Color Matching With Composite Resin: A Synchronized Shade Comparison

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While traditional shade guides have been developed to facilitate shade selection for various restorative procedures, these tools are often fabricated according to the properties of porcelain materials rather than composite resin options. Contemporary composite resin restorations are often fabricated using incorrect guides that can compromise the final result. This article describes a predictable procedure for shade determination, shade mapping, and custom shade tab fabrication for predictable restoration using direct composite resin materials.

Learning Objectives:

This article illustrates the role of shade determination, shade mapping, and use of composite resin for direct aesthetic restoration in the anterior region. Upon reading this article, the reader should:

- Understand the clinical protocol associated with restoration of the interproximal and incisal edge regions.
- Recognize the effect of proper shade selection on development of a natural-looking result.

Key Words: shade, aesthetics, composites, mapping, direct

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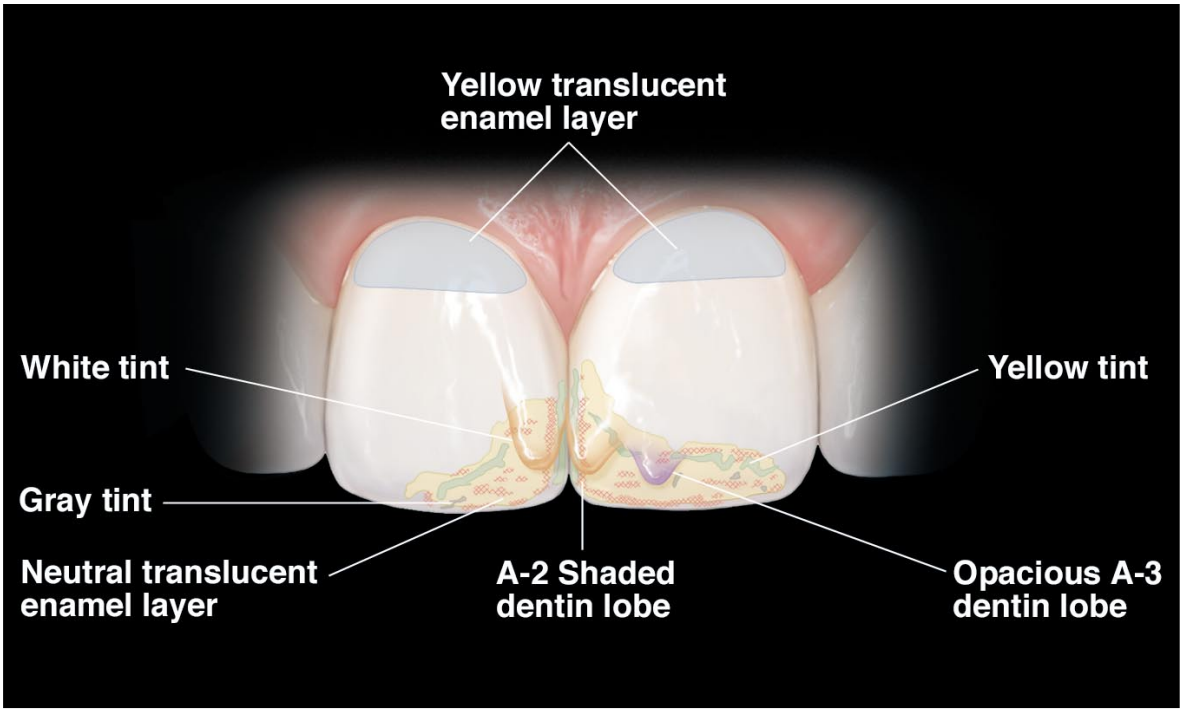

Figure 1. A color map can be used to diagram and record the selected composite shades and necessary modifiers to mimic the natural anatomical morphology of the tooth.

Since the inception of porcelain as a restorative material over two hundred years ago, the ongoing search for proper restorative shades has proven challenging in restorative dentistry.[1] The use of dental shade guides to identify and communicate color of all dental restorative materials originated with porcelain shade guides aimed at representing the available shades of porcelain teeth. E. B. Clarke's treatise in 1931 on "The Color Problems in Dentistry" and his efforts to define and reproduce natural tooth color with a system of porcelain formulas alluded to the complexities and frustrations encountered in the reproduction of consistent tooth color.[2,3] The subsequent challenges in dental color matching indicated the lack of development in color science within dentistry and the complexity of tooth color measurement.[1]

In the last decade, innovations in restorative materials, bonding systems, function-based treatments, conservative preparation design, and adhesive placement techniques have increased the restorative opportunities available for discriminating patients. While these options have provided solutions to many of the aesthetic challenges faced by clinicians, complications associated with aesthetic color matching have remained. To simplify shade matching, manufacturers have continued to develop restorative materials matched to traditional ceramic shade guides.[4-6] This effort has resulted in inconsistencies due to: the range of shades that do not mimic natural tooth colors;[3,7-9] the limited selection of colors available in traditional shade guides as compared to the hues found in natural teeth;[1,9,10] a lack of shade tabs fabricated using the exact restorative material;[3] and an incorrect match between the samples and restorative material.[3] Non-uniform colors,[11] shade guides that do not match other shade guides, and inadequate control of different shade batches from the same manufacturer further affect the clinician's ability to develop an aesthetic result.[3,11]

The colors of many composite resins are synchronized to porcelain shade guides. Since the standard shade guides for composite resins are manufactured with unfilled methacrylates, they do not accurately represent the true shade, translucency, or opacity of the final

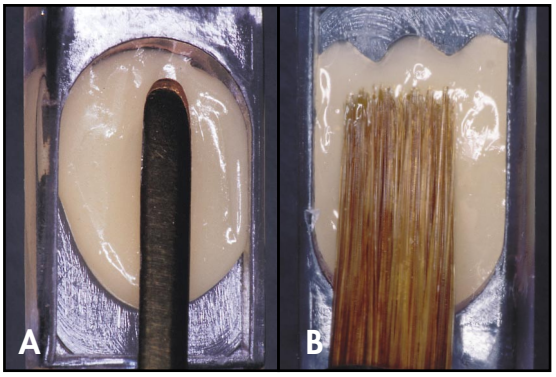

Figure 2A. An "artificial dentin layer" of A3.5 opacious composite resin was placed to create the base of the customized shade tab. 2B. The composite was thinned to 0.3 mm, formed into dentin lobes, smoothed, and light cured.

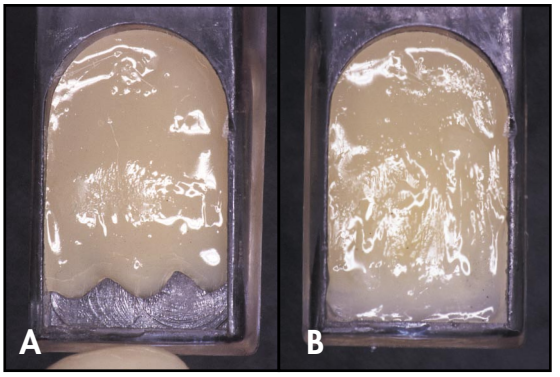

Figure 3A. A second dentin layer of an opacious A-2 shaded hybrid composite was selected. 3B. The incisal edge was then layered to form an underlying scaffold, smoothed with a sable brush, and light cured.

polymerized restorative material.[12] This requires clinicians to translate the final polymerized results to these shade guides for proper color comparison. Arbitrary and subjective shade designations (eg, universal, yellow, light) further complicate precise shade selection.

Additional factors that can cause inconsistent shade determination include the surrounding environment,[13-14] physiological and psychological responses to radiant energy stimulation,[15] metamerism,[16] and the viewing angle of observation. The size of the field of view, mood, drugs and medications, age, previous eye exposure/fatigue,[17] and/or gender may also affect shade selection.[18]

Stratified Shade Development

Aesthetic shade development requires an understanding of the stratification process, knowledge of color, and an understanding of the anatomical morphology of the tooth. In a clinical crown, there is a three-dimensional variation in the structure of the dentin and the enamel layers. In natural teeth, different colors are distributed through the enamel and dentin; hence, a variation in hue, chroma, value, and translucency render the tooth polychromatic.[19] The dentin imparts all the colors of a tooth (ie, hue and chroma),[20] while the enamel functions as a fiberoptic structure that conducts light through its rods to capture the underlying color of the dentin (value).[21] Since no single monochromatic composite resin can duplicate the complex orientation of the color evident in the natural dentition, it is necessary to select various colors for the artificial enamel and artificial dentin layers.[22]

In order to reconstruct the natural polychromatic effect, resin cannot be stratified in uniform layers of equal dimension, but rather in a deliberate, irregular variety of colors. This allows the restoration to reflect, refract, absorb, and transmit light according to the optical densities of the hydroxyapatite crystals, enamel rods, dentinal tubules, and the restorative material, thus rendering the tooth multicolored.

Fabrication of the Restorative Formula

Consideration of the surrounding environment is crucial for optimal color matching of composite restorations. Composite resin, enamel, and dentin cause considerable light scattering, which produces internal diffusion of incident light and allows the composite restoration to blend with the tooth appearance. This "chameleon effect" occurs as diffused light enters from the surrounding tooth and, when emitted from the restoration, will alter its color by absorbing color from the tooth. This color alteration depends on the scattering and absorption coefficients, which can produce an undetectable color match by blending with tooth color.[23] The objective is to create a restorative formula with minimal effort that can be used to facilitate the process of shade matching.

Custom-Fabricated Composite Shade Guide

The use of a custom-fabricated, layered shade guide of polymerized resin and a corresponding composite system may assist the clinician in replicating natural tooth color. These customized shade guides are synchronized with the same polymerized restorative material as the composite system that is being matched, which allows the clinician to compare the actual polymerized composite to the natural tooth color for a more accurate aesthetic color match. The restorative material can be applied to approximately 1.5 mm to 1 mm in depth, which further allows the clinician to compare the potential appearance of the composite to the natural tooth structures.

Considering the need for further refinement in almost all shade guides and the importance of synchronized shade comparison, the fabrication of customized composite shade tabs may be particularly beneficial. Custom shade guides may provide a full range of natural colors, and the variability between tabs can be significantly minimized. Since the actual polymerized restorative material is used to fabricate the shade tab and the definitive prosthesis, any technique sensitivity affecting the parameters of color can be incorporated into the shade guide for a more predictable result. Custom shade tabs can be fabricated to conform to specific space limitations for opacious dentin and enamel layers, characterizations may be placed at any depth in the restoration, and a more accurate representation and design of the anatomical surface morphology (eg, macro- and micromorphological characteristics) can be incorporated to provide increased accuracy. These devices will allow efficient color verification, ease of correction (increasing or decreasing hue, chroma, and value), communication for laboratory-processed composites, and can even compensate for adjustment to "lot" variations of composite resin materials.[24-26] Since traditional shade guides are not fabricated from the actual restorative material, the following procedure will provide the clinician or the technician with a method to construct a custom shade guide from the actual restorative material.[27]

This two-part article will provide the clinician with the procedure for shade determination, shade mapping,

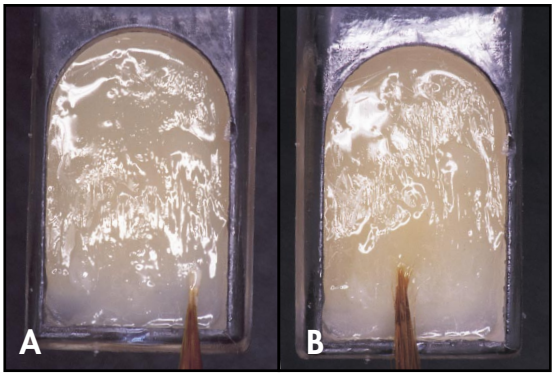

Figure 4A. A diluted white tint was applied vertically between the projected dentin lobes to accent their presence. 4B. A diluted yellow tint was applied corresponding to the shade mapping diagram.

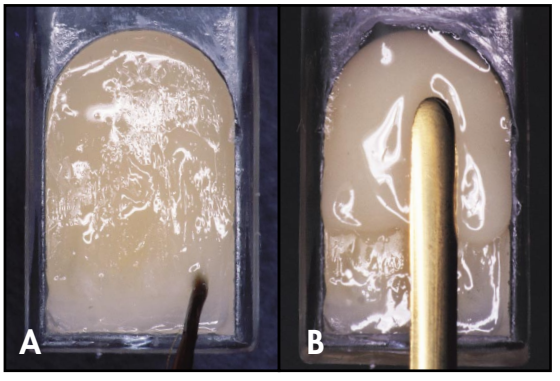

Figure 5A. A diluted gray tint was applied between the dentin lobes to create an illusion of translucency. 5B. A T-3 shaded hybrid was placed to establish part of the enamel layer at the gingival portion of the shade tab.

Figure 6. A T-2 shaded hybrid composite resin was placed at the incisal portion of the shade tab and smoothed to complete the enamel layer.

Figure 7. Surface morphology of natural teeth influences the surface gloss and color perception.

Figure 8. A diffuse reflection is produced by the macromorphologically roughened or coarse surface, and a specular reflection is obtained from a smooth surface.

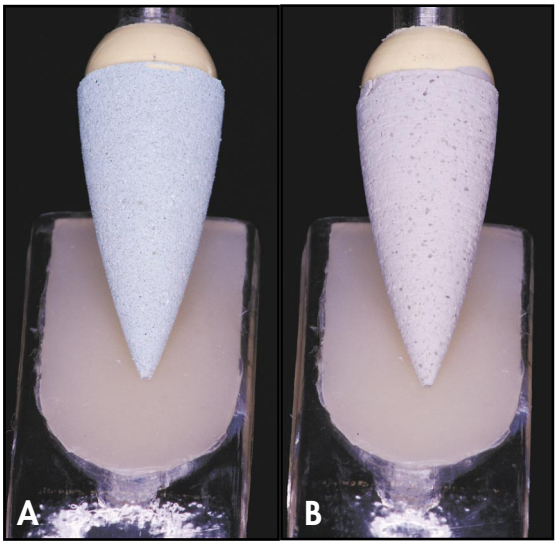

Figure 9A. Finishing and polishing the surface was initiated. 9B. Aluminum oxide discs and silicone polishing points were incorporated to add surface luster.

and the custom fabrication of a specific restorative recipe for the direct reconstruction of the interproximal zone and incisal edge of the maxillary right and left central incisors with a small-particle hybrid composite resin (eg, Venus, Heraeus Kulzer, Armonk, NY; Esthet-X, Dentsply Caulk, Milford, DE; Point 4, Kerr/Sybron, Orange, CA).

Clinical Procedure

Shade comparison should be performed prior to rubber dam application to prevent improper color matching that may occur due to subsequent tooth dehydration, which elevates values. The shade matching process is initiated with color comparison of the individual composite shade tabs from the customized shade system. The composite tabs are moistened with the patient's saliva, and shade comparison is performed to the dentin base and translucent enamel shades of the patient's dentin and enamel. Each shade tab is hand-layered with an opaque dentin stratum and encased with a superficial layer of enamel corresponding to the specific shade. The use of a color-corrected daylight source (5500°K) is necessary for proper color registration.[28]

A color map can be used to diagram and record these selected composite and modifier shades with their appropriate orientation and mapping of the anatomical morphology of the tooth to be prepared. A definitive restoration can then be visualized prior to initiation of treatment (Figure 1). Since composite resin materials are placed in direct contact with translucent dental tissues, a visual comparison can be developed with a composite mock-up from the color mapping diagram. Using a clear plastic shade tab, an "artificial dentin layer" of composite resin (eg, Venus, Heraeus Kulzer, Armonk, NY; Esthet-X, Dentsply Caulk, Milford, DE) can be placed with an interproximal instrument approximately 0.5 mm from the gingival region, thinned to 0.3 mm in thickness, formed into dentin lobes, and smoothed with an artist's sable brush to prevent surface irregularities that could have interfered with placement of internal characterizations. The increment should then be polymerized for 40 seconds with a curing light (Translux, Heraeus Kulzer, Armonk, NY; Apollo S, Lares Research, Chico, CA)

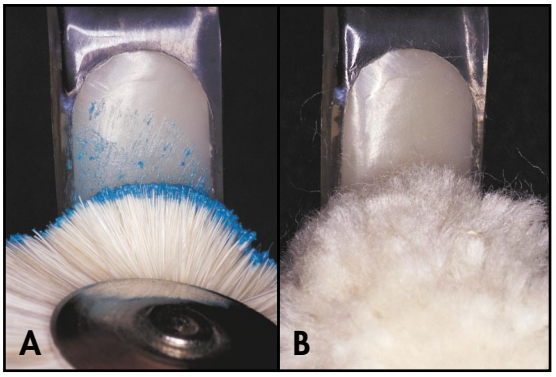

Figure 10A. A high surface reflectivity similar to the natural tooth can be achieved using traditional polishing methods. 10B. Polishing paste was applied using a goat-hair brush and a dry cotton buff at conventional speed.

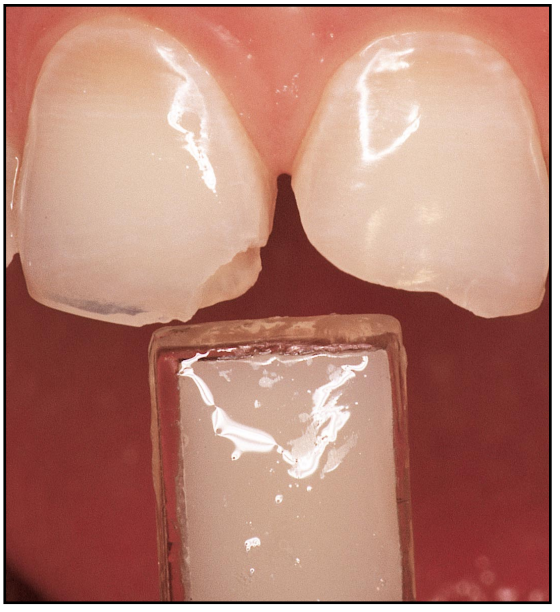

Figure 11. Development of a custom shade tab of the exact restorative material allows a more accurate and realistic representation of the natural tooth.

(Figure 2). A second dentin layer of composite resin can then be placed at the incisal edge to form an underlying scaffold before being smoothed with an artist's brush and light cured for 40 seconds (Figure 3).

The composite should be monitored from the incisal aspect of the tab to prevent overbuilding of the artificial dentin layer and ensure that adequate space is provided for the final artificial enamel layer. A diluted white tint should then be applied vertically between the projected dentin lobes to accent their presence (Figure 4A). A diluted yellow can be applied according to the shade mapping diagram and gray tint can then be applied between the dentin lobes to create a translucent region (Figures 4B and 5A). The incorporation of color variation emphasizes the subtle nuances in the incisal edge and provides a three-dimensional effect. To re-create the natural translucency of enamel, two different shaded composites can be used. A small increment of a yellow translucency-shaded hybrid composite resin can be added to provide a natural appearance at the gingival aspect (Figure 5B). A small increment of a neutral translucent resin can then be positioned using an interproximal instrument and covered with a Mylar strip to produce a smooth surface prior to curing (Figure 6).[29]

Developing Surface Characteristics

The surface morphology of natural teeth influences the surface gloss. A variety of surface contours and textures can affect light interaction. A macro- or micromorphologically roughened or coarse surface allows more diffuse reflection (Figure 7),[30] whereas a flat or smooth surface allows specular reflection (Figure 8). This optical scattering has an effect on the color perception and translucency of the tooth or restorative material.[31,32] Therefore, surface gloss should be considered when shade matching between restorative material and the surrounding tooth enamel.[33]

To mimic the natural surface luster, an initial polishing can be performed with aluminum oxide discs (eg, OptiDiscs, Kerr/Sybron, Orange, CA; FlexiDisc, Cosmedent, Chicago, IL; Sof-Lex, 3M ESPE, St. Paul, MN) and silicone polishing points (Diacomp, Brasseler USA, Savannah, GA; Astropol, Ivoclar Vivadent, Amherst, NY) (Figure 9). To impart a high luster or surface reflectivity on the tab, the final polishing can be accomplished with composite polishing paste and goat-hair brushes applied at conventional speed (Figure 10). Loose abrasive pastes impart an enamel-like appearance to the surface of the tab. A final polishing surface gloss can be achieved with a dry cotton buff (eg, Ceroshine, Brasseler USA, Savannah, GA) using an intermittent staccato

motion applied at conventional speed. Once the polishing procedure is completed, a final 2-minute post-curing improves the degree of conversion and ensures the hardest surface possible (Figure 11).[34]

Conclusion

This article has provided an overview of contemporary methods of color determination for aesthetic restorations. Aesthetic shade matching of restorative materials to natural teeth may require a combination of instrumental and visual methods for determining color and developing optimal aesthetic results. The introduction of customized composite shade guides reinforces the fact that dental manufacturers understand the importance of developing predictable methods and techniques for newly developed restorative materials. Use of such a shade system offers the clinician a more accurate and realistic representation of the natural tooth color combination. Custom fabrication of specific shade tabs stimulates the clinician and technician to consider integrating an anatomical thought process using imagination, form, and color to create natural aesthetics. Part II of this article, "Direct reconstruction of the interproximal zone and incisal edge of the maxillary central incisors," will demonstrate a stratification process for restoration using a small-particle hybrid composite resin to develop an optimal definitive result.

Acknowledgment

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Continuing Education (CE) Exercise No. 20

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 "Color matching with composite resin: A synchronized shade comparison," by Douglas A. Terry, DDS. This article is on Pages 515-521

1. Contemporary shade guides may result in inconsistent matching due to:
- a. The limited selection of colors available.
- b. The range of shades that do not mimic natural tooth colors.
- c. A lack of shade tabs fabricated using the exact restorative material and an incorrect match between the samples and restorative material.
- d. All of the above.

2. The colors of many composite resins are synchronized to:
- a. Natural tooth colors.
- b. Porcelain shade guides.
- c. Composite resin shade guides.
- d. The final polymerized restorative material.

3. All of the following factors can influence accurate shade determination EXCEPT:
- a. The patient's intraoral environment.
- b. Metamerism, and the viewing angle of observation.
- c. Physiological and psychological responses to radiant energy stimulation.
- d. The size of the field of view, mood, drugs and medications, age, previous eye exposure/fatigue, and/or gender.

4. Custom shade guides may:
- a. Minimize variability between tabs.
- b. Provide a full range of natural colors.
- c. Both a and b are correct.
- d. Neither a nor b are correct.

5. The creation of custom shade guides allows the practitioner to use the actual polymerized restorative material for the shade tab, which:
- a. Limits potential technique sensitivity that may affect the definitive color parameters.
- b. Allows the shade tabs to conform to specific space limitations for opacious dentin and enamel layers.
- c. Enables efficient color verification, ease of correction, simplified laboratory communication, and adjustment to "lot" variations.
- d. All of the above.

6. Which of the following characteristics may influence light interaction in restored dentition?
- a. The observer's age.
- b. Surface contours and textures.
- c. The patient's intraoral condition.
- d. The restorative material's composition.

7. According to the clinical presentation depicted herein, an artificial dentin layer of composite resin can be placed using an interproximal instrument approximately _____ from the gingival region. This increment should be thinned to _____ in thickness and formed into dentin lobes.
- a. 0.3 mm; 0.5 mm.
- b. 0.5 mm; 0.3 mm.
- c. 0.7 mm; 1 mm.
- d. 1 mm; 0.7 mm.

8. The composite should be monitored from the incisal aspect of the tab to prevent overbuilding of the artificial dentin layer and ensure that adequate space is provided for the final artificial enamel layer. A diluted white tint should then be applied, followed by diluted yellow and grey tints between the dentin lobes for the desired translucency.
- a. Both statements are true.
- b. Both statements are false.
- c. The first statement is true, the second statement is false.
- d. The first statement is false, the second statement is true.

9. Aesthetic shade development requires:
- a. Knowledge of color.
- b. An understanding of the stratification process.
- c. An understanding of the anatomical morphology of the tooth.
- d. All of the above.

10. A three-dimensional variation exists in the:
- a. Monochromatic restorative material.
- b. Translucent incisal shade.
- c. Structure of the dentin and enamel layers.
- d. None of the above.