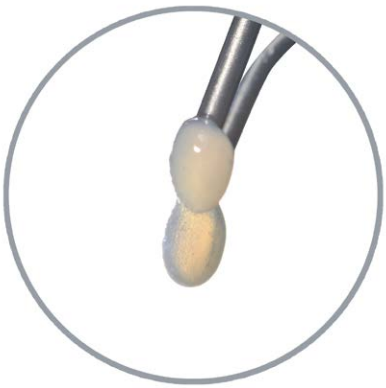

Figure 4: Opal effect material showing orangish appearance under transmitted light.

Figure 5: Bluish and orangish appearance seen simultaneously under different light sources.

Figure 6: Tooth restored without using any colors.

Figure 7: Effect achieved using blue color.

Figure 8: Effect achieved using violet color.

Figure 9: Effect achieved using a mix of blue and violet color.

Figure 10: Opalescent effect achieved using Trans Opal.

Clinical Application

Determining Optical Effects

A lingual shelf with translucent composite of 0.37 mm is considered an ideal average thinness to produce a desirable optical effect of natural enamel with tints.[28] The subtle and judicious use of different colors and effect materials—as opposed to using no color—can greatly enhance a restoration's optical effects **(Figs 6-10)**. Therefore, just as they utilize a shade guide for shade matching, clinicians should employ an incisal optical effects guide to closely mix and match the different colors/tints to achieve the specific desired effects.

Applying the Colors/Tints

After determining the customized optical effects, the next step—before placing the enamel and translucent shades—is to subtly apply the colors/tints. Once the dentinal lobes are completed, polymerization is done. Finally, the enamel composite is used to restore the outermost layer. It is important to note that as the enamel layer is applied, its restoration thickness will initially mask the visibility of the colors/tints; they will reappear after finishing and polishing when the incisal effects are well established. When surface craze line effects, grooves, or depression areas need to be created, they must be done on this enamel layer.[15]

Creating Surface Grooves or Impressions

Surface grooves or depressions can be created using various techniques, such as the following:

- Scar and paint: Scar or scribe the tooth with a thin metal disc or diamond bur, then apply the desired color.
- Matrix: After placing the second-outermost layer and before curing, place a thin strong polyester film or metal matrix (preferably not straight) into the composite and light cure. Remove the matrix, paint the desired colored tint in the grooved area, and clean the excess. Then light cure.
- Vertical wall for depth: While placing the second-outermost layer, create a wall in the composite. Paint the desired colored tint on the walled area and clean the excess. Then light cure.
- Anneal material over the tint: While placing the most outer enamel or dentin layer, create a notch or groove (preferably not straight) in the composite. Paint the desired colored tint in the notched or grooved area and anneal the composite toward and within itself, preferably in a non-straight pattern. Then light cure.[15]

Figure 11: Tint is applied directly from the syringe through the cannula.

Figure 12: Color application using a probe.

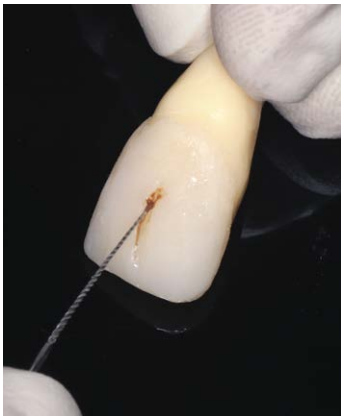

Figure 13: Color application using an endodontic file.

Figure 14: Color application using a thin brush.

Carrying the Tint

To avoid over application, which may make it difficult to remove excess material, carry the tint on the restoration with precision. Apply tints directly from the syringe using delicate manufacturer-supplied cannula sizes (e.g., 0.9 mm or 0.4 mm) **(Fig 11)**. Additionally, many manufacturers supply the colors in bottles. In these cases, and in situations requiring the mixing of colors, it is better to dispense the color in a plastic well and then carry it with a suitable instrument such as a sharp thin probe, an endodontic file, or a thin brush **(Figs 12-14)**.[22] While the application mode is entirely the clinician's choice, the authors recommend using an endodontic file, which provides the best control. Any excess flowable tints can be removed using superfine and ultra-fine micro applicator tips.

Judicious Use of Colors

Creating/Accentuating Effects

Keeping the final outcome in mind, clinicians must predetermine which tints will be needed to replicate the natural incisal translucency. A wide variety of translucent composites are available on the market. However, sometimes it might be necessary to also use tints, such as blue and violet, to achieve the desired results. To attain incisal translucency, the authors recommend using either blue (IPS Empress Direct Color, Blue) **(Figs 15-18)** or a mixture of blue and violet; using only a violet tint is not recommended. Many clinicians also use the opal effect material described earlier to achieve desired incisal translucencies. For example, IPS Empress Direct Effect, Trans Opal was used in the Class IV fracture case shown in **Figures 19 through 22**.

Brown tint is often recommended for creating craze lines and to mimic stained fissures and grooves. In this case, a groove was created on the final enamel layer and polymerized **(Fig 23)**. Later the brown color was applied in the groove and polymerized (brown tint needs to be used judiciously because a thicker layer will not completely polymerize); the groove was filled with a layer of enamel composite before the restoration was finished and polished **(Fig 24)**.

White is recommended for restoration cases where white spots and hypocalcifications need to be recreated. Gray can be used to recreate isolated areas of translucency. The case shown here has an isolated area of translucency in the distal end along with a white spot **(Fig 25)**. In this case, depressions were created in the final enamel layer and IPS Empress Direct Color, Gray was used to create the translucency effect while IPS Empress Direct Color, White was used to create the white spot effect. After final enamel layer placement, the restoration was finished and polished. Again, note that the color/tint is never applied on the restoration's outer surface; instead, for best postoperative results, it should always be covered with a layer of composite to prevent the colors from disappearing during the finishing and polishing procedures **(Fig 26)**.

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Figure 15: Preoperative retracted frontal view.

Figure 16: Preoperative frontal view (1:1).

Figure 17: Postoperative retracted frontal view.

Figure 18: Postoperative frontal view (1:1).

Figure 19: Preoperative retracted frontal view showing Class IV fracture.

Figure 20: Preoperative frontal close-up view (1:1) of Class IV fracture.

Figure 21: Postoperative retracted view after restoring with opal effect material.

Figure 22: Postoperative frontal close-up view (1:1) of final restoration demonstrating desired incisal translucency.

Tips for Clinicians

Beginner

To ensure desired incisal effects, apply tints between the dentinal lobes with a light and subtle touch.

Intermediate

Don't start the restorative process without first fully understanding the optical properties of the particular tooth needing restoration, and the effect each color/tint you plan to use will have on that tooth.

Advanced

To achieve seamless incorporation, pay careful attention to how the human tooth's optical properties are displayed, particularly in correlation with respective restorative and effect materials.

Figure 23: Groove created in the final layer.

Figure 24: Crazed line formed by use of brown color.

Figure 25: Preoperative view showing isolated area of translucency and a white spot.

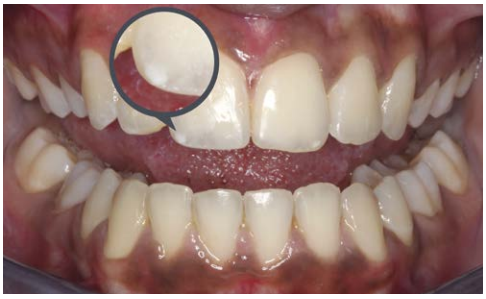

Figure 26: Postoperative view showing the recreation of translucency and white spot.

Masking Discoloration

Just as certain colors can be used to create and/or accentuate effects, other colors—or opaquers—can be utilized to mask discoloration. Opaquers are highly intense and should be reserved for isolated areas. Other alternatives (e.g., bleaching and ceramic restorations) have to be considered since using opaquers on the entire tooth will likely result in an esthetically unappealing, overly opaque final restoration.[29]

Opaquers increase the value, thereby reducing the tooth's chroma.[15] To best evaluate the change in value, black and white digital photographs are taken during the application of opaquer until the correct value is obtained.[30] The authors recommend using opaquers only for masking metal surfaces, intraoral repair of metal ceramic restorations, or to mask metal posts. Alternatively, the authors recommend using white, then toning it down using other colors, such as yellow or honey. It is always preferable to mask discolorations with white rather than an opaquer **(Fig 27)**.

Discoloration, which may be congenital or due to arrested caries decay, can range from yellowish-brown to blackish-brown.[31] Yellowish discolorations **(Fig 28)** are best masked by using a layer of yellow or honey color, such as IPS Empress Direct Color, Honey **(Fig 29)**. Typical of the decay process of arrested cavities, blackish-brown discolorations **(Fig 30)** are more acid-resistant than normal dentin, so it is wiser to preserve, rather than remove, them. The best way to mask such discoloration is to apply white **(Fig 31)** then tone it down with honey **(Fig 32)** for a well-managed blend of multiple colors **(Fig 33)**. To ensure the desired incisal effects, clinicians can use a guide such as the one shown in **Figure 34**.

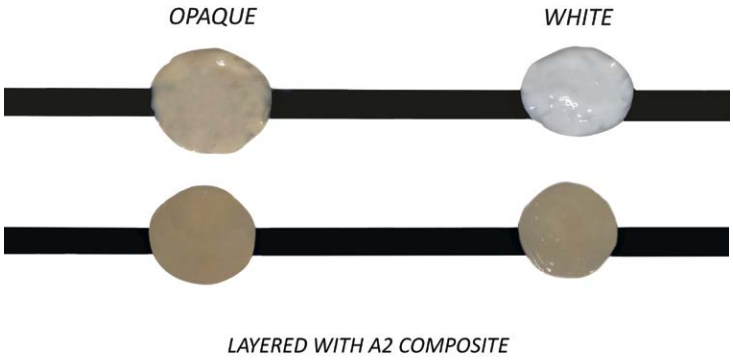

Figure 27: Comparison view of opaque and white color.

Figure 28: View of teeth #24 and #25 showing yellowish discoloration.

Figure 29: Discoloration managed with the use of honey color.

Figure 30: Blackish-brown discoloration of arrested caries.

Figure 31: Discoloration masked with white color.

Figure 32: White color toned down with the application of honey color on top.

Figure 33: Discoloration managed by the use of multiple colors.

Figure 34: Incisal effects guide.

Summary

The likelihood of achieving predictable and consistent esthetic results increases exponentially when the dentist understands the optics of natural dentition and their correlation with the optical and physical properties of the restorative materials. While admittedly more technique-sensitive and time consuming, a polychromatic technique can produce lifelike restorations. Superior natural-looking restorations are possible through prudent use of tints and effect materials in tooth-specific situations such as the ones discussed here. It also is clear that a natural-appearing composite restoration is the result of many factors; skillful layering of the dentin, enamel, and translucent composites along with detailed characterization and the clinician's artistry and imagination all work together to create results that rival nature and satisfy patients' cosmetic concerns and emotional needs.

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