Review Article

Shade Selection in Dentistry: A Review

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Abstract

Contemporary dentistry is facing growing demands for esthetic tooth-colored restorations. This makes shade selection, on the chair-side and its accurate formulation in the laboratory, the key determinant to the overall success of these restorations. The process of shade selection itself is based on scientific, artistic, and physiological principles, which should be properly understood to avoid any shade mismatches and consequent remakes. Hence, the aim of this article was to review the basic principles involved in the shade selection process and present them in an easy-to-understand manner.

Keywords: Tooth shade, Shade guide, Principles of shade selection.

Introduction

Contemporary dental practice mainly revolves around three mainstays: the use of non-metallic materials, such as composite resins and ceramics; adhesion to dental structures; and the achievement of a natural esthetic look. The level of aesthetic requirement in restorations has risen spectacularly in recent years, and this has made it necessary for dental professionals to explore this field to satisfy the existing social demand in this area.

The first step to achieving clinical success in esthetic dentistry will therefore be to correctly identify the tooth color we need to imitate, the material that most closely matches and finally to communicate this information to the laboratory if the restoration is to be made out there.

Nature of Color

When we talk about color, we are making reference to a sensation which is captured by our eyes. The human eye is an organ specialized in the reception of images obtained from an electromagnetic radiation that we refer to as light and which actually corresponds to a narrow segment of the entire spectrum situated between the 400 and 800 nm wavelengths (colors of the rainbow). Radiations below these wavelengths are not visible to the human eye and are referred to as ultraviolet; those which are situated above these wavelengths are not visible either, and are referred to as infrared.

The sensation we call color would be that which corresponds to the wavelength of luminous radiation that reaches the eye. If this corresponds to the wavelength of one of the colors of the rainbow, we see that color. If it contain combined wavelengths of two colors, we perceive a new color composed of both of these colors; and when it contains all of them; we see the resulting color as white.[1,2]

Measurement of Color

The first problem we face is a failure to convey a clear and precise description of the color, a description that can be understood and reproduced by our technician and which can also be verified in the resulting restoration. This problem can be reduced by a process of measurement that is exact, reproducible and communicable.

There are generally three accepted dimensions of color:

- Hue (tonality): This indicates the feature which is normally referred to as color, directly related to the wavelength of the observed luminous radiation (e.g., red, green, blue, yellow…)
- Value (luminosity): This expresses the amount of light that makes up the color under study, corresponding to the tonalities of grey ranging from a maximum value (white) and a minimum value (black)
- Chroma (saturation): This refers to the amount of dye that the color contains the chromatic brightness that we

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observe. This dimension refers to the different dilutions of the base color we are starting from.

To these three dimensions, and within the field of dentistry, we must add a fourth one which would include all of the chromatic features that personalize the tooth apart from its average color, and which are fundamental for the reproduction of the color of a tooth.[3]

Elements that Influence the Appreciation of Color

We human beings appreciate the color of an object when we perceive through our eyes the light that reflects in it, or that goes through it, or both at the same time. Moreover, this is why we must pay attention to each of the different elements one by one.

The human eye as receiver of color

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. The basic hue of the tooth is determined by the color of the underlying dentine, while value is a quality of the enamel overlay. Muia in 1993 stated, "The dentine 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 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 dentin. As teeth age, the enamel becomes more translucent and duller (low value) revealing the underlying dentine. This layering can make reading of tooth color difficult since the value of enamel and surface luster often complicate color evaluation of the underlying dentine.

In the event of awareness of the possibility of suffering in color perception, substances or situations in which they are produced must be avoided, or some electronic measuring device must be used in order to avoid subjectivity and circumvent the problem. If the eye observes a given color over an excessively long period of time, a virtual image superimposes itself, an image which corresponds to the complementary color of the one observed, as a result of fatigue. This is known as complementary post-imaging, and it makes short readings of color necessary, thus impeding the occurrence of this phenomenon.

There is also another very important element, which is the eye itself. We have a short chromatic memory, and this is why we must observe two objects simultaneously and very closely to be able to appreciate whether their color is the same or different.

Environmental light

The nature of the light source that illuminates the clinic is essential. In fact, its spectrum will influence chromatic appreciation in a critical way. The ideal light for color measurement will be that which is closest to the light spectrum of daytime sunlight; this is the reason why a correct natural illumination is desirable at the moment of shade recording. Since this is not always possible because not all the clinics have access to this ideal natural light, and because at certain hours of the day, or at certain seasons of the year, daylight is insufficient, we must use artificial light sources. These are corrected fluorescent light sources which offer color temperatures of between 5000ºK and 6500ºK, and are suitable for all processes that require a correct chromatic perception.[4-6]

Observation under two different light sources (natural light and artificial light) is also interesting, in order to assure the selection to an even greater degree, because sometimes two objects (e.g., the color guide and the tooth) can be seen as the same color under one light source and as a different color under another one; this phenomenon is called metamerism and it must always be taken into account when a color is determined by eyesight.[7,8]

Industry has been trying to solve this problem through the use of normalized light sources, with a pre-established color temperature, which would help us to have available constant observation conditions at any time of the day. At the present time, the "Shade Light™" (KERR) (Figures 1 and 2) lamp is on the market, offering D65 light that provides ideal observation conditions, and given its relatively low cost and ease of use.[9]

The object of observation

The usual chromatic estimation technique consists in comparing the color of the tooth with an artificial guide and checking which of the samples of the guide is most similar to the studied tooth. The main problem in this case is that there are as many color guides as there are manufacturers, and at the same time, they are organized in different ways Figure 3.[6] The Figure 5 traditional guides that are most used are the Vita Classic and Chromascop, and these are organized by groups of hues: A, B, C, and D for Vita; and 100, 200, 300, 400, and 500 in the case of Chromascop. Dimensions relative to brightness and saturation (chroma and value) are noted from 1 to 4 in the Vita guide and from 10 to 40 with Chromascop.

Figure 1: Shade light

Figure 2: Clinical shade matching with shade light

Figure 3: Vita classical shade guide[10]

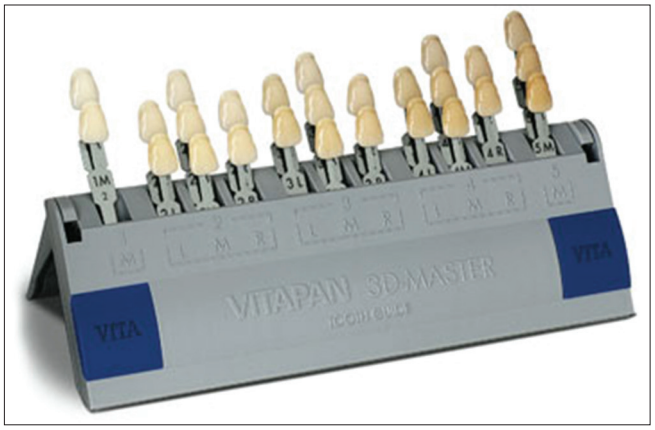

Figure 4: Shade guide Vitapan 3D-Master, by Vita

Today, there is a tendency to order the color guides on the basis of the luminosity of the colors and not according to tonality, due to the fact that our eye is more sensitive to changes in brightness than to differences in tonality. It is also important that a guide includes homogeneous chromatic differences between the different steps of these, but this normally is not the case.

These present-day concepts take form in the guide which is known as the Vitapan 3D-Master Figure 4, from Vita, which

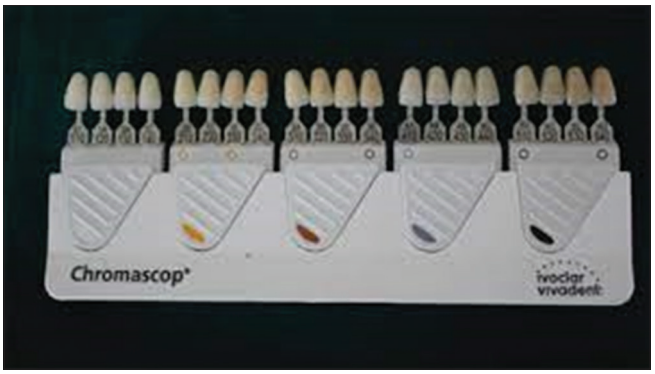

Figure 5: Shade guide Chromascop, by Ivoclar

Figure 6: Easy shade by vita[11]

Figure 7: Clinical shade matching with easyshade.digital shade guide[12]

establishes groups by their luminosity, decreasing from 1 to 5, and divides them into subgroups according to chromatic saturation, increasing from 1 to 3. It is then determined whether within these groups the medium color tone M is maintained, or whether it moves toward yellow L or red R. It would appear, according to the manufacturer, that this kind of organization facilitates work in dentistry, due to the fact that as we have seen, the eye better appreciates changes in brilliance and

saturation than changes in tonality, especially in lighter and less chromatic colorations, such as the those that correspond to normal colors in human teeth. There are even those who recommend reorganization of the color guides Figure 3 on the basis of lightness, instead of tonality. In this way, the Vita Classic guide would be organized as follows: B1, A1, A2, D2, B2, C1, C2, D4, D3, A3, B3, A3, 5, B4, C3, A4, and C4.[7]

The Clinical Process of Color Measurement

General Principles – regardless of which system is used, the principles for shade selection do not change.[4,8,13]

1. Teeth to be matched should be cleaned of all debris and stains.
2. Brightly color lipstick/makeup should be removed and bright clothing draped. Protective gloves of bright colors should be swapped out for a neutral color. The operatory walls should not be brightly painted.
3. Patient should be viewed at eye level, so the most sensitive part of the retina will be used.
4. Shade comparisons should be made under different lighting conditions. Initial shade may be taken under a color corrected fluorescent light and then reevaluated or confirmed in natural daylight. (Taking patient to an operatory window).
5. Shade comparisons should be made at the beginning of a patient's visit. Teeth increase in value, particularly if a rubber dam is used. (DESSICATION).
6. Shade comparisons should be made quickly (to avoid COLOR FATIGE), with shade tabs placed just under the lip and adjacent to the teeth to be matched. This ensures that the background of both the shade tab and the tooth to be matched are the same – essential to shade matching. Blue fatigue can accentuate yellow sensitivity so dentists can look at a blue object, bib, etc., while resting the eyes.
7. Examine tooth for translucency and any characterizations, for example, craze line, hypocalcification, etc.
8. Create a shade/chromatic map – divided into different sections to ensure correct placement of different effects, characterizations, and shades.

The first chromatic dimension to determine will be the value or brightness of the tooth, followed by saturation and tonality. It is important to note down the distribution of colors that we determine in a simple drawing. If the information expressed is very poor, the laboratory will be obliged to "invent" a tooth without knowing whether or not it corresponds to the natural model.[13,14] A more precise method would be to note down the color by thirds (cervical, mid and incisal third), somewhat more descriptive, but still ignoring the fine shades that personalize the chromatic aspect of a tooth. The correct way is for these basic chromatic annotations to be accompanied with a topographic description of the color, also referred to as a chromatic map, in which the distribution of the colors that the tooth presents (sometimes relatively many) must be precisely expressed with special attention to a clear description of translucent areas and particular color areas of the tooth

The inclusion of color photographs of the tooth together with the selected samples of the color guide can be of great help. The more information the dental technician has during the manufacturing of the restorations, the more natural and similar to the tooth they will be.[15,16]

All this information must be interpreted by the technician and transferred correctly to the manufactured restoration. The practitioner should be able to confirm that the color of the restoration corresponds to that which was planned before the patient arrives to the clinic, checking to see that the colors in the work order have been reproduced in the way they were requested.

Instrumental Color Measurement

Given the great subjectivity that predominates all during the color measurement process in the clinic, a series of electronic instruments designed to facilitate and make more objective the process of color measurement have recently been appearing on the market. The practitioner thus needs only to use these devices to be able to indicate the tooth's color in a more precise, reliable, and repeatable way.[17]

From the point of view of the clinical information that we are provided with, we can talk about one spot reading devices, devices which indicate the color at one spot of the tooth, and which therefore need several readings to be able to appreciate the regional color variations of the tooth; and extensive reading devices, capable of capturing all of a tooth's surface each time, or even of several teeth simultaneously, and which with a computer program can draw up a chromatic map of the tooth.

Chromatic maps obtained with these devices are usually very detailed and it is sometimes feasible to choose the color guide in which the annotation method is preferred; some of these devices even allow for the personalization of the guides, which can be made up with specific combinations of restorative materials. This opens the door for allowing their intraoperating use in direct restoration with composite or with CAD-CAM manufacturing systems for in-clinic restorations (CEREC-3D, Sirona).

One of the most interesting applications for these devices is the objective measurement of the results obtained in vital whitening treatments, making it possible to clearly verify the degree of effectiveness obtained.

According to the action principle, clinical color meters are based on the analysis of RGB digital imaging (Shadescan, Ikam), spectrum photo metering (Spectroshade, Easyshade) Figure 7, or color metering (Shadevision, Shadeeye-NCC, Digital Shade Guide) Figure 6.

The main disadvantage of these electronic systems is their cost, which is very high in some cases, and sometimes the technical complication, which makes some professionals decide not to use them. The advantages are the elimination of subjectivity in the color measuring process, and a great improvement in

being able to reproduce the colour (Paul *et al*.), the elimination of the environmental factor in color measurement due to the utilization of constant light sources that are calibrated each time they are used. Another very important element is that if the laboratory is working with the same system, the control of the desired chromatic reproduction is total.

Conclusion

Color measurement may seem to be a minor element within the field of Restorative Dentistry, but its importance is essential, although not from the biological point of view. However, given the present-day level of esthetic exigency, a technically correct restoration can be a clinical failure if it fails to achieve the aesthetic integration the patient nowadays demands.

Knowledge of the correct use of the conventional color measurement systems is becoming more and more important if we wish to satisfy present day esthetic demands. This, together with the gradual entry and perfectioning of the electronic color meter systems, will serve to reduce the possibilities of esthetic failure, and thus increase the quality of restorations.

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