A Comprehensive Approach to Color Matching in the Esthetic Zone

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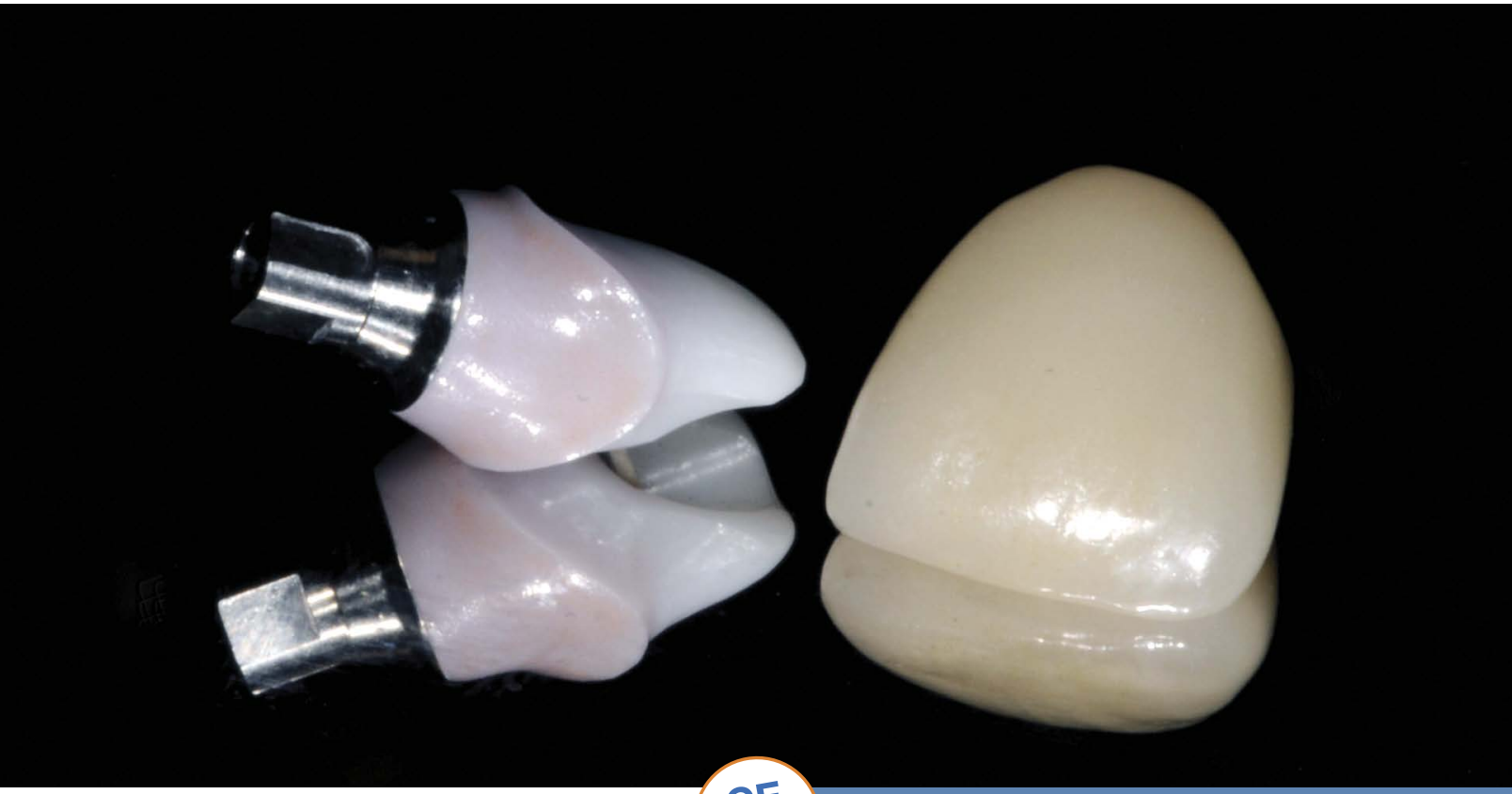

CE CREDIT

Learning Objectives

Abstract

Accurate color determination of teeth and soft tissue is critical to achieving ideal color reproduction. Working in the esthetic zone requires a comprehensive approach with advanced laboratory techniques, multispecialty support, and skill. The dental spectrophotometer is one tool that can be employed for shade determination to achieve success in the ideal color reproduction of both teeth and soft tissue. This article describes a case in which an esthetic color match on a #9 implant crown was established utilizing both soft tissue and tooth color data, resulting in an attractive, harmonious smile for the patient.

Key Words: color matching, esthetic zone, whitening, comprehensive approach, spectrophotometric analysis

After reading this article, the participant should be able to:

1. Provide the cosmetic dentist additional tools for the critical color matching of an anterior tooth to the adjacent dentition.
2. Improve a dentist's ability to communicate with the laboratory technicians objectively – not subjectively - about the color required.
3. Gain knowledge in the use of spectrophotometric analysis for shade determination and communication.

Introduction

Color matching in the esthetic zone is a challenging task. With the advent of implant placement, the color match of the peri-implant mucosa and the soft tissue of the adjacent teeth has become an additional challenge. The limiting factor in shade matching in the esthetic zone is how great a color difference exists and is acceptable between the tooth structures to be matched.[1] When evaluating color, the human brain assesses many different factors, including the differences in light sources, the effect of surrounding color, and the variability of surfaces.[2] Color is both an objective and a subjective phenomenon, which is in part why it is so challenging for the dentist to measure.[2]

Due to improved materials and techniques and a more informed public, there is an increased demand for more esthetic restorations.[3] One of the most challenging restorations in dentistry is the single maxillary central incisor. To successfully color match the tooth and gingival color, that information must be accurately analyzed and relayed to the laboratory. Visual shade matching has several limitations. Typically, shade guides are used as the primary method of communication with the laboratory. Limitations in shade guides exist, however, as they rely on the subjective variability of the clinician taking the shade and oftentimes the shade guides themselves are inadequate in that they do not represent the full color range of natural dentition.[4-9] Digital photography is another tool used to provide color information to the laboratory. However, like shade guides, interpretation of color using digital photography is still subjective, being thoroughly dependent upon the individual camera, the camera settings, lighting, and several other conditions.[9-11]

In contrast to shade guides and digital photography, color measurement instruments are objective and have the ability to remove many of the subjective variables that create several of the aforementioned challenges of communicating with the laboratory. Colorimeters and spectrophotometers are examples of these color measuring instruments. Typically, spectrophotometers are more sophisticated instruments that are able to measure the amount of light reflected from objects throughout the visible spectrum.[12,13] Due to their ability to objectively analyze a two-dimensional image of a subject, spectrophotometers provide a way for standardized and accurate color communication that can be used for both teeth and gingiva.[9,14-16] The following interdisciplinary case demonstrates the use of a dental spectrophotometer to aid in the shade matching of both teeth and soft tissue in the restoration of a single implant crown in the esthetic zone.

Case Report

Patient Complaint and History

A 40-year-old female presented wishing to restore her missing maxillary left central incisor (#9) **(Figs 1-4)**, which had been extracted and grafted previously at another dental school due to vertical root fracture. Her medical history included gastroesophageal reflux disease. Her ASA status was determined to be Class II.[17]

The patient, who had a history of bruxism and clenching, saw her previous dental provider twice a year for regular cleanings and checkups, brushed her teeth twice a day, and flossed occasionally. She reported growing up with a diastema between #8 and #9 and that she had difficulty chewing in the anterior. She was unhappy with her smile, especially the anterior esthetics.

Clinical Examination

The patient presented with a missing #9 and was found to have an existing mesial-incisal-facial-lingual (MIFL) composite on #8 that was previously placed to close the diastema between #8 and #9. There also was a MIFL composite on #7 and a ML composite restoration on #10. Other findings included abfraction lesions on #20, #21, #22, #25, #28, and multiple existing restorations including composite and amalgam. No caries (confirmed with radiographs), tooth mobility, or deep periodontal probing depths were detected.

After presentation to the clinic, surgical placement of the implant (4.1 x 10 mm bone-level taper, Straumann USA; Andover, MA) was performed along with frenectomy by an advanced graduate trainee in periodontics. Tissue contour and emergence profile were established using a custom provisional crown on #9.

Problems Found

The result of the esthetic evaluation revealed the following problems:

- shade-matching discrepancy of teeth in the anterior esthetic zone
- shade-matching discrepancy of gingiva in the anterior esthetic zone
- tooth size discrepancy due to previous diastema between #8 and #9
- abfraction lesions.

Treatment Plan and Objectives

After completion of the examination and evaluation of articulated study casts, photographs, and diagnostic wax-ups, several treatment plans were presented to the patient. The objectives were to address the patient's chief complaint, repair the abfraction and discoloration of the restorations, and optimize function and esthetics, as well as educate her regarding the oral hygiene and diet choices that had contributed to the erosion.

A comprehensive treatment plan was initially presented that involved orthodontics to align her maxillary and mandibular teeth due to her previous diastema, whitening, and four anterior crowns on #7-#10 to alter the size, shape, and color of her anterior maxilla. Ultimately, the patient declined this option and instead chose a treatment plan that included whitening, anterior composite restorations, and a single implant crown on #9 to alter the shade, size, and shape of her anterior maxillary teeth. A dental spectrophotometer (Crystaleye, Olympus America; Center Valley, PA) would be used to shade match the teeth and gingiva as well as to communicate with the laboratory.

Figure 1: Preoperative full-face frontal view.

Figure 2: Preoperative full-smile frontal view.

Figure 3: Preoperative retracted intraoral frontal view.

Figure 4: Preoperative maxillary occlusal view.

Treatment

Tooth whitening: The patient's teeth were whitened with Opalesence Boost PF 40% (Ultradent Products; South Jordan, UT). Whitening was performed on the anterior maxilla to address the patient's goal of brightening her smile. Spectrophotometric analysis was used to evaluate the tooth shade prior to whitening. Three weeks after whitening, spectrophotometric analysis was again used to evaluate the shade of the maxillary anterior teeth. Three weeks elapsed prior to reevaluation of tooth shade to allow for color stability of the whitened teeth prior to resin bonding.[18,19] Color analysis was completed before and after whitening to determine the shades to be used for the anterior composite restorations **(Fig 5)**.

Multiple factors were analyzed during the color-matching process. CIELAB color space coordinates[20] were used for the analysis. The L* (lightness), a* (red-green), and b* (yellow-blue) values were examined to verify the color difference (ΔE) and determine whether the magnitude of color change was within the 50:50% perceptibility threshold (PT) or 50:50% acceptability threshold (AT) (ΔE > 1.2 50:50% PT or ΔE > 2.7-3.0 50:50% AT).[15, 21,22] For example, #7 had a ΔE of 4.15. Therefore, after whitening, there was a clinically perceptible change **(Fig 6a)**. After whitening, the tooth color shifted toward a higher L* (value) and lower b* (yellow), which is confirmed in **Figure 6b**.[9]

Anterior composite restorations: The Class IV MIFL composite restorations on #7 and #10 were replaced after whitening to reflect the new shade values and improve esthetics. The #8 MIFL composite was replaced after whitening to enhance the shade as well as to produce a desirable size and shape in #8 and #9. Color analyses were utilized in determining the shade of these restorations. In addition to evaluating L*, a*, and b*

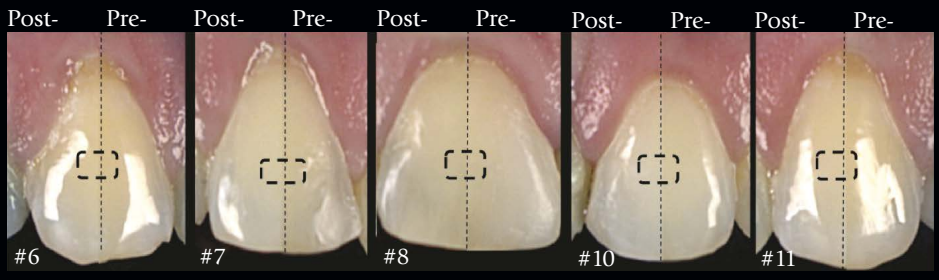

Figure 5: Before and after whitening spectrophotometric images of #6, #7, #8, #10, and #11.

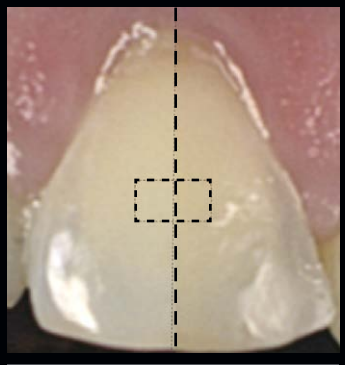

Figure 6a: Spectrophotometric image of #7 before (right) and after (left) whitening.

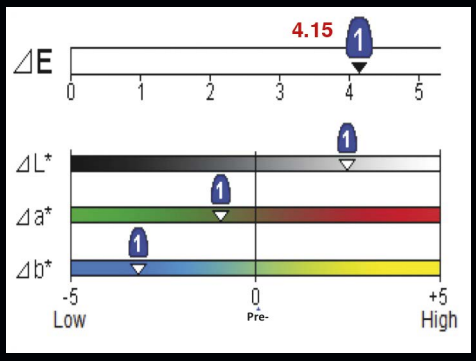

Figure 6b: Significant color change for #7 after whitening with ΔE 4.15 (ΔE: magnitude of color change; clinical perceptible threshold: ΔE > 2.67 to 3.3).

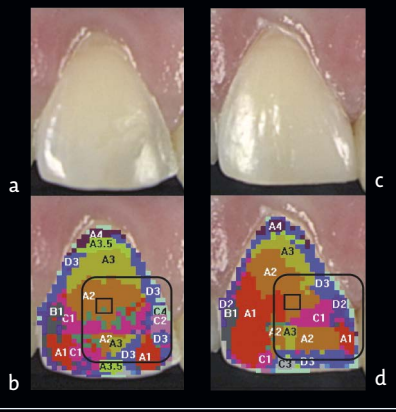

Figure 7: Composite color selection. a) #7 spectrophotometric image after whitening; b) Color map of #7; c) #7 spectrophotometric image after composite; d) Color map of #7 after composite completed. Harmonized color reproduction was established.

values, color mapping was used to evaluate the post-whitening shades and this data was used to create esthetic Class IV composites on #7, #8, and #10 **(Figs 7a-7d)**. As seen in **Figure 7b**, the color map of the mesial portion of #7 after whitening is darker than the rest of the tooth due to a previously placed composite. The color map was used to choose shades that matched the rest of the tooth to create a new harmonious Class IV composite, as seen in **Figure 7c**.

Final restorations: A final impression of #9 was taken after tissue contouring had been established with a custom-made provisional crown and the surrounding composite restorations were completed.

Spectrophotometric analyses of the soft tissue surrounding #9 in comparison to that of #8 were utilized to fabricate a custom CAD/CAM zirconia implant abutment that was stained pink **(Fig 8)** to reduce gray show-through for #9 **(Fig 9)**.[16] As seen in **Figure 10**, the a* mapping shows that the tissue surrounding provisional crown #9 indicates less redness than that around #8 due to the titanium abutment of the provisional crown. Soft tissue surrounding the #9 final crown with the pink-stained custom abutment indicates the same redness as that at #8, indicating less gray show-through in the soft tissue with the custom-stained abutment. Similar L* values were also produced with #8 and #9.

A cement-retained porcelain-fused-to-zirconia (PFZ) crown (Katana, Kuraray Noritake Dental; New York, NY) on #9 was customized after the new anterior composites were placed on the surrounding teeth to reflect the ideal size, shape, and color match of #8 **(Fig 11)**. Spectrophotometric analyses of the #8 composite were completed to color match the #9 PFZ crown with the pink-stained custom abutment. The ΔE between the #8 composite and the #9 final crown was 2.8, which falls below the 50:50% acceptability threshold.[15,21,22] The ΔE on the soft tissue between #8 and #9 was 3.4 **(Fig 12)**. The clinically perceptible threshold for gingival color ranges from ΔE > 1.2 to 4.6.[16,23-27]

Finally, Class V composites were placed on #20, #21, #22, #25, and #28 to restore the existing abfraction lesions. The patient was then instructed on the importance of maintaining her new restorations with proper oral hygiene, dietary modifications, and recall appointments.

Figure 8: Custom pink-stained implant abutment (CAD/CAM zirconia over Ti-base).

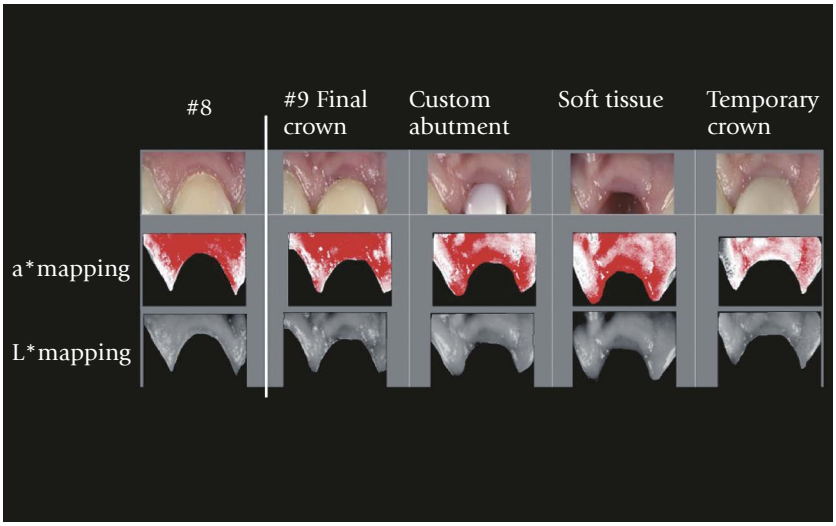

Figure 9: A spectrophotometric analysis of the soft tissue for #9 and #8 was utilized to fabricate a custom CAD/CAM zirconia implant abutment, which was stained pink to reduce gray show-through.

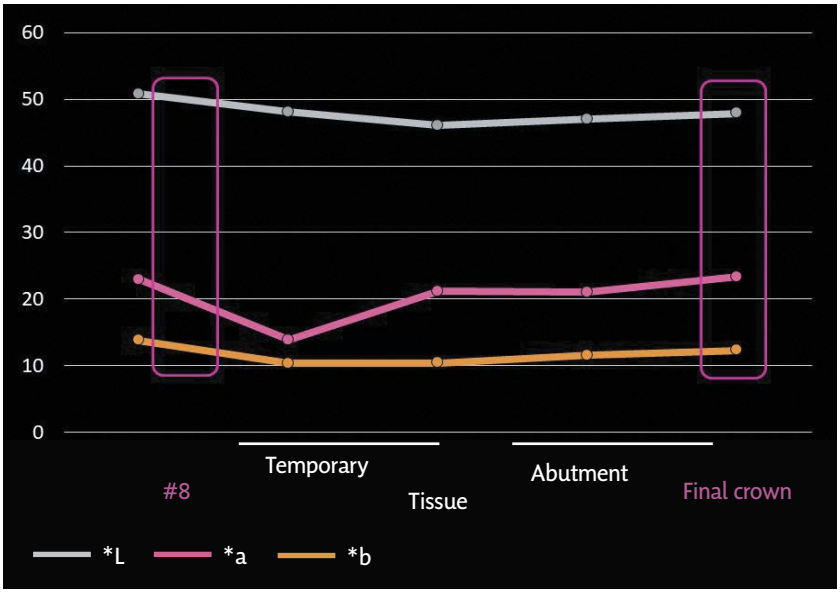

Figure 10: Numerical graph of L*a*b* values.

Figure 11: The PFZ cement-retained #9 crown.

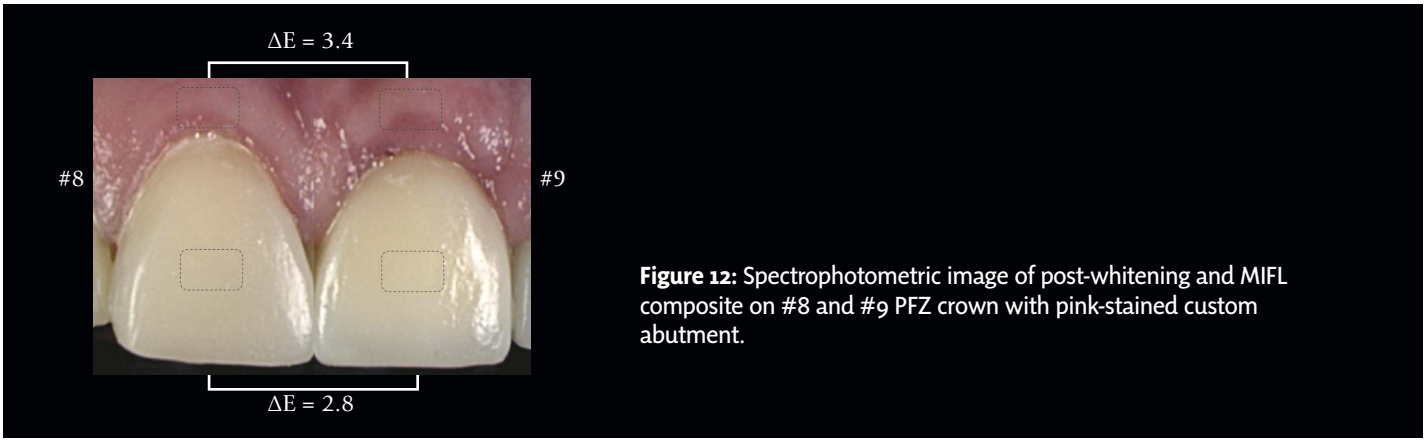

Figure 12: Spectrophotometric image of post-whitening and MIFL composite on #8 and #9 PFZ crown with pink-stained custom abutment.

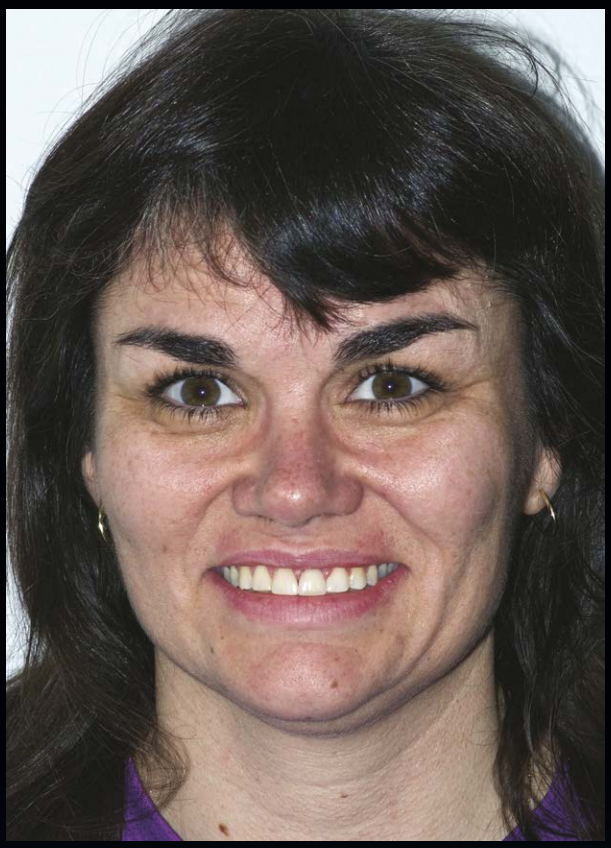

Figure 13: Postoperative full-face frontal view.

> *"Due to their ability to objectively analyze a two-dimensional image of a subject, spectrophotometers provide a way for standardized and accurate color communication that can be used for both teeth and gingiva."*

Figure 14: Postoperative full-smile frontal view.

Summary

Color matching in the esthetic zone requires a comprehensive approach. The case described here showcases how dental spectrophometric analysis can be used for shade determination to achieve success in ideal color reproduction of both teeth and soft tissue. Multiple measures were taken to ensure the establishment of an esthetic restoration of this patient's anterior maxilla. After tooth whitening, color change toward higher L* (value) and lower b* (yellow) was confirmed. Esthetic Class IV composite shades were achieved with the use of these color data. An esthetic color match on the #9 custom abutment and implant crown was established with both soft tissue and tooth color data to produce an attractive, harmonious smile for the patient **(Figs 13 & 14)**.

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AACD Self-Instruction

Fixed Prosthodontics (CE) Exercise No. jCD38a AGD Subject Code: 610

3 Hours Credit

This Continuing Education (CE) self-instruction exam is based on the article, *A Comprehensive Approach to Color Matching in the Esthetic Zone* by Dr. Sara Rosenberg, Dr. John Da Silva, Dr. Shigemi Ishikawa-Nagai. This article appears on pages 50-57.

The examination is free of charge and available to AACD members only. AACD members must log onto www.aacd.com to take the 10 question exam. Note that only Questions 1 through 5 appear in the printed and digital versions of the *jCD*; they are for readers' information only.

1. Which of the following is an objective way to communicate color?

a. Visual comparison with the Vita 3D shade guide.
b. Digital photography using multiple shade tabs.
c. The use of color measurement instruments.
d. Black and white photography to determine the value.

2. How does a spectrophotometer objectively communicate color?

a. By measuring the amount of light reflected from objects throughout the visible spectrum.
b. By analyzing the color of a specific shade tab and then comparing this to the tooth.
c. By using infrared light to penetrate gently into the tooth structure to evaluate the warmth of different areas.
d. By comparing the reflective color of a tooth to a variety of shade tabs.

3. Which of the following defines the ability of color measurement instruments to objectively color map a tooth?

a. Spectrophotometers can analyze a three-dimensional image of a tooth.
b. Spectrophotometers provide accurate color communication for both gingiva and teeth.
c. Colorimeters can analyze a three-dimensional image of a tooth.
d. Colorimeters are more sophisticated instruments for color measurement than spectrophotometers.

4. In the case presented, why was a color analysis completed before and after whitening?

a. To select the proper type of porcelain material to be used.
b. To evaluate the effect of the tooth color on the color of the gum tissue.
c. To determine the shade of porcelain to be used for the temporary restorations.
d. To determine whether the magnitude of color change was within the perceptibility threshold.

5. The CIELAB color space coordinates use which of the following for color analysis?

a. Red-green and yellow blue compared to the lightness.
b. The difference in color change determines the color selection.
c. Lightness and color change is compared to Vita shade tabs.
d. L* a* and b* values were examined to determine the difference in color change.

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