SHADE MATCHING IN RESTORATIVE DENTISTRY: AN UPDATE

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Abstract:
In the current media-driven era, the primary need has turned to aesthetically acceptable restorations which requires proper shade selection. Shade matching is one of the most challenging phases of restorative dentistry. The process of shade duplication has many attributes like environment, practitioner, lighting conditions and more that can lead to negative results. If proper protocol is not followed, a practitioner can make mistakes during the process. It is, hence, of utmost importance to have proper knowledge and understanding about the concepts behind shades and how to select them to achieve the most natural appearance of teeth. The current study focuses on understanding the concept of colour, its dimensions, factors that affect the tooth shade, optical properties of the teeth and by what methods can be used to measure teeth shade, and their recent advancements. This Study also focuses on the preferred clinical setting for the shade selection.

Key Words: Shade matching, Dimensions, Factors affecting shade, Optical properties

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INTRODUCTION

The esthetic dentistry is centered on three concepts –non-metallic restorative material (composites and ceramics), adherence to the tooth structure and achieving the most natural yet esthetic appearance. It is very necessary for a dental professional to understand aesthetics to satisfy the demands of society. And the best way to achieve this is by correctly identifying the right color and trying to imitate it by finding the material that most closely matches the tooth. (1)

Basically, two factors, intrinsic and extrinsic colors affect the tooth shade. Intrinsic color depends on the property of enamel and dentin that reflect the light, which can be affected due to some systemic pathology, or a pulpal disease. Extrinsic color depends on material absorption by the surface of the tooth, which inturn depends on the dietary intake of the individual. (2, 3)

THE THREE DIMENSIONS OF COLOUR

Colour is a subjective attribute that cannot be measured objectively, whereas hue value and chroma are objective in nature, and can be measured. The concept of three dimensions of colour was taken from the Musell Colour Order System.(4)

Perpendicular to the vertical axis, around it is the colour wheel that tells us the hues and chroma. (5, 6)

Hue

According to Munsell, hue "is that quality by which we distinguish one colour family from another, as red and yellow, green from blue, or purple." It is basically the character of colour that differentiates it from one family to another. (4)

Value

Value is the property of colour where we define the brightness of it. Munsell defined it as "quality by which we distinguish a light colour from dark colour." It is an achromatic scale in which we match the 'gray' of the Value scale to the lightness or the darkness of the colour. Though there are many shades of gray, in Munsell System only ten shades are used which ranges from 0-10, where o is pure black and 10 is pure white. 'High' value is for lighter colours and 'low' Value is for darker colours. (4)

Chroma

Chroma is the brightness or the saturation of a colour. Munsell said, "It is that quality by which we distinguish a strong colour from a weak one: the departure of a color sensation from that of white or gray; the intensity of a distinctive Hue; color intensity." It is in a way, the chromatic amount. (4)

FACTORS AFFECTING THE SHADE OF TOOTH

Age

Tooth shade and age of the individual is found to have a definitive relationship. Studies show that age has a significant influence on the shade of the tooth.

- **Goodkind RJ, Schwabacher WB (1987)** conducted a study design in which they investigated the natural colour of the anterior teeth, in vivo, using a fiber-optic colorimeter. They observed that after the age of 35, the teeth shade starts getting darker and more saturated. (7)
- **Esan TA, Olusile AO, Akeredolu PA (2006)** did a study to understand the possible relation between tooth shade and gender, age and skin tone in 212 edentulous individuals in black Africans. They used a Vita-Lumin shade guide to assess the tooth shade. It was seen that there is a statistical difference between tooth shade and age.(8)
- **Rodrigues S, Shetty SR, Prithviraj DR (2012)** conducted a study on 400 individuals to evaluate the shade differences in different age groups and gender. To evaluate the shade of the teeth, they used three different shade guides that are Vita Lumin, Chromascope, and Vita 3D Master. They found that there is significant darkening of the shade of tooth with increase in age. (9)
- **Veeraganta SK, Savadi RC, Baroudi K, Nassani MZ (2015)** designed a study to investigate the differences in tooth shades with respect to age, gender and skin tone. They did this study on 100 subjects between the age group of 16 to 55 years. The tooth considered was left or the right of the permanent maxillary central incisors, of which the middle third was assessed. Vitapan 3D Master shade guide was used to decide the shade of the tooth. On analyzing the results, it showed a highly significant difference between the two age groups (Group I: 16-35 years and Group II: 36-55 years). Group II showed a higher proportion of darker shade teeth, i.e. more the age, darker is the tooth shade. (10)

In conclusion to the above studies, it can be said that there is a relation between the two factors, age and tooth shade. As age increases, tooth shade gets darker. This can be due to the fact that there is formation of secondary dentine by the age of mid 30's. In a study by Hasegawa A, et al, it was found that the incisal site was getting darker by age. It can be due to the natural wearing of teeth by age. (11,12)

Gender

- **Goodkind RJ, Schwabacher WB (1987)** constructed a study design in which they investigated the natural colour of the anterior teeth, in vivo, using a fiber-optic colorimeter. They measured three sites of tooth, the incisal, the middle and the cervical third. According to the demographic details of the subjects, the subjects were identified as male and female. It was found that the female counterparts had lighter and less saturated colour shade than that of male. (7)
- **Esan TA, Olusile AO, Akeredolu PA (2006)** did a study to understand the possible relation between tooth shade and gender, age and skin tone in 212 edentulous individuals in black Africans. They used a Vita-Lumin shade guide to assess the tooth shade. They found that men are more likely to have darker shaded teeth than females. And, it was statistically significant. (8)
- **Rodrigues S., Shetty S.R., Prithviraj D.R., (2012)** conducted a study on 400 individuals to evaluate the shade differences in different age groups and gender. The evaluation of the tooth shade was done by the use of shade guides- Vita Lumin, Chromascope, and Vita 3D Master. It was observed that though the incidence of darker shade in men is more than female, there was no statistical significance to support this. (9)
- **Veeraganta SK, Savadi RC, Baroudi K, Nassani MZ (2015)** designed a study to investigate the differences in tooth shades with respect to age, gender and skin tone on 100 individuals having both the gender groups, male and female. On statistical analysis it was noted that there was no statistical difference between both the gender groups. (10)

Though all the studies together say that men tend to have darker shade of teeth than females, only half of the articles' results were statistically significant. But it can be due to the ratio of both the genders considered in each study.

OPTICAL PROPERTIES OF TEETH

Metamerism

Metamerism is a phenomenon in which two colour-matching objects appear to be different under different light sources. This is due to the incident light's spectral content being different, hence the light reflected or transmitted through will also be different. The perceiving of colour depends on the illumination under which the shade is being observed. Pupillary diameter is regulated by the intensity of the light, which then controls the amount of light that will cause retinal receptors' stimulation. (13)

Translucency

The natural tooth of a person has various gradients between opaque and transparent. The amount of translucency differs from individual to individual and with age. With age the translucent part of the tooth, which is usually the incisal edges in younger individuals wear off, thus decreasing the translucency of the tooth too. (14) The refractive index of enamel, which is 1.62, also affects the translucency. And the refractive index depends on the health of enamel. If the enamel layer is demineralized, the translucency changes as the RI changes too. (3,15)

Fluorescence

Fluorescence is a phenomenon in which shorter wavelength radiation, which is invisible light, 1-400 nm, is absorbed and is emitted back in much longer wavelengths, 430-450 nm, which is visible light. Fluorescence gives the human teeth vitality. In human teeth, this property is primarily due to dentin. On increase of chroma of dentine, the fluorescence decreases. (16, 17)

Opalescence

It is a property caused by the enamel in a natural tooth, due to the different refractory indices of organic and inorganic components of enamel, as well as hydroxyappetite crystals' property scattering the incident light. The long wavelength waves go through the tooth, whereas the short wavelength waves incident on the tooth are reflected back. This results in giving teeth a bluish gleam like appearance, which can range from blue to gray to white colour. (6)

MEASUREMENT OF COLOUR

Maintenance of the natural shade of the tooth is the most challenging phase of restoration for esthetics. For measuring shades, there are two broad ways- visual technique and instrumental technique.

Visual technique

For visual measurement, shade guides are the most conservative yet feasible technique. It is most commonly used. In clinical dentistry, visual technique is the most frequent approach. Shade guides are a set of standard fabricated shades that are used to compare the natural teeth with them. Shade guides are based on different materials such as acrylic based, ceramic based, composite based. There are different types of shade guides used in the clinical practices. (3)

1. Vita Classical Shade Guide

This shade guide is divided into four groups- A, B, C, and D. It groups shades by hues. These groups

are further divided into sub-divisions, marked in Arabic numbering system, from 1-14. The total shades present in this guide are 16. Group A is for red and brown, group B is red and yellow, group C has gray, and red and gray in group D. As there is increase in number, chroma also increases, but the value decreases. (Fig 2) (3, 18)

Figure 2: Vita Classical Shade Guide [3]

2. Vita 3D Master Shade Guide

It is a shade guide consisting of 26 samples, which are organized into groups of 5 on the basis of their value. Each group is arranged in two or three axis. Hue is arranged in horizontal axis and chroma is arranged in the vertical relation. They are arranged in yellow to red order, i.e. lowest to highest intensity. Each group is numerically assigned a number; from 1-5 where 1 has the highest value and 5 has the lowest value. When moving from top to bottom, the chroma increases. Except for the 1st and the 5th group, the rest groups are assigned letters, L, M and R. These letters represent different hues; L represents yellow, M represents yellow-red and R for red hue. (Fig 3) (3,19)

Figure 3: Vita 3D Master Shade Guide [3]

3. Chromascop Shade Guide

On the basis of hue, this shade guide is categorized into 5 groups- 100 meaning white, 200 for yellow, 300 for orange, 400 for gray and 500 for brown. Then each of these groups is divided into increasing order of chroma from 10 to 40. (Fig 4) (19)

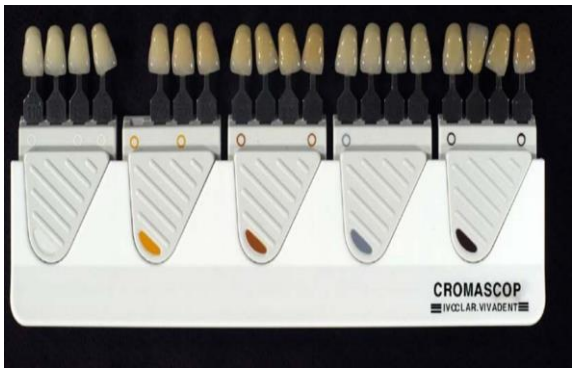

Figure 4: Chromascop Shade Guide [18]

Shade guides are not only the most commonly used methods to detect shade, but also readily available, feasible and durable. They make it easy for the practitioner and clinician to communicate regarding the shade of the tooth. But the downside is, each company has different shade coding and the material used for the shade guide can be different from the material used for the restoration. It is also subjective and can be affected due to factors such as the light under which the shade is being compared, or the practitioner who is comparing. (3),

Instrumental technique

Due to the subjective nature of shade guide usage, there was development of instrumental techniques. Though they are expensive, and not easily available, they are rapidly increasing in common practice.

1. Spectrophotometers

Spectrophotometers are considered to be one of the best color detectors. They are flexible and precise. At every 1-25nm intervals, they measure the amount of light energy that is reflected from the object. A spectrophotometer contains-

- An optical radiation,
- A means of dispersing light,
- For measuring, an optical system,
- A detector, and
- A means of converting light obtained to a value/signal that can be analyzed.

The obtained value/data is then converted into a form which can be easily be used by the dental practitioner. From the gained data, they are compared with the shade guides and the appropriate shade guide is selected. It was found that, there is 33% increase in precision on using spectrophotometers than the conventional method. (Fig 5) (Fig 6) (20)

Figure 5: EasyShade Compact spectrophotometer.

Figure 6: Colour measurement by spectophotometer

2. Colorimeters

Tri-stimulus values are recorded in the colorimeters. From the visible light, they filter the red, green and blue regions. There are three databases collected through this, for incisal, for middle and gingival third. Through this database, we can get a full image of the tooth. Due to their lack of ability to record the measure the reflected energy, they are not as accurate or as precise as spectrophotometers. (3, 20,21)

3. Digital Cameras and Imaging Systems

Digital camera and Imaging is the most basic method of electrical or instrumental shade selection method. But even this method has a certain degree of human eye involvement. Even the quality of image and camera affects the shade selection. Many techniques are used to transfer this data into the dental colour information. One of the ways is by using software, and one such software is ClearMatch. It uses a system that uses high-resolution images. They collect shades over the entire tooth, known as reference shades, and that data is used in the shade selection. The software has an in-built database according to the normal industrial colour shade guides. (19, 20,21)

CLINICAL SHADE SELECTION

Working Site lighting

If the observer, in this case, a clinician is free of any pathological disease that might affect his/her ability of chromatic perception colour, the factor that needs to be considered is the light. For shade selection, the ideal light is considered to be midday sunlight. As compared to the rest of the day, midday has the same wavelength of the blend of whole light. Mornings and evenings have more red and yellow wavelengths, hence affecting the shade matching process. The type of light illuminated, affects the pupil, which controls the amount of light entering the eyes, which further controls the retinal receptors.(13, 22)

Distance and position of the patient

For match shading, the ideal distance is considered to be around 61 cm to 183 cm (2-6 feet). The patient should be at such a level where their teeth are at the height of the practitioner's eye level. (23)

Condition of teeth

The tooth that is being assessed should be free of any biofilm layer or stains or any other sorts of deposition over it. It should be moist with saliva, as a dry tooth surface appears to be whiter. That is why the colour matching is done before applying a rubber dam as the tooth on isolating becomes dry and saliva can no longer come in touch with the tooth surface. The tooth, while selection of shade, should be divided into three parts, the incisal area, which tells us the translucency, the middle third, and the gingival third, that provides us with the chroma. (23, 24)

Environment

The background where shade is being determined should be devoid of any bold colours or patterns that might affect the practitioners perception of colours. (3)

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