

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/12031874>

Determination and communication of color using the five color dimensions of teeth

Article in Practical procedures & aesthetic dentistry: PPAD · January 2001

Source: PubMed

CITATIONS

73

READS

6,959

2 authors, including:



Francesco Mangani

University of Rome Tor Vergata

70 PUBLICATIONS 475 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Bonding ability of experimental resin-based materials containing (ion-releasing)-microfillers applied on water-wet or ethanol-wet root canal dentine [View project](#)



Long term inlays followup [View project](#)

DETERMINATION AND COMMUNICATION OF COLOR USING THE FIVE COLOR DIMENSIONS OF TEETH

Lorenzo Vanini, MD*
Francesco M. Mangani, MD†

The determination and communication of color in dentistry is based on dated concepts that cause difficulty for clinicians and technicians who use their personal experiences to interpret this parameter, which is so important in aesthetic care. In this article, the author proposes a concept of color that has evolved from the observation and study of extracted and in vivo natural dentition. This research has been performed with the aim of providing the clinician with a predictable method of determining color from clinical evidence.

Key Words: color, shade, chroma, intensives, opalescence

The dental profession's knowledge of the aesthetic subject has always been relatively superficial, commercial, and confused — particularly with regard to color. In 1931, Clark stated, "we aren't qualified to solve the problem of color,"¹ and in 1979, Lemire maintained that "the selection and determination of color has remained stuck in the last century."² This notion was reaffirmed several years later by Preston who declared, "routinely the color for dental prosthesis is determined using a shade guide. The use of these has proved frustrating and not very satisfactory."^{3,4} Miller, too, attempted to define color,

writing, "the traditional system for determining tooth color shades in dentistry is the chromatic scale. Every shade is defined by a letter or a number or both together."⁵

Starting with the theory of three dimensions of color formulated by the American artist Munsell in 1898 (Figure 1), the dental literature has discussed and supported this three-dimensional theory (ie, hue, chroma, value) for more than a century.⁶ In 1982, Muia introduced another dimension (ie, characterization) to this model, thereby expanding the dimensions of color from three to four.⁷ In the last decade, Yamamoto made a significant contribution toward the understanding of the relationship between light, color, and ceramic materials.⁸ This investigator later devised the use of a spectrophotometer in dentistry to produce the "recipe" for the fabrication of restorations using Shofu ceramics.

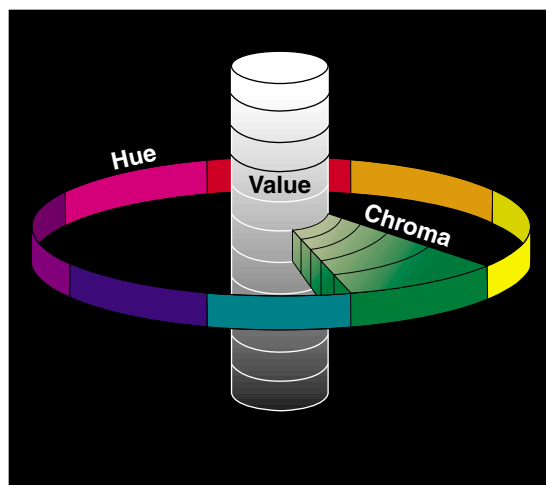


Figure 1. Illustration of the three-dimensional color theory (hue, chroma, value) according to Munsell.

*Private practice, San Fedele Intelvi, Como, Italy.

†Research Professor, University of Rome, Tor Vernata, Italy.

Lorenzo Vanini, MD
Via Provinciale 86
22028 San Fedele Intelvi, Como, Italy

Tel: (011) 390-31-83-06-46

Fax: (011) 390-31-83-04-13

E-mail: lorvani@tin.it



Figure 2. An accurate clinical photograph can document numerous details that are invisible to the human eye.

During these years, clinicians continued shade selection using the shade guide developed by Vita. Shade selection was thus based only on hue and chroma (eg, A2, B2, C1) without taking value into consideration. This resulted in restorations that were flat, lacked luminosity, and had a three-dimensional appearance. Several investigators attempted to use the first commercially available spectrophotometers, but they yielded disappointing results. These expensive devices, in fact, had difficulty analyzing hue and chroma, and many outcomes were controversial. Even when reliable data were obtained, only hue and chroma were determined — conclusions that dentists with minimal clinical experience could already draw. Therefore, it was difficult to justify the acquisition of this instrument.

When one carefully studies natural teeth, he or she is soon aware that color composition is determined by other factors besides hue, chroma, and value. Considering only these parameters means ignoring the obvious and not seeing that which is inside the tooth. The interpretation and reproduction of color and the difficulties accompanying these tasks must be approached with a simple, flexible technique that allows a final aesthetic result to be achieved. Thus, determining color in dentistry requires the consideration of all factors that combine to create teeth according to a three-dimensional system that goes beyond just a simple letter A or B.

By canceling reflected light with a polarizing filter, it is possible to visualize the chromatic chart (as introduced



Figure 3. Utilization of a polarized filter allows the user to visualize chromas of varying intensity.

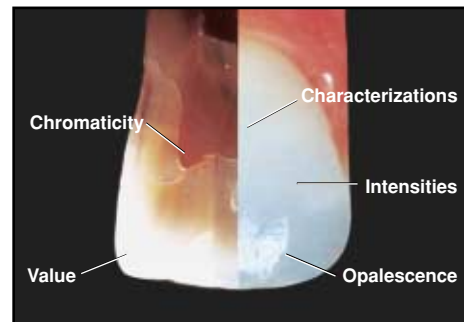


Figure 4. Five dimensions of color are evident in the natural tooth.



Figure 5. When viewed under appropriate light, a shade guide enables the determination of the tooth's hue (chroma).



Figure 6. Clinical view of adolescent maxillary central incisors.



Figure 7. Captured with the aid of the polarized filter, the high value of the teeth is evident.



Figure 8. Clinical facial view of adult anterior dentition under conventional light.



Figure 9. The medium value of the adult teeth is apparent when viewed with the filter.



Figure 10. Facial view of maxillary central incisors in an elderly patient.

by the author) with increased intensity.^{9,10} This allows one to clearly isolate the arrangement of tooth color as seen three-dimensionally (Figures 2 and 3). Thus, five aspects are highlighted and should be considered (Figure 4):

- Chromaticity (hue and chroma).
- Value (luminosity).
- Intensities.
- Opalescence.
- Characterizations.

It is convenient, therefore, to introduce the concept of a chromatic chart as a means of highlighting and communicating, in which all the parameters that contribute to the creation of color in the tooth are refined and noted. From this, a color card is created as a more complete means of determining and communicating the three-dimensional color of the teeth. On this card, all the parameters present in the elements to be reconstructed are noted according to a logical order that first considers the chromaticity of the dentin body and then the enamel and its numerous aspects.

Chromaticity

Based on the spectrophotometer study by Yamamoto on natural teeth, only shades A and B are considered important, where A is statistically closest in average chromaticity to the natural teeth (Figure 5).⁸ In these shades, A has orange-red as the dominant hue; B has yellow-green. (Touati et al found that 80% of hues form



Figure 11. The teeth in the elderly patient exhibit a low value according to the filtered image.



Figure 12. Type 1 Intensity: present in the enamel are one or more round areas similar to small white stains.



Figure 13. Type 2 Intensity: white is present in the form of small clouds distributed in the enamel at various levels.

group A.⁹⁾ The C and D hues are essentially A and B of a lower value and are no longer considered.

Value

It is useful to implement a system that simplifies the classification of the luminosity of the enamel. Such a system theoretically consists of three types of enamel (ie, high, medium, and low value), which can be compared to adolescent, adult, and aged enamels (Figures 6 through 11). These three enamel groups express diverse density, translucency, and reflectance.

Intensities

In the natural tooth enamel, one notes the presence of dotlike (and occasionally irregular) opaque, intense, milky white stains. These stains are distributed over various parts of the enamel in a particular arrangement that can be reproduced using a set plan. The reproduction of these intensities is very important — particularly in teeth with high value (ie, children and young adults). These intense white pigmentations have been classified into four categories according to their form:

- Stains (Figure 12).
- Small clouds (Figure 13).
- Snowflakes (Figure 14).
- Horizontal (Figure 15).

On the color card, it is easy to visualize and identify the situation that is closest to that being considered by the clinician.

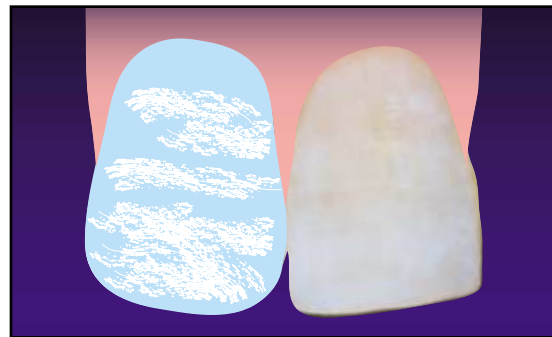


Figure 14. Type 3 Intensity: appears as small snowflakes or white spots distributed in a uniform way in the enamel.

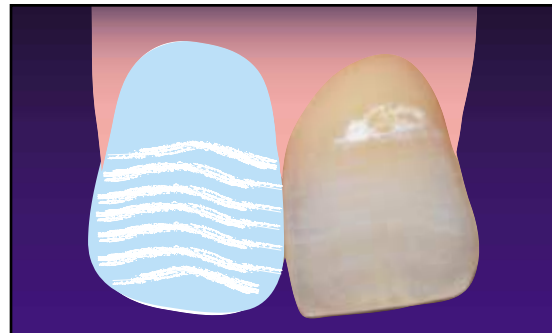


Figure 15. Type 4 Intensity: white spots in the form of a horizontal band arranged more or less uniformly dense.



Figure 16. Type I Opalescence: the halo follows the incisal outline of the mamelon of the dentin body, hence the term “mamelon-like.”



Figure 17. Type 2 Opalescence: presents with a large central mamelon divided by an accessory vertical groove.

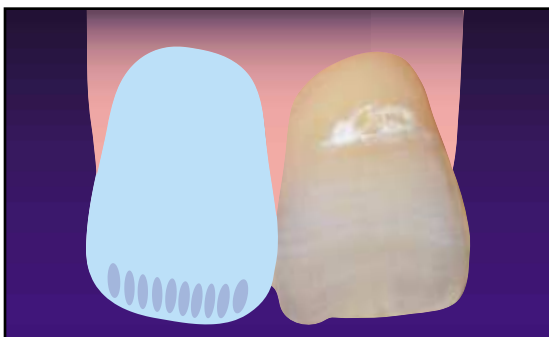


Figure 18. Type 3 Opalescence: one notes many small vertical grooves that create a "comb-like" halo.



Figure 19. Type 4 Opalescence: a regular halo creates a narrow "window" between dentin body and incisal margin.

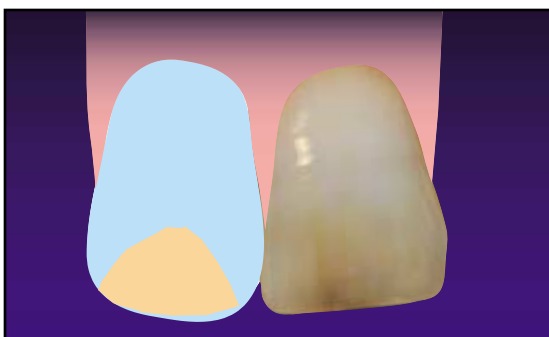


Figure 20. Type 5 Opalescence: the shape of this halo is an amber "stain" that rises from the incisal margin towards the coronal/middle third in the shape of a triangle.

Opalescence

The enamel — due to its translucent character — is responsible for the opalescence of natural teeth. In fact, enamel has the capacity to enhance the short wavelength component of the spectrum of light that it encounters, rendering life to the blue-gray shades that are so evident at the incisal halo level.¹⁰⁻¹³ On the basis of observation and polarized photography of the natural dentition, this author suggests the following classification of the incisal halo of the maxillary incisor:

- Mamelon-like (Figure 16).
- Split mamelons (Figure 17).
- Comb-like (Figure 18).
- Window-like (Figure 19).
- Stain (blotch)-like (Figure 20).

With regard to the tonality of color in the incisal halo, the human eye recognizes gray, blue, white, and amber. The various gradations of color most often found are the blue (in children) and gray (in adults), while the amber halos are most often present in aged dentition. During the compilation of the chromatic chart of a tooth, it is therefore important to search for these characteristics and note them on the color card for reproduction in the definitive restoration.

Characterization

The chromatic chart is finished with the characterization that, according to the author, can be divided into five types:



Figure 21. Type 1 Characterization: the incisal aspect of the mamelons appears to be covered by a thin layer of white that characterizes internally and raises the value of the tooth.

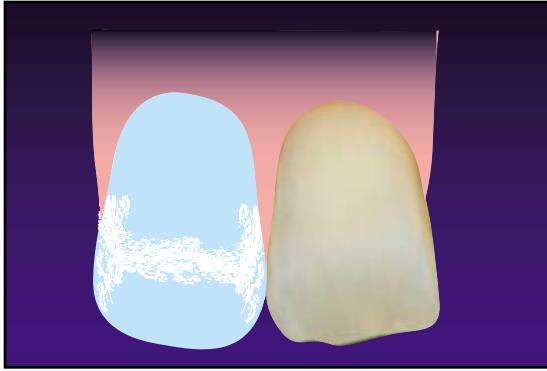


Figure 22. Type 2 Characterization: one notes white bands of subtle intensity that arise internally; they are horizontal on the labial surface and vertical on the interproximal.

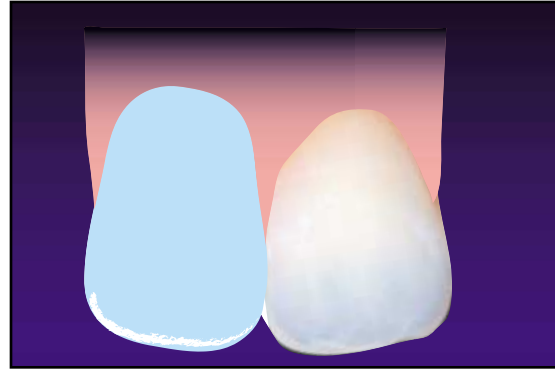


Figure 23. Type 3 Characterization: the incisal margin presents with a white line that clearly defines it.

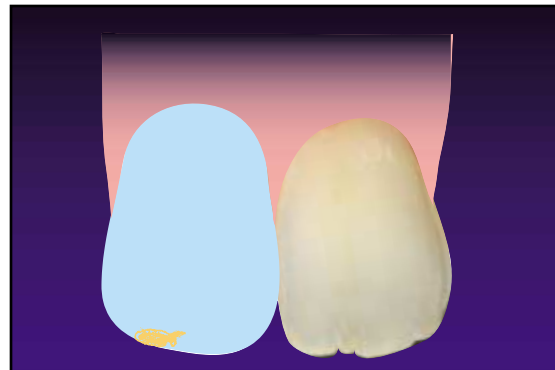


Figure 24. Type 4 Characterization: represented by one or more small amber or brown stains. This appearance is not to be confused with stain-like opalescence, which has a different distribution.

- Mamelons (Figure 21).
- Bands (Figure 22).
- Margins (Figure 23).
- Stains (Figure 24).
- Cracks (Figure 25).

The characterization of mamelons helps to increase the value internally in the incisal area. This is achieved by the placement of a subtle layer of opalescent white composite (OW, Enamel Plus HFP, Micerium, Avegno, Italy) between the dentin body and generic enamel of the incisal aspect. This type of situation is most frequently found in the younger dentition. Using a stronger diffusion of white, the high-value enamel partially obscures the backs of the mamelons that arise from the middle third and ascend to the incisal third of the tooth. The band characteristic creates an off-white horizontal fascia between the dentin body and generic enamel. In order to create this effect, one uses opalescence white (OW) as well.

The margin characterization recreates the white border, which is often present along the extremity of the incisal edge and frames the margin. This effect is achieved by the placement of a fine layer of opalescent white (OW) between lingual and labial layers of generic enamel at the incisal rim for a delicate effect and intensive white (IW) for a stronger effect. For stain or crack characterization, the brown or ocre color modifiers are used inside the generic enamel.

All the information with regard to the chromatic chart of a tooth should be transferred to the color card, where the clinician finds the essential guide to the research and recognition of all the parameters described. With the aid of the color card and attentive observation, it is possible to compile a correct chromatic chart that makes the reconstructive phase much simpler by providing the clinician all relevant information for the fabrication of the restoration and minimizing the possibility of errors (Figure 26). The chromatic chart, therefore, provides comprehensive directions for the reconstruction of a tooth in natural color. It should be completed prior to the preliminary constructive phase (ie, cavity preparation, isolation of teeth) and then followed throughout the stratification of the restoration. The color card is the blueprint of a specific tooth's chromatic composition (chromatic chart) compiled prior to tooth dehydration. Although the

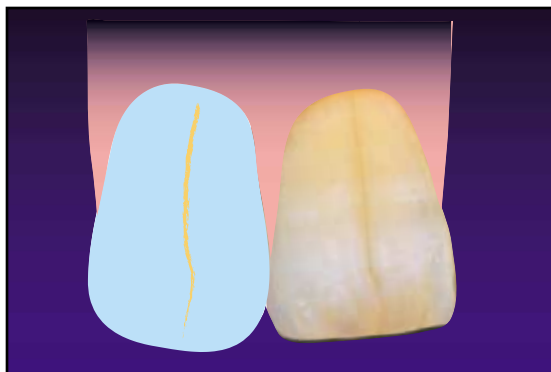


Figure 25. Type 5 Characterization: cracks can be either white or brown and are confined to the depth of the enamel.

original information may no longer be visible as a result of dehydration, restoration can be performed through the use of the color card.

For many years, restorations have been created by clinicians attempting to define and improvise the construction of the color arrangement. The lack of adequate knowledge about color composition of natural teeth results in recurrent errors and an unpredictable outcome. The restoration has to be first created in the clinician's mind and then in the patient's mouth.

Once the chromatic chart has been compiled (Figures 27 and 28), the clinician must have a predetermined and repeatable reconstructive technique. The stratification technique, for example, enables the recreation of a light-color-material relationship similar to that of the natural dentition (Figures 29 and 30). To date, proposed techniques have hardly referred to the normal anatomy of the natural tooth and have failed to consider the relationship between light and restorative material. These methods have been based on intuition, artistic ability, and individual experience. They have no point of reference with regard to thickness, nor do they utilize any rationale for the quantities used. Simply stated, this technique is based on nothing; it can be neither planned nor repeated.

In order to achieve aesthetic success, a practical clinician needs a point of reference. The only technique supported by scientific knowledge of tooth anatomy and

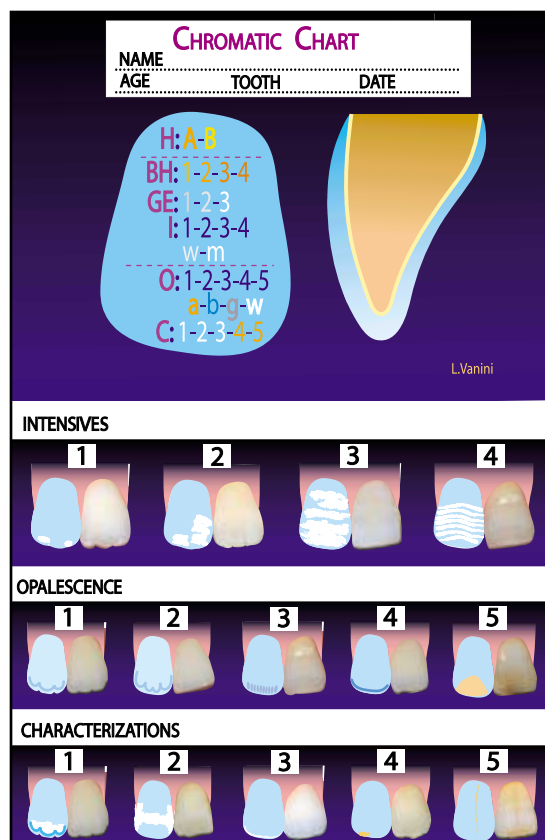


Figure 26. Diagram of the chromatic chart. This system allows the clinician to indicate color as a function of intensities, degrees of opalescence, and characterizations.

thickness of tissues is the anatomic stratification technique proposed by the author in 1995.^{14,15} This technique demands rigorous respect for the reproduction of the enamel and dentin tissues with regard to thickness and position. Emphasis should also be placed on the importance of the proteinaceous layer between dentin and enamel, which causes internal diffusion of light and controls luminosity of the restoration. For extensive restorations, the author recommends the use of a silicone index for improved refinement of volume and outline.

Conclusion

The routine use of the aforementioned chromatic chart enables the clinician to comprehend the chromatic composition of the teeth and to consider dimensions of color in dentistry not explored until now. Furthermore, due to the three classifications (ie, intensities, opalescence, and



Figure 27. Preoperative facial view of a 10-year-old male patient who presented for direct restoration of severe Class IV fracture.



Figure 29. Viewed postoperatively, the polarized filter reveals the natural diffusion of light and luminosity.

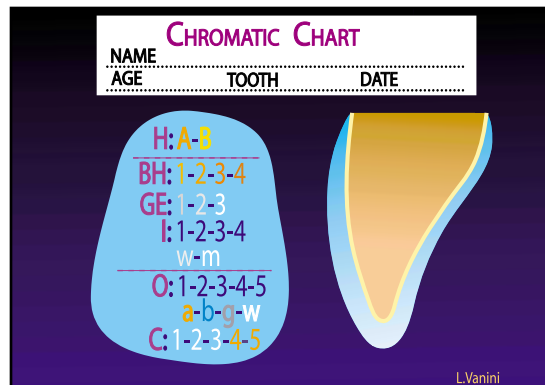


Figure 28. Diagram of the completed chromatic chart.



Figure 30. Postoperative facial view demonstrates the successful restoration of aesthetics. Note the characterization of the restoration when compared with the adjacent natural tooth.

characterizations), the chromatic chart represents an organized and valid method for documenting and communicating between clinician and laboratory technician.

Acknowledgment

The authors mention their gratitude to Dr. Olga Klimoskaia and technicians Franco Monti and Alessandro Tentardini for their research on the chromatic chart. The authors also thank Dr. John Theunissen for his assistance in preparing the article. Dr. Vanini declares that he is the owner of International Patent Application No. DM/053 372 (Chromatic Chart).

References

1. Clark BE. The color problem in dentistry. Dent Digest 1931;8.
2. Lemire PA, Burk B. Color in Dentistry. Bloomfield, CT: Ney, 1975.
3. Preston JD. Der gegenwartige Entwicklungssand der Farbbestimmung und Farbanpassung (I). Quintessenz Zahntech 1985; 11(8):863-873.
4. Preston JD. Der gegenwartige Entwicklungssand der Farbbestimmung und Farbanpassung (I and II). Quintessenz Zahntech 1985; 11(9):957-965.
5. Miller L. Organizing color in dentistry. J Am Dent Assoc 1987; 26E-40E.
6. Munsell AH. A Color Notation. 2nd ed. Baltimore, MD: Munsell Color Company; 1961:15-20.
7. Muia PJ. The Four-Dimensional Tooth Color System. Carol Stream, IL: Quintessence Publishing, 1982.
8. Yamamoto M. The value conversion system and a new concept for expressing the shades of natural teeth. Quint Dent Technol 1992; 19(1):2-9.
9. Touati B, Miara P, Nathanson D. Esthetic Dentistry and Ceramic Restorations. London, UK: Martin Dunitz Ltd, 1993.
10. Winter R. Visualizing the natural dentition. J Esthet Dent 1993; 5(3):102-117.
11. Ubassy Gerald. Shape and Color: The Key to Successful Ceramic Restorations. Carol Stream, IL: Quintessence Publishing, 1993.
12. Magne P, Magne M, Belser U. Natural and restorative oral esthetics. Part 1: Rationale and basic strategies for successful esthetic rehabilitations. J Esthet Dent 1993; 5(4):161-173.
13. Dietschi D. Free-hand composite resin restorations: A key to anterior aesthetics. Pract Periodont Aesthet Dent 1995; 7(7): 15-25.
14. Vanini L, Toffenetti F. Nuovi concetti estetici nell'uso dei materiali compositi. Quaderni di progresso odontostomatologico a cura degli. Amici di Brugg 1995; N°13.
15. Vanini L. Light and color in anterior composite restorations. Pract Periodont Aesthet Dent 1996; 8(7):673-682.

CONTINUING EDUCATION (CE) EXERCISE No. 1



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 "Determination and communication of color using the five color dimensions of teeth" by Lorenzo Vanini, MD, and Francesco M. Mangani, MD. This article is on Pages 19-26.

Learning Objectives:

This article discusses a concept of color that has evolved as a result of observation and evaluation of extracted and in vivo natural dentition. Upon reading this article and completing this exercise, the reader should:

- Demonstrate an awareness of the five components of the chromatic chart.
- Understand the arrangement of tooth color as seen three-dimensionally.

1. Which of the following aspects should be considered in order to clearly isolate the three-dimensional arrangement of tooth color?

- a. Chromaticity.
- b. Value.
- c. Characterization.
- d. All of the above.

2. What is the chromatic chart?

- a. A color card.
- b. An enamel shade.
- c. A means of communicating the parameters that contribute to the creation of tooth color.
- d. All of the above.

3. Which shade is statistically closest in average chromaticity to natural dentition?

- a. Shade A.
- b. Shade B.
- c. Shade C.
- d. Shade D.

4. Enamel luminosity remains consistent throughout life. This statement is:

- a. True.
- b. False.

5. The reproduction of intensive enamel stains are of particular importance in teeth with high value. This statement is:

- a. True.
- b. False.

6. The mamelon effect occurs as a result of:

- a. Incisal opacity.
- b. Dentinal translucency.
- c. Dentinal structure and enamel translucency.
- d. All of the above.

7. The characterization of the mamelons facilitates:

- a. Creation of the mamelon effect.
- b. Illumination of the incisal edge.
- c. Reduction of the internal value of the incisal area.
- d. Augmentation of the internal value of the incisal area.

8. Which aspect of natural dentition causes opalescence?

- a. Dentin.
- b. Stains.
- c. Enamel.
- d. None of the above.

9. The chromatic chart should be compiled from the dehydrated tooth. This statement is:

- a. True.
- b. False.

10. The proteinaceous layer:

- a. Causes light reflection.
- b. Is transparent.
- c. Controls luminosity through the internal diffusion of light.
- d. None of the above.



Figure 27. Preoperative facial view of a 10-year-old male patient who presented for direct restoration of severe Class IV fracture.



Figure 29. Viewed postoperatively, the polarized filter reveals the natural diffusion of light and luminosity.

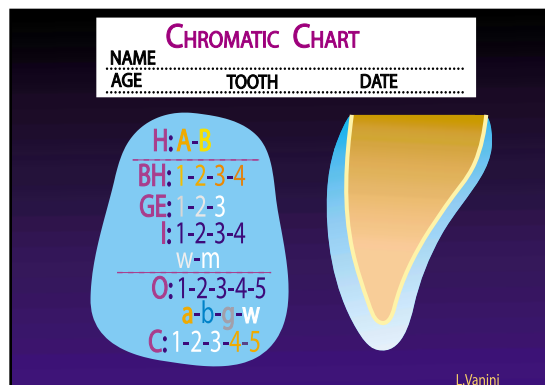


Figure 28. Diagram of the completed chromatic chart.



Figure 30. Postoperative facial view demonstrates the successful restoration of aesthetics. Note the characterization of the restoration when compared with the adjacent natural tooth.

characterizations), the chromatic chart represents an organized and valid method for documenting and communicating between clinician and laboratory technician.

Acknowledgment

The authors mention their gratitude to Dr. Olga Klimoskaia and technicians Franco Monti and Alessandro Tentardini for their research on the chromatic chart. The authors also thank Dr. John Theunissen for his assistance in preparing the article. Dr. Vanini declares that he is the owner of International Patent Application No. DM/053 372 (Chromatic Chart).

References

- Clark BE. The color problem in dentistry. Dent Digest 1931;8.
- Lemire PA, Burk B. Color in Dentistry. Bloomfield, CT: Ney, 1975.
- Preston JD. Der gegenwartige Entwicklungssand der Farbbestimmung und Farbanpassung (I). Quintessenz Zahntech 1985; 11(8):863-873.
- Preston JD. Der gegenwartige Entwicklungssand der Farbbestimmung und Farbanpassung (II and III). Quintessenz Zahntech 1985; 11(9):957-965.
- Miller L. Organizing color in dentistry. J Am Dent Assoc 1987; 26E-40E.
- Munsell AH. A Color Notation. 2nd ed. Baltimore, MD: Munsell Color Company; 1961:15-20.
- Muia PJ. The Four-Dimensional Tooth Color System. Carol Stream, IL: Quintessence Publishing, 1982.
- Yamamoto M. The value conversion system and a new concept for expressing the shades of natural teeth. Quint Dent Technol 1992; 19(1):2-9.
- Touati B, Miara P, Nathanson D. Esthetic Dentistry and Ceramic Restorations. London, UK: Martin Dunitz Ltd, 1993.
- Winter R. Visualizing the natural dentition. J Esthet Dent 1993; 5(3):102-117.
- Ubassy Gerald. Shape and Color: The Key to Successful Ceramic Restorations. Carol Stream, IL: Quintessence Publishing, 1993.
- Magne P, Magne M, Belser U. Natural and restorative oral esthetics. Part 1: Rationale and basic strategies for successful esthetic rehabilitations. J Esthet Dent 1993; 5(4):161-173.
- Dietschi D. Free-hand composite resin restorations: A key to anterior aesthetics. Pract Periodont Aesthet Dent 1995; 7(7):15-25.
- Vanini L, Toffenetti F. Nuovi concetti estetici nell'uso dei materiali compositi. Quaderni di progresso odontostomatologico a cura degli Amici di Brugg 1995; N°13.
- Vanini L. Light and color in anterior composite restorations. Pract Periodont Aesthet Dent 1996; 8(7):673-682.

CONTINUING EDUCATION (CE) EXERCISE No. 1



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 "Determination and communication of color using the five color dimensions of teeth" by Lorenzo Vanini, MD, and Francesco M. Mangani, MD. This article is on Pages 19-26.

Learning Objectives:

This article discusses a concept of color that has evolved as a result of observation and evaluation of extracted and in vivo natural dentition. Upon reading this article and completing this exercise, the reader should:

- Demonstrate an awareness of the five components of the chromatic chart.
- Understand the arrangement of tooth color as seen three-dimensionally.

1. Which of the following aspects should be considered in order to clearly isolate the three-dimensional arrangement of tooth color?

- a. Chromaticity.
- b. Value.
- c. Characterization.
- d. All of the above.

2. What is the chromatic chart?

- a. A color card.
- b. An enamel shade.
- c. A means of communicating the parameters that contribute to the creation of tooth color.
- d. All of the above.

3. Which shade is statistically closest in average chromaticity to natural dentition?

- a. Shade A.
- b. Shade B.
- c. Shade C.
- d. Shade D.

4. Enamel luminosity remains consistent throughout life. This statement is:

- a. True.
- b. False.

5. The reproduction of intensive enamel stains are of particular importance in teeth with high value. This statement is:

- a. True.
- b. False.

6. The mamelon effect occurs as a result of:

- a. Incisal opacity.
- b. Dentinal translucency.
- c. Dentinal structure and enamel translucency.
- d. All of the above.

7. The characterization of the mamelons facilitates:

- a. Creation of the mamelon effect.
- b. Illumination of the incisal edge.
- c. Reduction of the internal value of the incisal area.
- d. Augmentation of the internal value of the incisal area.

8. Which aspect of natural dentition causes opalescence?

- a. Dentin.
- b. Stains.
- c. Enamel.
- d. None of the above.

9. The chromatic chart should be compiled from the dehydrated tooth. This statement is:

- a. True.
- b. False.

10. The proteinaceous layer:

- a. Causes light reflection.
- b. Is transparent.
- c. Controls luminosity through the internal diffusion of light.
- d. None of the above.