



SHADE MATCHING AND COMMUNICATION IN CONJUNCTION WITH SEGMENTAL PORCELAIN BUILDUP

Sang K. Jun, CDT*

To the majority of patients, the aesthetic appearance of a restoration is often as important as its biological compatibility and function. While technological advancements have significantly improved the procedures and bio-materials utilized to fabricate ceramic restorations, the definitive result must address these increasing aesthetic expectations. A means of properly matching a crown restoration with the surrounding natural dentition is therefore critical. This article discusses shade communication between the members of the restorative team as well as ceramic layering techniques that can be utilized to achieve enhanced aesthetic results.

Key Words: shade, color, porcelain, buildup, dentin

One of the most challenging procedures in aesthetic dentistry is to accurately match the shade of a single anterior tooth. Despite the efforts of clinicians and dental technicians, patients can be dissatisfied with restorations that match neither the adjacent natural teeth nor their aesthetic expectations. Consequently, numerous factors (eg, lighting, environment, perception) must be considered during the taking of shades in order to ensure proper match.¹ In addition, the members of the restorative team must use identical standards of measurement and effectively communicate with one another when discussing

shade and color. Failure to address such concerns during the treatment risks the development of a mismatched restoration and unaesthetic results.² This article highlights a predictable method of performing shade and color communication that enables the restorative team to fabricate aesthetic ceramic restorations.

Lighting

Lighting conditions influence shade perception in numerous manners. Color is interpreted differently when viewed in varying levels of sunlight. Since color temperature varies daily, perception of color is also influenced by the time of day that shade is taken. Orange colors prevail in morning light, and blue light is dominant at midday.³ Consequently, "true color" is optimally determined when the sun is in its most northern location. While it is impossible to control natural light, it is imperative that operator and laboratory environments are as uniform as possible.

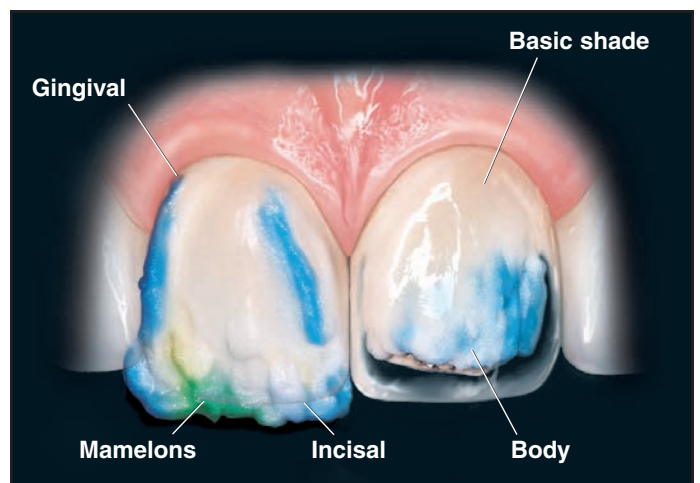


Figure 1. Diagram illustrates the color of the base shade, gingival, body, and incisal components, as well as mamelon characterizations.

*Laboratory technician, Bay Dental Laboratory, Monterey, California.

Sang K. Jun, CDT
Bay Dental Laboratory
484 Lighthouse Avenue, Ste. 201
Monterey, CA 93940

Tel: 831-375-7338
Fax: 831-375-7339



Figure 2. The PFM restoration on tooth #9(21) was virtually indistinguishable from the adjacent natural teeth. Note the heavy gingival stain on #8(11), which causes its monochromatic appearance.

Insufficient light is one of the primary causes of mismatched shades. Color is perceived when light reflected from an object strikes an observer's eye in different wavelengths³; if the operator or laboratory provides insufficient light, colors with small wavelengths (ie, violet, indigo, blue) cannot be accurately perceived. Sufficient lighting has been defined as approximately 5500 K,⁴ although this level is difficult to quantify. It has been suggested that the use of eight (1.2 m) color-corrected lights per operator (2.4 m × 3.1 m) provides adequate light for viewing the entire color spectrum.⁵ A color-viewing light selector (Kodak, Rochester, NY) has been developed to indicate when a room has been lit at 5500 K. The ability to discern colors with small wavelengths allows the clinician and the dental technician to develop an optimal shade match.

Environment

While natural light is often absent in operatories and laboratories, this provides an advantage in color matching, since the environment can be controlled artificially.⁶ In order to prevent the misinterpretation of shade, the color of the room walls must be regulated. Since neutral gray is a combination of all primary and secondary colors of the light spectrum (and has no contrasting complementary color),⁶ it forms the ideal environment in which to accurately evaluate shade.

The ideal laboratory consists of a separate, interior "shade room" that is painted neutral gray and is illuminated

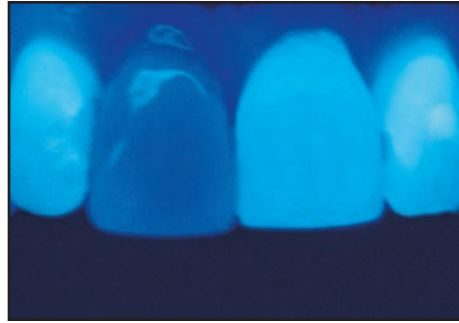


Figure 3. Viewed under fluorescent light, variation of fluorescence is evident between the different porcelain materials used to restore teeth #8(11) and #9(21).



Figure 4. Preoperative facial view of a 50-year-old patient with an unaesthetic appearance due to worn and fractured dentition.



Figure 5. Facial view demonstrates the uneven soft tissue between teeth #8(11) and #9(21).

by a sufficient number of color-corrected fluorescent bulbs. As the room itself must be "neutralized" to ensure accurate shade registration, so must the patient. The patient's clothing is covered with a gray bib; the patient should not be wearing lipstick. Once the proper environment has been established, the technical process of shade taking can be initiated.



Figure 6. Diagnostic waxup on the model. The restorations must be integrated with the uneven soft tissue margin and the existing natural teeth.



Figure 7. Facial view of the diagnostic waxup placed intraorally to allow comparison with natural teeth and evaluation of aesthetics.



Figure 8. Definitive porcelain (Creation, Jensen, North Haven, CT) crown restorations are fabricated and placed on the model.

Perception

When shade is evaluated, the clinician or technician often determines the hue of the patient's dentition and subsequently utilizes a shade tab to measure its intensity. Although this interpretation is often regarded as a proper match, the clinician's preconception is not always accurate. Since shade selection systems rarely provide a

precise match, the restorative team must determine an appropriate match independent of such guides. While the preconceived notion of shade is important in locating a suitable match, this process becomes complicated as the observer experiences ocular fatigue.

Color is determined by a signal sent to the brain from the cone cells located on the surface of the retina.³ These cells become fatigued when a color is viewed for an extended period, thus decreasing the acuity of the signals relayed to the brain. In order to counteract this fatigue, several universities advocate the use of a blue patient bib during shade taking since the basic tooth shade is yellow-orange to red-orange. The theory is that, as the clinician views the patient's mouth, the eye muscle gradually becomes fatigued to the color orange and alters the accurate perception of shade. Observing the complementary blue shade of the bib, however, recharges the sensation of orange in the cone cells and corrects the inaccurate shade perception. In addition, teeth — particularly aged teeth — have a glossy surface that absorbs the shade of any color placed in close proximity to them, and this must be considered in the comprehensive process.

Accurate Shade Determination

The determination of shade without properly addressing lighting, surroundings, and contrasting colors can easily result in mismatched shades. While it may not be practical for an operator or laboratory to be painted in neutral gray or dedicate a single room to shade taking, several alternatives can be utilized to achieve successful results.



Figure 9. Postoperative facial view of the definitive restorations following cementation. Note the enhanced aesthetics achieved due to proper shade communication.

Since the adjacent teeth become dehydrated during preparation, shade should be taken prior to the initiation of this process to prevent compromised shade reading. In order to minimize light reflection from the tooth surface, patients should be instructed to sit with their chins tilted down rather than to lie prone. The shade selection system should then be placed below the patient's closed mouth to ensure that all elements will be equally affected by the surroundings, time of day, or contrasting colors. The shade guide is then manipulated to determine the hue and intensity of the color. While the guide rarely achieves a precise match with the natural dentition, the closest shade should be quickly selected and modified as necessary to correspond to the tooth.

One alternate technique requires the shade guide to be placed by value rather than order.⁷ While clinicians and technicians are often taught to use hue initially, in doing so the importance of value can be underestimated. By considering value prior to hue, an improved match can often be achieved. Since value can only be perceived by a squinting viewer,⁵ this may provide a third means of determining value.

Once the basic shade has been determined, the author uses a second color system (Color Wheel, Jensen, North Haven, CT) to verify that the correct basic shade has been selected. This system has individual tabs for each aspect of the tooth (eg, dentin, enamel, incisal) and shade variations that facilitate the breakdown of color; consequently, the system permits the layering of porcelain materials that result in an accurate shade match (Figure 1). Once the basic shade and value have been determined, it is necessary to determine if any color difference exists between the crown and the root (if it is exposed). The gingival region may be warmer or more chromatic than the rest of the tooth. Due to its natural curvature, the body of a tooth generally has a brighter value than its gingival or incisal aspect. On occasion, a white band can be created across the surface of a tooth to increase its value.

Numerous internal characterizations are present in the incisal aspect of a tooth. In adolescent patients, the mamelon structure may be intact, which adds a challenge in color matching. In aged patients, however, the



Figure 10. A 33-year-old patient presented with preexisting laminate veneers that had discolored over extended function.



Figure 11. The diagnostic waxup was seated intraorally to obtain approval of the anticipated aesthetics.



Figure 12. Facial view of the preparations on the model. The diagnostic waxup allowed the fabrication of the definitive restorations in single or paired units.



Figure 13. Once the initial layer of opacious dentin was placed, indentations were made to allow light to be scattered.

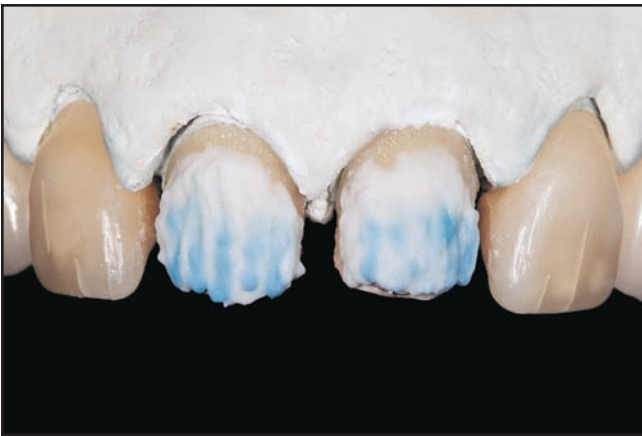


Figure 14. The indentations were filled in with clear translucent porcelain to trap the scattered light.



Figure 15. The dentin was layered to exact size and contour and cut back as necessary.

incisal edges may become worn, which exposes the dentin layer. As this layer is exposed, the resulting discoloration between the dentin and enamel layer allows multiple colors to be observed in the incisal region. This area should be meticulously examined to determine all the colors present in the incisal aspect, which can often be viewed with a mirror.

When a distinctive difference exists between the color of the gingival and incisal layers, it is common to mask the former while taking the shade of the latter (and vice versa). The shade guide used to measure these colors should not be held manually, but with a hemostat in order to prevent misperception of color.

Proper Communication Techniques

Restorations that exhibit a natural appearance can be fabricated if the closest shade has been determined using the aforementioned techniques and all apparent colorations have been considered. Once the closest basic shade has been selected, an overlay or underlay of colored translucent porcelain can occasionally be used to achieve a shade that closely resembles the surrounding dentition.

In combination with a shade selection system, accurate photographs can be used to communicate color. The camera should be slightly angled, however, to minimize light reflection that can distort color. In addition, the shade guide should be placed adjacent to the corresponding tooth and similarly angled so that the correct information is exchanged between the members of the restorative team, who should always utilize identical shade selection systems.

Learning proper communication techniques is essential in the fabrication of aesthetic restorations. Even severely stained teeth can be accurately restored when shade is recorded and described to the laboratory technician. When staining of the restoration is required, it must be performed in an optimal environment with corrected, neutral light to ensure that the crown will match the adjacent teeth (Figure 2). If the basic shade does not precisely match the shade tab, all varying colorations applied to the restoration will be fruitless, since it was initially misdetermined.

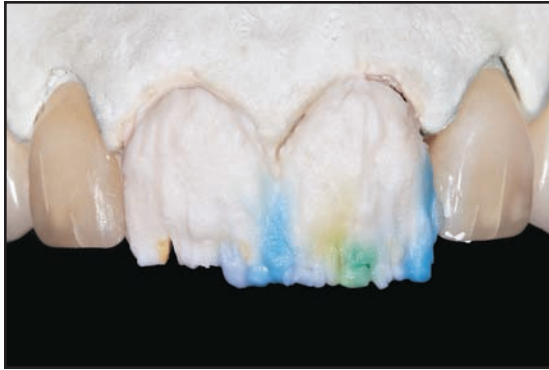


Figure 16. The spaces in the mamelons were filled with alternating different-colored incisal powders.

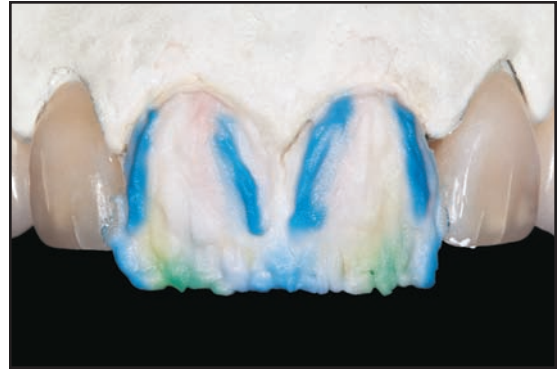


Figure 17. A bright incisal powder was used to highlight the line angle.



Figure 18. Facial view of the porcelain buildup following the initial firing.

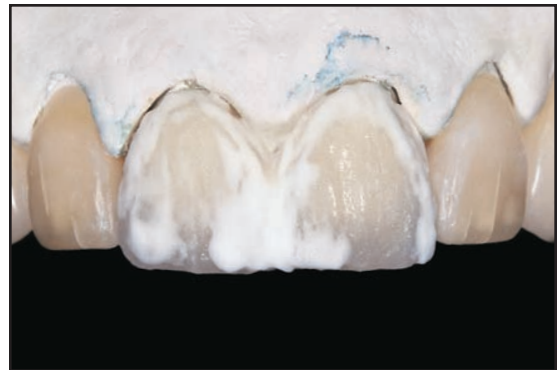


Figure 19. Porcelain material was added to compensate for shrinkage in subsequent firings.

Material Considerations

The inherent characteristics of the porcelain material should also be considered. While these materials may exhibit a shade that accurately corresponds to that of the shade system, several porcelains require additional staining to achieve a proper match. In such procedures, the underlying optical characteristics of the tooth or restoration are masked by metallic-oxide stains, which subsequently demonstrate a monochromatic appearance. When staining is necessary, it must be performed in color-corrected light to prevent mismatched shades postoperatively. In addition, the fluorescence of porcelain materials has a tendency to cause an iridescent effect that reacts to and reflects light as a natural tooth does (Figure 3).⁸ While a material may be suitable for use in one or two firings, it may prove inadequate if multiple bakes are required to modify the colors and the anatomy of the tooth. It is essential that the product maintain proper morphology and color after repeated firing.

In order to satisfy the aesthetic expectations of patients, it is critical to maintain communication between the patient, clinician, and laboratory technician. Computer technology can now be used to provide patients with an image of the anticipated restoration prior to treatment. While such technology can be beneficial, a diagnostic waxup can provide a more accurate demonstration of the final appearance of the restorations (Figures 4 through 7). Once the patient has approved the waxup, the definitive restorations can be fabricated and cemented into their final position (Figures 8 and 9).

Case Presentation

A 33-year-old patient presented for the restoration of pre-existing laminate veneers that had discolored over extended function (Figure 10). Since proper communication had to be established with a third party in addition to the patient, a diagnostic waxup was fabricated



Figure 20. Right lateral view of the porcelain restorations.



Figure 21. Left lateral view of the porcelain restorations on the model.



Figure 22. Facial view of the definitive porcelain restorations on the model prior to final delivery.



Figure 23. Postoperative right lateral view of the restorations following cementation and polishing.

in the laboratory and seated intraorally to obtain approval (Figure 11). In this instance, a softening of the internal characterization and additional lightening were requested. Once the waxup had been approved, a matrix was fabricated by the laboratory technician to be duplicated in porcelain. The waxup permitted improved communication with the patient and allowed the restorations to be fabricated individually (Figure 12).

Segmental Buildup

In order to achieve a natural appearance for the metal-ceramic crown restorations, light had to be diffused, and the illusion of depth had to be created. The initial opaque layer was placed unevenly to scatter the light. A white opacous dentin layer (Creation, North Haven, CT) was subsequently applied to re-create value that may have been lost as the layering progressed. During the layering process, indentations were placed (Figure 13) and

filled with clear translucent material to scatter and trap the light (Figure 14). The dentin layer was then built up to the exact size and contour of the definitive restorations and cut back as necessary (Figure 15).

Once the dentin layer was completed, the “finger-like” mamelon structure was created. In order to establish dynamic characterizations, internal stains (In-nova, Creation, North Haven, CT) were painted on the side wall of the mamelons instead of directly on their surfaces. The spaces in the mamelons were filled with alternating variations of colored incisal powders (Figure 16), which extended the length of the restorations to compensate for future firing shrinkage. Any additional internal characterizations were developed at this stage.

A bright incisal layer was subsequently utilized to highlight the line angle (Figure 17). The upper two thirds of the tooth were covered with translucent powders of varying colors using the lateral segmentation buildup



Figure 24. Left lateral view of the porcelain restorations postoperatively. Note the harmonious integration between the soft tissues and the restorations.



Figure 25. Postoperative facial view of the definitive full-coverage crown restorations. Note the enhanced aesthetics that were achieved through proper shade communication.

technique.^{6,9,10} While performing this buildup, the reproduction of the enamel crack line was easily achieved by painting the side wall of the translucent porcelain with a colored stain (Crack Liner, Creation, North Haven, CT). Once the buildup had been performed, the translucent layer was completed.

In order to compensate for the inevitable shrinkage that would occur during the initial firing (Figure 18), an auxiliary layer of appropriately colored porcelain material was added (Figure 19) as necessary following each firing until the crown restorations were completed (Figures 20 through 22). While matching the shade and

characterization of the restorations was important, simulating the surface texture and luster was also extremely significant. Consequently, grinding and polishing were accomplished once the definitive full-coverage crown restorations had been seated and cemented (Figures 23 through 25).

Conclusion

In recent years, the dental profession has observed a significant increase in the demand for aesthetic restorations. Fortunately, contemporary developments in methods and materials have enabled these expectations to be achieved with success and predictability. The understanding of the methods used to take and match shades — coupled with proper communication skills — can result in the fabrication and delivery of aesthetic restorations that exhibit a natural appearance. This article has highlighted several factors that influence the determination of proper shade and color. In addition, it has detailed several means utilized to facilitate color communication between the members of the restorative team and demonstrates the use of such techniques during the segmental buildup of porcelain restorations.

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CONTINUING EDUCATION (CE) EXERCISE No. 14



NEW YORK UNIVERSITY
College of Dentistry
Center for Continuing Dental Education

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

The 10 multiple-choice questions for this Continuing Education (CE) exercise are based on the article "Shade matching and communication in conjunction with segmental porcelain buildup" by Sang K. Jun, CDT. This article is on Pages 457-464.

Learning Objectives:

This article highlights a predictable method of performing shade and color communication that enables the restorative team to fabricate aesthetic ceramic restorations. Upon reading and completing this exercise, the reader should have:

- An awareness of the factors involved in proper shade selection.
- An understanding that each member of the restorative team must follow the same standards of measurement and must effectively communicate regarding shade selection.

1. According to the author, "true color" is determined:

- At sunrise.
- At midday.
- When the sun is in its most northern location.
- When the sun is obscured by clouds.

2. The discoloration between the dentin and enamel layer can:

- Allow multiple colors to be observed in the gingival region.
- Allow multiple colors to be observed in the incisal region.
- Allow multiple colors to be observed in the opposing teeth.
- Allow multiple colors to be observed in the adjacent dentition.

3. In a laboratory where shade selection takes place, the ideal wall color should be:

- Gray.
- White.
- Black.
- Blue.

4. Which of the following is NOT recommended when determining an optimal tooth shade?

- Using color-corrected fluorescent bulbs in the room.
- Covering the patient's clothes with a gray bib.
- Asking the patient to remove facial cosmetics (eg, lipstick).
- Isolating the teeth with a rubber dam for contrast.

5. In order to minimize light reflection from the tooth surface, patients should be instructed to:

- Sit with their chins tilted up.
- Sit with their chins tilted down.
- Sit with their chins parallel to the floor.
- Lay prone.

6. According to this article, the difficulty in matching the dentition of older patients is:

- The mamelon structure may be intact.
- Few colors adequately match the color of aging dentition.
- The incisal edges of their teeth may be worn, exposing the dentin layer.
- Overerupted teeth may contain multiple shades.

7. According to this article, sufficient light for shade selection is:

- 4500 K.
- 5000 K.
- 5500 K.
- 6000 K.

8. When taking photographs in order to match the shades of teeth, the camera should be:

- Directed at a slight angle to the teeth.
- Used from a distance of at least 10 feet.
- Directed at a severe angle to the teeth.
- Directed perpendicularly to the teeth.

9. According to the author, the anticipated restoration is optimally demonstrated through the use of:

- A picture of the patient.
- A detailed description.
- Computer imaging.
- A diagnostic waxup.

10. In the clinical case presented in this article, communication with a third party (in addition to the patient) was facilitated by the use of:

- Photographs of the patient.
- A diagnostic waxup fabricated in the laboratory and seated extraorally.
- A diagnostic waxup fabricated in the laboratory and seated intraorally.
- Idealized computer-generated images.