

Connotation for shade selection

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ABSTRACT

Patient's aesthetic demands and expectations in dentistry are ever increasing, the traditional "need - based" discipline, is also becoming "want - based". The current trend is resulting in a variety of new techniques, materials, and devices for the profession. This is particularly true for the advances related to color and appearance. Black stated that the best esthetic result was obtained when the proper color (hue) and translucency (value) were found. Shade selection done by visual or instrumental assessment should replicate the natural tooth color. Thorough knowledge of color and color perception is a must for an uncompromised esthetic treatment. This paper presents the significance of color, features affecting the shade, guidelines and sequence for shade selection.

Introduction

An "attractive smile" can be a prime asset to a person's appearance and can be powerful factor of ego and desirable life experiences of a human being. The goal of an aesthetic restoration is to achieve morphologic, optical and biologic acceptance. Wide and subtle gamut of colour is a real perceptual challenge for dentist, who has to match natural teeth for restoration. A restoration of wrong color will be like disharmony created by a discordant note in a symphony. The measurement of tooth color is possible using visual and instrumental methods. Visual method of shade matching is performed using dental shade guides under more or less controlled conditions. This is a comparison between a natural tooth and sets of tooth shaped tabs made of ceramic or resin. Instrumental assessment is performed using spectrophotometers, colorimeters, spectroradiometers, digital and spectral imaging. Properly selected and implemented instrumental methods are objective and can render useful information that can aid visual color matching. Color matching still remains one of the most challenging tasks in clinical dentistry. Following factors influence color and its applications during shade selection.

Color and color space

The phenomenon of color is a psychophysical response to the physical interaction of light energy with an object, and the subjective experience of an individual observer.

Shade selection involves the perception of color, which depends on three entities.[1,2]

1. Light source (illuminant);
2. Object; and
3. Detector (ocular or instrumental).

The light source can emit radiant energy of a range of wavelengths and this is characterized by the relative amount of energy emitted at each wavelength in the visible spectrum (380nm to 780nm). Object to be visible must transmit, reflect or refract part or

all of light, thereby producing the quality of color. Furthermore, different parts of the same object exhibit varying amounts of this phenomenon. A red object looks red primarily because it reflects red wave-lengths more than green and blue. The property of light source to influence color of objects is called "color rendition". There are three main illuminants within any dental practice; natural, incandescent and fluorescent. Natural sunlight is itself variable with light appearing blue at noon when the sun has fewer atmospheres to penetrate and red/orange during the morning and evening. Incandescent lighting is predominantly red/yellow and lacking in blue while fluorescent lighting is high in blue tones and low in red. There are special lights that are color corrected to emit light with a more uniform distribution of color that can be utilized. Initial shade selection should be initially made with these lights then the shade should be matched under different lights to avoid metamerism (the phenomenon that occurs when shades appear to match under one lighting condition and not another). When the energy absorbed by object is converted into light with longer wave length, in which case the object actually becomes a light source. This phenomenon is called fluorescence. The emitted light, a blue-white color, is primarily in the 400-450nm range. Fluorescence makes a definite contribution to the brightness and vital appearance of a human tooth. The reflected light intensity and combined intensities of the wavelengths present in incident and reflected light determine the appearance properties (hue, value, and chroma). A high value object often reflects most of the light falling on its surface and appears bright. The converse is true with a dark object absorbing most of the light and appearing dull or of low value. Hue is wavelength of light, and dependent on the spectral reflectance from an object. Chroma is the concentration of color or color intensity. The basic hue of the tooth is determined by the color of the underlying dentin, while value is a quality of the enamel overlay. Muia in 1993 stated, "The dentin imparts all the color. Enamel is like a fiberoptic structure conducting light through its rods". Chroma is the saturation of color in the dentin, but is influenced by the value and thickness of the enamel. Teeth are

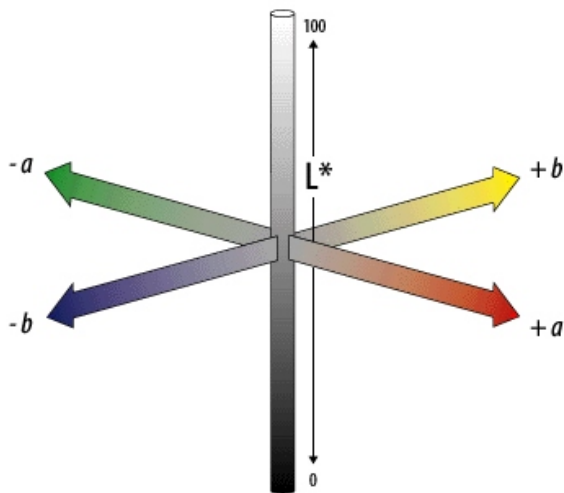


Figure1. CIE Lab color space.

often termed "polychromatic" and have the variation in hue, value and chroma within the teeth and give three dimensional depth and characteristics. A young dentition is characterized by opaque, high value enamel, which blocks underlying dentine. As teeth age, the enamel becomes more translucent and dull (low value) revealing the underlying dentine.

In 1976, the CIE (Commission Internationale de l'Eclairage) defined a color space, CIE Lab, that supports the accepted theory of color perception based on three separate color receptors (red, green and blue) in the eye and is currently one of the most popular color spaces. The CIE Lab color space represents a uniform color space, with equal distances corresponding to equal perceived color differences. In this three-dimensional color space the three axes are L^* , a^* and b^* (Fig. 1). The L^* value is a measure of the lightness of an object and is quantified on a scale such that a perfect black has an L^* value of zero and a perfect reflecting diffuser an L^* value of 100. The a^* value is a measure of redness (positive a^*) or greenness (negative a^*). The b^* value is a measure of yellowness (positive b^*) or blueness (negative b^*). The a^* and b^* co-ordinates approach zero for neutral colors (white, grays) and increase in magnitude for more saturated or intense colors. The advantage of the CIE Lab system is that color differences can be expressed in units that can be related to visual perception and clinical significance.[3]

The observer's visual system of eye and brain finally affects the overall perception of the color. Many individuals have some form of color-blindness and are incapable of seeing certain colors. If the condition is severe, the dentist can have a laboratory technician or a well-trained assistant match shades.[4]

Translucency, contour, surface texture, and luster affecting shade selection

The translucency pattern contributes to the shade by affecting value: with increasing translucency the value decreases. The amount,



Figure2. Vitapan 3D-Master shade guide

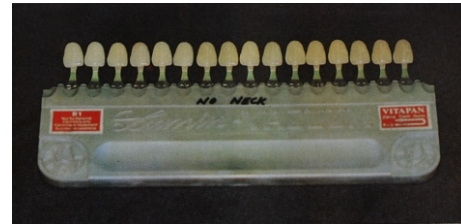


Figure3. Shade guide Vita Lumin type arranged in decreasing order of value (lighter to darker) and with neck of tabs grounded away to facilitate the selection of tooth shades.

location and quality of translucency vary with individuals and with age. Young teeth often exhibit a great deal of incisal translucency, with the enamel appearing almost transparent at times. With age, from daily functions like eating and brushing, the enamel becomes thinner and allows the underlying dentine to appear. This is seen in the older individuals with the teeth becoming lower of value and higher in chroma commonly seen in young adults. The pattern of translucency will dictate the depth and extent of the enamel and translucent porcelains built into the restoration.

Vanini (2001) has suggested that there is a definite pattern to the translucencies. He postulates that the sum total of all opalescent, translucent or enamel effects fall into one of three categories:

1. Intensive effects;
2. Opalescent effects; and/or
3. Characterization.[5]

Surface texture influences aesthetics by determining the amount and direction of light reflected off the facial surface. Texture should be designed to simulate the reflectance pattern of the adjacent natural teeth. Young teeth may have a lot of characterization with stippling, ridges, striations and lobes. These features may be worn away with age leaving smoother, highly polished surfaces. Surface texture of teeth can be vertical ridges, vertical grooves, horizontal ridges, horizontal grooves, perichymata, enamel pits and irregularities.[6]

Types of shade guides

The most popular shade guides are:

- o Vita Classic
- o Vitapan 3D-Master
- o Chromascope
- o Custom or specific chroma and value guides

Commercially available shade guides do not adequately cover the entire range of tooth color as seen in nature. These guides are made of porcelain without a metal backing, and the thickness of the porcelain

is much greater than the veneer on a metal-ceramic restoration. The porcelain used for shade tab is different from that used for restorations.[1]

Vitapan 3D-Master (Fig. 2) was introduced by Vita company dentists, in February 1998. Hall worked with the Vita to design a simple guide that incorporated all components of color: hue, value, chroma. Shade tabs are arranged systematically and logically, rather than randomly in the Classic shade guide. It consists of 11 fired porcelain tooth shaped samples built up with cervical, dentinal and incisal powders and composed of feldspar nepheline and high temperature ceramic pigments. The 11 sets consist of 26 samples ranging from lightest to darkest value, from lowest to highest intensity and from yellow to red. Vita Value, Chroma and Hue correspond similarly to Munsell value, hue and chroma representing the three dimensions of colour. The tabs are grouped into 5 categories, sequentially numbered with increasing value (1-5). All tabs within the value group have the same brightness. In each of the groups the chroma increases from top to bottom. All the groups except 1 and 5 have 3 letters: L, M, R, which allows the hue to be chosen. L (light) is yellow, M (medium) is yellow-red, and R is a red hue. Documenting of this shade is with a number/letter/number system. The first number indicates the value group (1-5), letter is the hue (L, M, R) and the chroma (1-3). E.g. 3M2 is the 3rd value group, M hue sub-group, and 2 chroma level. The shades of the lightness level 3 cover 50% of the natural tooth shades. The shades of the lightness levels 2 and 4 cover an additional 46%. VITA has also created a bleached tab, labelled the "0" (zero) group, to allow dentists to create bleached restoration shades. One of the other advantages of the Vita System 3D-Master is the repeatability of shade selections with the system.[7]

Guidelines for shade selection

1. Shade guide must match the porcelain which the technician will be using for restorations.
2. Patient is asked to remove all the distractions (lipstick, heavy facial make up, ear rings and glasses).
3. Necks of shade guide (Vita Lumin) should be grinded away, because the correct color is determined from gingival half and not from the neck and the tabs should be arranged in decreasing order of value (lightest to darkest) (Fig. 3).[1,8] Ideally Vita System 3D-Master can be used.
4. Place the patient under different lighting conditions because the spectral reflectance from and tooth or else a color-corrected fluorescent bulb can be used as it closely reproduces natural daylight and also allows the truest relationship to exist between the shade guide and tooth.
5. Proper distance of operator from tooth should be 2 feet to 6 feet.[9]
6. Observations should be made quickly (5 seconds) to avoid fatiguing the cones in the retina. The longer the observer's gaze is held, the less there is to discriminate, and cones will become sensitized to the complement of the observed color. Since blue fatigue accentuates yellow sensitivity, the dentist should gaze at a blue object (wall, card, drape, etc) while resting the eye.
7. Ensure that the surrounding environment is of neutral color so that there is no color cast onto the teeth.
8. Shade should be matched by value, chroma and hue in that order.
9. To match value squint the eyes to reduce angular reflection and to increase light on rods (although color discrimination decreases, it facilitates selection of tooth's relative lightness or darkness.)
10. Shade selection should be completed before preparation as teeth can become dehydrated and result in higher values.
11. A shade/chromatic map - divided into nine sections apical to incisal, and mesial to distal to ensure correct placement of different effects, characterizations and shades is to be used.[10]

Sequence for shade selection

1. Distractions should be removed.
2. Quick rubber cup & paste prophylaxis should be performed and the area is rinsed thoroughly.
3. Seat patient upright with the mouth at operator's eye level.
4. Operator should be positioned between the patient and light source.
5. Quick observations should be made (5seconds).
6. Should gaze at blue object to avoid fatigue.
7. Scan the entire shade guide quickly and remove worst match by half closing the eyes. This will leave with few tabs.
8. If decision has to be made between two tabs, they should be held on either side of tooth and chosen for the best.
9. If no tab will permit good match than matching to the gingival portion of the shade tabs with the gingival area of the tooth and incisal segments of those tabs which most nearly match with the incisal portion of the tooth should be done.[1]

Shade selection for Vitapan 3D-Master

1. Selection of value tab is done by squinting.
2. Chroma should be selected by moving down in previously selected value group.
3. Hue should be selected from "M" row (yellow - red), "L" row (yellow), or "R" row (red-yellow).[7]

Stump shade selection

With the increasing use of all-ceramic restorations, 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. 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 like Empress[2].

Later after shade selection pattern of translucency, characterization like craze lines, areas of hypo-calcification should be examined, located and extent measured by means of periodontal probe or by miniature measuring device are noted on patients chart including even texture (young teeth may have a lot of characterisation with stippling, ridges, striations and lobes but these features may be worn away with age leaving smoother, highly polished surfaces).

Transfer the details like effects, characterizations and shade on patient's chart with drawing of facial surface of tooth with different sections (also a custom made guides or extracted teeth can be sent to specify these features) on to laboratory work authorization, photograph of teeth and tabs using different lighting conditions to

minimise metamerism, e.g. flash (5500K) and natural daylight (6500K) before and after preparations, shade tab, a cast including the contra lateral tooth and photograph of teeth at a 1:1 ratio for detailed characterizations can be sent to communicate with the laboratory.

Instrumental assessment of shade

Colorimeter/Spectrophotometric analysis measures the spectral reflectance, transmittance, or relative irradiance of a color sample. The late 1990's marked the birth of instrument based color measurement systems, with the development of the ShadeScan system (Cortex Machina, Montreal, Canada). This was first effort toward a shade analysis system for complete tooth surface measurement. Spectrophotometers are amongst the most accurate, useful and flexible instruments for overall color matching and color matching in dentistry. They measure the amount of light energy reflected from an object at 1-25 nm intervals along the visible spectrum. A spectrophotometer contains a source of optical radiation, a means of dispersing light, an optical system for measuring, a detector and a means of converting light obtained to a signal that can be analyzed. The data obtained from spectrophotometers must be manipulated and translated into a form useful for dental professionals. The measurements obtained by the instruments are frequently keyed to dental shade guides and converted to shade tab equivalent.

Colorimeters measure tri-stimulus values and filter light in red, green and blue areas of the visible spectrum. Colorimeters are not registering spectral reflectance and can be less accurate than spectrophotometers.[11]

There are 3 basic types of devices used for shade selection:

1. Spectrophotometry e.g. Vita EasyShade (integrates a powerful spectrophotometer into a small and compact unit for determining the shades of teeth).
2. Colorimeter e.g. ShadeVision (incorporates a colorimeter and integrated light source).
3. Digital camera and RGB devices e.g. ShadeScan (features a digital camera linked to a LED spectrophotometer).

Overall, instrumental analysis is more accurate and reproducible than a visual assessment. However, the difference is clinically acceptable.[12]

Conclusion

The goal of Dentist and Laboratory Technician must unite biology & technique and understand creations of nature and implement them in

technology. The use of the Vita System 3D-Master 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. 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.

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