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Shade Selection: Blending of Conventional and Digital Methods - An Updated Review

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Abstract: Major challenges in cosmetic dentistry are to accomplish appropriate and satisfactory reproduction of natural shade of teeth. The procedure of choosing a shade can be performed using visual method or by an instrument. The kind of shade guide, individual ability to choose shades and conditions the choice is made under, all have influence on reliability and accuracy of the procedure. Therefore, it is necessary to introduce instrumental color determination in everyday work .They include RGB devices, colorimeters, spectrophotometers. The impact of the color science can be seen on various restorative materials ranging from ceramics to maxillofacial prosthetic materials. Good communication between the dental team of all these details is paramount to a successful aesthetic result.

Keywords: Tooth color, shade guide, spectrophotometer, colorimeter.

Introduction

Dentistry represents a significant portion of dental services encompassing on the blend of science and art. New improvements in technologies in dental materials and consequent aesthetic enhancement of direct and indirect restorations require trained practitioner enabling to choose the right shade. The path to the appropriate choice of shade for future restoration is not simple. Achieving the satisfying morphological, optical and biological form of a restoration is one of the most important goals of esthetic dentistry and dentistry.[1]

Color is defined as subjective perception of the quality of light and colorimetry is a scientific discipline which enables measuring and specifying the color.[2] Basic knowledge about shades is prerequisite to make the right choice. In 1900, American painter and teacher of art Albert Henry Munsell wrote about tri-dimensional property of color and parameters such as: hue, chrome and value or lightness.[3]

Shade selection procedure in cosmetic dentistry can be done by visual or instrumental color determination. Visual color determination considers comparing the shade with already known physical standard accepted as a reference. Basically, it is the use of color atlas or shade guide in more or less controlled conditions.[4] The most common and widely accepted way to choose shade is by the shade guide.The first shade guide "Tooth Color Indicator", made by Clark, and contained 60 porcelain samples of shades. Years back "Vitapan Classic Shade Guide" was the gold standard in choosing shades. Although still in use today, it shows various shortcomings successfully overcome in new guides.[5,6] Hall (1991) work was base for the development of "Vitapan 3D-Master Shade Guide" which was the first commercial system for determining and reproduction the shades based on the principles of colorimeter classification.

Vita pan 3D-Master Shade Guide is a highly improved compared to the classic shade guides with better organization, wider range and uniform distribution of shades.[5,6]A new version of VITA Tooth guide 3D-Master called "Linear guide 3D Master" is also available. It has a practical linear structure of shades more suitable for dentists who use Vitapan Classic shade guide which also has a linear structure of shades.[5] The instrumental color determination requires devices such as spectrophotometers, tri-stimuli colorimeters, spectroradiometers as well as digital cameras.[7] This article discusses the

different selection procedures involved for correct shade matching, the various systems available for the restorative dentist, and the recent developments in the field.

Shade matching in dentistry

Teeth are often termed "polychromatic" and have the variation in hue, value, and chroma within the teeth and give three dimensional depth and characteristics. Christopher8 stated that the difficulty of shade selection is that clinicians must be able to interpret a multi-layered structure of varying thickness, opacities, and optical surface characteristics. This can affect the way that the eye perceives color. He stated that a number of related factors in selecting shades must also be understood to achieve a successful result. These factors includes (Winter 1990) translucency, contour, surface texture, luster, and fluorescence. The various Color perception elements are, the light source, the tooth, including textures and layers, the environment, the receiver (eye)

Ideal environment for the perception of color is a challenge, and this environment does not routinely occur in the dental operatory. Even in the ideal environment, the following limitations can make accurate color assessment problematic. Retinal fatigue is rapid. The inability to accurately distinguish hue and chroma is most noticeable at times of fatigue, and the color may be perceived as faded. Background effects trick the eye/brain interpretive process. Binocular difference in color results in a perception variance between the right and left eyes.

Measurement of color

Color determination in dentistry can be divided into two categories, visual and instrumental

Visual technique

Dental shade guides are shade matching tools used most commonly by the clinicians in day to day practice. Although the groups of tabs of most shade guides appear to be well arranged, the overall tab arrangements of some shade guides seem illogical because they contain light and dark tabs within each of the groups. The fact that tab arrangement can influence shade-matching results increases the importance of this issue.9. Group division of shade guides is necessary for reducing the number of potentially adequate tabs as quickly as possible. It is easier to work with fewer tabs, because the vision pigment depletes within seconds (it regenerates quickly, as well). To achieve consistent group division, the total color difference (E*) between the lightest and the darkest tab should be divided into several equal segments. Laboratory and simulated clinical conditions have demonstrated the effectiveness of this tab arrangement (small discrepancies recorded by different color-measuring devices only confirm the efficacy).9

The most popular shade guides include the vitapan classical shade guide, Vita 3D master shade guide system, and the chromascop shade guide system. The shade tabs arrangement in the Vita Classical is by hue whereas in the Chromascop guides,10 the tabs are arranged in five clearly discernible value levels. VITAPAN introduced in 1956, the current American Dental Association gold standard for monitoring of tooth whitening, is supposed to correspond to decreasing lightness (from left to right). A very popular shade guide where in tabs of similar hue are clustered into letter groups A (red-yellow), B (yellow), C (grey), D (red-yellow-gray), and chroma designated with the numerical values (e.g. A1). The manufacture protocols include hue selection followed by chroma and value effect.

Classical shade guide introduced by Miller11was too low in chroma and too high in value when compared to natural extracted tooth samples. The "value scale" is inaccurate in terms of decreasing L* values, exhibiting redundancy and uneven lightness differences among neighboring tabs, which to a certain extent compromises the results of clinical studies that have been performed so far.9 The Vitapan 3D master shade guide, introduced in 1998, system reflects systematic and equidistant coverage of the natural tooth shade spectrum. The design features selection of value levels followed by the chroma and determination of hue.

Bayindir et al12 stated that the Vitapan 3D master shade guide system results in lower coverage errors than the Vita lumin or Chromascop shade guide systems. Ahn et al. 13 concluded that the color distribution of the Vitapan 3D master shade guide was more ordered than previously reported color distributions of other, traditional shade guides. However, the interval in the color parameters between adjacent tabs was not uniform. According to the literature, the new Vita Bleached guide 3D master shade guide (Vident), designed primarily for tooth-whitening monitoring, has significant advantages over the Vitapan Classical: the tab arrangement corresponds to visual finding, it includes extra light shades, the color range is almost doubled, the color distribution is more uniform, and the chroma steps are consistent.

Christopher et al 8 suggested the shade selection sequence to be as follows:

1. Make sure teeth are clean and unstained before attempting shade selection.
2. Shade selection should be completed before preparation as teeth can become dehydrated and result in higher values.
3. Shades should be done when the dental team is not fatigued as in the end of the day.
4. Ensure surgery surroundings are of neutral color so that there is no color cast onto the teeth.
5. Remove lipstick; ask patients not to wear lurid clothing or any items that may distract the attention of the teeth.
6. Patient should be in an upright position at a level similar to the operator and the shade guide should be at arm's length. This ensures that the most color sensitive part of the retina will be used.
7. Observations should be made quickly (5 seconds) to avoid fatiguing the cones of the eyes. If longer than this, the eye cannot discriminate and the cones become sensitized to complement the observed color.
8. Blue fatigue can accentuate yellow sensitivity so dentists can look at a blue object, bib, etc, while resting the eyes.
9. Use color corrected light illumination, which should be of a diffuse nature.
10. Choose basic shade at the middle of the tooth - using the Vita System 3D-Master technique of value, chroma then hue. Use blue card to avoid chromatic adaptation.
11. Viewing tabs through half-closed eyes can decrease ability to discriminate color but increases the ability to match value. Look at the other parts of the teeth, dividing the teeth into 9 sections from apical to incisal, and mesial to distal.
12. Necks of shade tabs often can be removed as they have a great deal of colorants that may introduce errors.
13. Examine tooth for translucency and any characterizations, e.g. craze line, hyopcalcification, etc.
14. Create a shade/chromatic map – divided into different sections to ensure correct placement of different effects, characterizations and shades.
15. Photograph teeth and tabs using different lighting conditions to minimize metamerism, e.g. flash (5500K) and natural daylight (6500K).
16. Photograph teeth at a 1:1 ratio for detailed characterizations.
17. Send digitized images and shade map to ceramist.

Conventional visual tools used to determine shade are highly susceptible to various optical illusions and contrast effects. Due to the errors with the use of commercial shade guides, many different devices and machine tools are used in order to make the color assessment more simple, rapid, precise, and perfect. The semi-translucent structure, small size, and irregular surface of teeth contribute to the complexity of this procedure. Several clinical studies have confirmed that computer assisted shade analysis is more accurate and more consistent compared with human shade assessment. The advantages are no influence of surroundings or lighting and the results being reproducible.[14]

Different types of technological shade systems includes: RGB devices, digital cameras, spectrophotometers, colorimeters.

1. RGB devices

RED, GREEN, BLUE image information to create a color image. They do not control key variables associated with accurate color determination.[14] ShadeScan™ measures shades over the entire tooth surface, then analyzes them and generate a shade match report. It likewise can generate a report to be used with any standard shade guide system. ShadeScan™ creates an image of the tooth with a translucency and characterization map, and then will generate a printed report. Besides using ShadeScan™ for crowns and bridges, the manufacturers suggest using it also for direct restorations and to monitor treatment.

2. Digital cameras

Digital cameras are efficient and easy to use and can be an ideal supplement for the clinician and lab technician in quantifying shade but alone not a very reliable method for shade analysis. [14]Factors such as illumination and the angle of the photograph will alter how color is perceived by the camera. Alvin et al.[15] stated the use of Commercial SLR cameras when combined with the appropriate calibration protocols showed potential for use in the color replication process. Spear stated the use of color-corrected professional quality film (e.g. Kodak EPN-100, E100-S, or EPP) and has a good photo lab to develop them, taking vector shots at 65-70° looking down with an incisal edge away from chroma and hue helps in increasing the amount of reflection.[16]

3. Spectrophotometers

It measures and records the amount of visible radiant energy reflected or transmitted by an object one wavelength at a time for each value, chroma, and hue present in the entire visible spectrum.[17,18] VITA Easyshade Compact is the device that meets the greatest number of requirements for choosing the shades in clinical settings . The device can be used to determine an overall tooth shade, the shade of each third of the tooth- cervical, middle and incisal, as well as to confirm the shade of the restoration . VITA Easyshade Compact is able to measure a wide range of colors which include VITA Linerguide 3D-Master, VITA Toothguide 3D-Master and VITAPAN A1-D4 classic shades.

4. Colorimeters

They provide measurements in CIELAB units (L*, A*, B*) that can compare the color parameters of different objects when analyzed mathematically. Colorimeters can be of two types mainly the photoelectric tristimulus colorimeters (Microcolor) and silicon photodiode array (Orient Scientific Ltd). Microcolor colorimeter (a photoelectric tri-stimulus colorimeter) is a self-contained measuring system that requires no external power source while a silicon photodiode array requires both an external power source and a standard light source; it is a compact color measuring instrument that is less prone to overheating and is cost effective.[19] Available colorimeters are X-Rite Shade Vision System and Shade NCC (Shofu). The shade vision system adds the advantage of shade information being sent to the dental laboratory via e-mail, disk, or by printout. The Shade Vision unit uses advanced colorimetry to scientifically determine the hue, value and chroma of the teeth. The Shade Vision unit will capture an image of the tooth and upload it to a personal computer for processing. Shade information can then be sent to the dental laboratory via e-mail, disk, or by printout. If the shade match information is sent by electronic file, the laboratory should have the proper software to interpret the data.

5. Stump shade selection

It is important to communicate the prepared tooth or “stump” shade to the ceramist so that they can build the restoration with the right opacity/translucency.[20] It may be necessary to use a more opaque ceramic to block out discoloration, e.g. an alumina- or zirconia based restoration may be a better choice than a glass-based ceramic.

Conclusions

Understanding the influence of different variables in shade selection from light illumination to the tooth’s hue, value and chroma and how the eye interprets this can assist in this selection. The use of the Vita System 3D-Master that allows a logical selection of color into hue, value and chroma. There are limitations of shade guides as they fail to account for the variability found in natural teeth, e.g. fluorescence, opalescence, translucency, enamel thickness, and objectivity. Effects of surface texture on light reflection and different characterizations must be recorded and duplicated in the final restorations. The use of technology with different devices in shade selection may eliminate subjectivity of choosing and the use of photography to communicate shades and characterizations has improved the selection process. A procedure of shade selection has been described to ensure consistent results considering the different variables that influence shade matching.

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