Shade Guide in Prosthodontics : A Review

Abstract:
Shade matching includes striking a fine balance between managing practical goals against individually held expectations. The placement of cosmetic restorations, which are a crucial component of routine practise, depends on consistent and accurate shade selection. These colours should be formally and quantitatively recorded within a mathematical formula so they may be projected on device/computer storage and apps. The technique of shading is complicated by the differences between natural teeth and ceramics, including the layers, degree of transparency, opacity, and how colours reflect. For results those are harmonious and visually pleasing, choosing and making prosthetic replacements requires greater skill.

Key-words: Characteristics of colors , color models , Munsell color system , guidelines for shade selection , recent advances

Introduction:

Dental shade guides are a collection of colour guidelines that closely resemble the hue of tissues that dentists seek to restore, such as tooth structures, gingival tissues, or facial structures in facial prosthodontics, such as skin, mucosa, eyes, etc. [1]Numerous research have determined that the shade determination approach is crucial for colour matching. Similarly, conventional shade choosing in ideal circumstances is a matter of personal preference.[2] However, in addition to using these innovative technologies, dentists must have a thorough understanding of colour and the natural appearance of teeth in order to obtain the best outcomes. [3]

Database:

A thorough investigation was done between April 1952 and March 2022.A PICOS frame work was used to guide the search method. The following electronic database was used to find peer-reviewed journal articles: Google Scholar (http://sholar.google.com), Science Direct (www.sciencedirect.com), and Pub Med (www.ncbi.nlm.nih.gov) are three online databases.

Charecteristics of Colors :

Properties of Color: Hue, Value, & Saturation

Hue :

Hue is simply a color's name. The terms "hue" and "colour" are equivalent and can be used to describe either the colours of light or their spectral counterparts

(Figure – 1)

Value:

A. Lightness or Darkness of a hue in a simple form.

B. White represents the maximum value. Between black and white, intermediate grey is a middle or middling value that is neither dark nor light. Black is the absolute minimum value.[4]

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Saturation :

Chroma and saturation confer to hue intensity, or the level of pure colour in a sample. It explains the contrast between dull and vibrant.

Figure 1 – The twelve – shaped color wheel of Johannes Litten

Other characteristics of colour:

Transparent,opaque, translucent :

Every time light moves from a source to a surface, a small quantity is lost, and a tiny fraction of that light immediately reflects back. An item is said to be opaque if all of the light that it receives is either reflected or absorbed. A substance or item is transparent if it transmits all (or nearly all) of the light that it receives. A common example of a transparent substance is window glass.

Iridescence :

Iridescence is a property of surfaces where the colour shifts depending on the observer's angle of view.

Luminosity :

In colour theory, the word "luminosity" frequently arises. It refers to the quality of producing light without producing heat.The adjective "luminous" is frequently used to describe colours that reflect light very well, as well as media like watercolour, dyes, and markers that have a high light reflectance.[5]

Metamerism :

When inspected with a different light source, an object may appear to be one shade of a given colour under one type of lamp yet look quite different. This experience is a metamerism.[6][7]

Factors That Influence Our Perception Of Color:

Color Context:

Various civilizations might assign various meanings to the same color. When many cultures are taken into account, colors can be used to distinguish between high-end and low-end products, lighthearted and serious, masculine and female, young and old, or even to signify a rite of passage.

Linguistics relativity and colors :

The Linguistic Relativity Hypothesis of Benjamin Whorf contends that a person's language restricts and shapes what they can experience. Not every language has an equivalent for every idea based on color.

Climate :

According to Jaensch's research, those who live in hotter, tropical climates with lots of sunlight choose bright, warm colors while people who live in colder climates favour less saturated, cooler hues.[8]

Shade perception is impacted by light characteristics :

a) A tooth's apparent brilliance depends on how much light is reflected; the more light is reflected, the brighter the tooth will look.[9]

b) The process of absorption, in which an object selectively absorbs some wavelengths of white light while reflecting others, is the most frequent source of colour.[10]

c) Light is completely transmitted through transparent materials like plain glass rather than being reflected or absorbed when they are transparent.[3]

d) The deflection of a light beam within the incident material when it moves from one medium to another with different refractive indices. Refraction is what causes a prism to divide white light into multiple colours.[11]

e) A certain wavelength of light can be absorbed and subsequently reemitted as a longer-wavelength radiation; a process known as fluorescence. [3]

Different Types Of Color Model:

A colour model is a mathematical model that uses some mathematical functions to quickly transform the position of the light's color coordinates into three color components in three dimensions.

According to the uses for image processing, color models can be split into three categories.(Table – 1)

A. Device-oriented colour models :

They are related to and impacted by the signal of the device, and the instruments employed for displaying t h e m have an impact on the color that results. [12]

B. User-oriented colour models :

These models enable the user to describe and approximation what he perceives from displaying the color. They are viewed as a path that existed between the observer and the device handles the colour information.

C. Device-independent colour models:

These colour models are unaffected by the qualities of the supplied device, and the same color will be produced by a given combination of parameters without taking the performance of the device into account.[13][14]

Color model	Classifications
Munsell	Device independent
RGB, CMY(K)	Device dependent
YIQ,YUV, YCbCr	Device dependent
HSI, HSV, HSL	User oriented-Device dependent
CIE XYZ, CIE L*U*V*, CIE L*a*b*	Device independent, color metric

Table – 1 types of color models[12][14]

Munsell Color System:

The American painter Albert Henry Munsell created the first effective and commonly used colour scheme during the first decades of the twentieth century.

The three-dimensional Munsell color space, which was developed by Professor Albert H. Munsell in the first decade of the 20th century, is where any colour is specified in the Munsell color system, which is based on the steps of visual perception. Munsell Hue (H), Munsell Chroma (C), and Munsell Value (V) are the three components that make up this system. They are represented in the Munsell notation, which takes the form H V/C.[15]

Hue :

Sunlight is made up of every spectrally pure colour imaginable, but they are all balanced so well together that no one colour dominates, giving off pure white light as a result.

When a sunlight ray passes through a prism, it separates the light into a band (the spectrum) of its individual colors, such as red, yellow, green, and blue, and this naming of each colour to distinguish it from the others reveals THE HUE or common name of the colour.

Value :

There are no colors visible in pure white since it is so light. There is no color seen in absolute black since it is so dark. However, there are many levels of light strength that can be recognised between the two, ranging from the darkest grey just above black to the lightest grey just below white.Perfect black is represented by the value 0 at the bottom of the value scale. The level above is 1 (below which few Blacks move), then comes 2, 3, 4, and so on all the way up to White at level 10, which is the following level.

Chrome :

It is possible for two colors to share the same value and hue (for example, both red) (That is neither lighter nor the darker than the others)and yet have a different color intensity. One might be a bright red, and the other could be a pale, greyish red. This variation is in the chroma dimension, which is used to quantify and indicate the level of colour strength (intensity).[16]

Color sphere and color tree :

Imagine a colored sphere with a black north pole, a white south pole, and an equator surrounded by a circuit of red, yellow, green, blue, and purple colors that blend seamlessly into one another. Imagine surface colors that have been subdued by the addition of neutral grey moving inward until they vanish in the vertical axis.[17]

General Principles of Shade Selection Procedure:
Start of the Appointment:

It is advisable to choose the shade of teeth at the beginning of the consultation, before they get dehydrated and after they have been cleaned of extrinsic stains. To ensure accuracy, it is a good idea for the dentist and staff to take a color perception exam.[18]

Light Source And Quality:

It is advisable to position the dentist chair facing a window, but not directly into the sun, as natural morning-afternoon light is the best for shade choosing.In comparison to sunrise

and sunset exposures,midday sunlight is thought to include an approximately equal blend of all light wavelengths, making it the best exposure for choosing a shade.[3]

The Observer :

View the patient at eye level to make use of the retina's most sensitive area. Have a close friend or member of your family assist you during the procedure. The ceramist is requested for assistance in complex colour cases.

Clothing and Surrounding Colors:

Remove any bright lipstick before covering the patient's clothing, the dentist, and the assistant with gloves that are natural in colour and pale blue or grey. Painting the operating room in grey and light blue is recommended. [18]Ask patients not to wear garish attire or anything else that might draw attention away from their teeth, and ask them to take their lipstick off.[19]

The state of the teeth :

There should be no plaque, other deposits, or surface stains on the tooth of interest or its neighbouring teeth. Before placing the rubber dam, colour matching should be done since the rubber dam causes the tooth to become dryer.There should be no plaque, other deposits, or surface stains on the tooth of interest or its neighbouring teeth.

Timing, patient position, and operator proximity to the tooth -

The optimal range for shade matching is between 61 cm (2 feet) and 183 cm (6 feet) away from the mouth cavity. In the dental chair, the patient should be seated such that their teeth are level with the dentist's eyes. Light should be directed at the patient's teeth as the operator stands right in front of them.[3][20]

Technique and steps for choosing colours -

It is advisable that whatever brand product is being used, the appropriate shade guide should also be used. The longer the observer's gaze is held, the less there is to discriminate and cones will become sensitised to the complement of the observed colour. Since blue fatigue enhances yellow sensitivity, the dentist should gaze at a blue object (wall, card, drape, etc.) while resting the eye.[21][22]

According to Hue

Utilising only four tabs—A4, B4, C4, and D4—and finding the best fit at the exact centre of the tooth and the middle of the tab is because hue is the genuine colour of the dentine.

According to chroma :

To prevent cone fatigue, choose chroma for each trail in or less than five seconds from an amount of 1 to 4 in the same hue.

An achromatic measure (value):

The grayscale tabs for the vita classic shade guide are arranged as follows: B1 A1 B2 D2 A2 C1 C2 D4 A3 D3 B3 A3 B4 C3 A4 C4. It's crucial that values are accurate. The tabs' incisal regions have to be most close to the tooth being chosen and parallel to its long axis.[18]

Other Considerations :

- For the practitioner to focus on the third area of a tooth, they mustuse a magnifier with a minimum magnification of x 3.5 to 4.5 (4 teeth in focus).

- Squint to determine the value level. Half-closed eyes reduce the amount of light entering the eye, inactivating the cones and enabling rods of the retina located in the periphery to distinguish between light and dark.

- Compare the choice of shade under various circumstances (such as wet versus dry, lip drawn back versus drawn down, and light sources at various angles).

- To eliminate metamerism and ensure appropriate shade selection, place the patient under various lighting circumstances because the spectral reflectance of natural, incandescent, fluorescent, or halogen light will be significantly distinct between the porcelain and the tooth.

- The cervical or incisal colour of a single tooth should be closely examined and noted when there is a vertical colour change. The shade tab can be adjusted appropriately for clear communication.

- Consideration should also be given to horizontal colour gradation of a single tooth between the middle and proximal thirds, as well as between various teeth and teeth groups within the samejaw. Mandibular incisors, for instance, areone chroma level below maxillary incisors. Maxillary incisors are two chroma levels below canines.[23][24][25][26]

Recent Advances In Shade Selection:

Different electronic colour measuring systems have been created with the aim of overcoming the limitations of optical shade analysis in order to increase the precision and dependability of shade choosing.

a) Shade Chroma Metre of Shofu

This comprises of a hand-held, free-standing contact probe with a 3 mm diameter. A button is pushed to activate the probe after it has been pressed against the tooth. This directs a Hash of light towards the tooth from the probe's edge, and the light that is reflected back travels through the probe's centre to the detector. There, the light is gathered and equally distributed through color filters that nearly resemble the three common observer functions. A docking unit receives data through an infrared signal.[27] [28] [29]

b) Vita easy shade :

A monocoil fibre optic cable assembly connects the hand component of this portable spectrophotometer to the base unit. The contact probe tip has a diameter of roughly 5 mm.19 fibre optic bundles with a diameter of 1 mm are present. The tooth is lighted during the measuring process by the periphery of the tip, which directs light from a halogen bulb in the base of the unit into the tooth surface.[28] [30]

c) Shade scan:

A handheld tool called Shade Scan helps with image localization and focus. It has a colour LCD screen. A halogen light source lights the tooth surface at a 45° angle through a fibre optic connection and captures the light reflected at a 0° angle. To ensure constant colour reproduction, light strength and calibration to grey and colour standards are continuously checked and adjusted.Although the halogen light is sufficiently bright to be undisturbed by ambient light, ShadeScan can be utilised in any lighting situation. [31][32]

d) Shade Rite Dental Vision System:

It consists of a portable gadget with a built-in light origin, and location on the tooth is made easier by an LCD screen. A "glare spot" must be found at the intersection of the gingival and central thirds of the tooth in order to focus and orient the camera. Through a sequence of rotating filters that mimic the CIE standard observer functions, measurements are acquired.[30]

e) Clear match system:

The strength of ClearMatch[TM] is its ability to match teeth perfectly regardless of issues brought on by various cameras, light sources, and light colours. To put it simply, this involves comparing an image's shades to known shades. In the patient photo, ClearMatch[TM] uses a white, grey, and black reference as well as a dental shade guide to precisely estimate the shade of the patient's teeth. [28] [29]

f) The Vita Easyshade Compact:

Easyshade Compact offers avariety of measurement options, including tooth single mode, tooth area mode (incisal, middle, and cervical shades), restoration colour verification (which includes lightness, chroma, and hue comparison), and shade tab mode (practice/training mode).

g) Shade-X (X-Rite, Grandville, MI)

This is a small, cordless "spot measurement" spectrophotometer that is keyed to most widely used shade guides. It has a 3-mm probe diameter. To match the hues of the dentin, which is more opaque, and the incisal tooth areas, which are more translucent, Shade-X has two databases.[33]
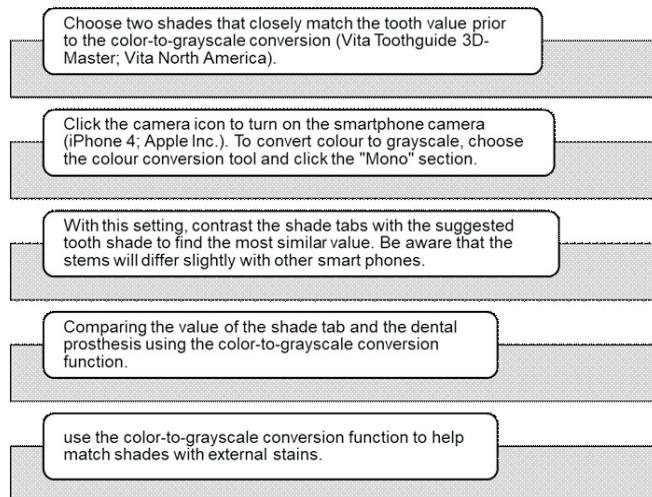
h) Spectro Shade Micro:

This is an image spectrophotometer made by MHT Optic Research, Niederhasli, Switzerland. It makes use of a digital camera and LED spectrophotometer combo. It contains a computer inside with analysing software. During colour measurement, the tooth positioning guiding system is used.[33] [34].

i) Graphic software:

This software system needs a computer running Windows and a digital camera. The graphic software may examine a picture in terms of its values for brightness (L), chroma (C), and hue (h). The software is used to see and evaluate the colour of the digital photos of the shade tabs after digital images have been captured. Software is used to open image files. Using the software's "circle marque" tool (Adobe Photoshop), a region of the shade tab's digital image with a diameter of 4 mm is picked. Due to the fact that this position could be consistently reached on all shade tab photographs, this area (4 mm diameter) is chosen from the centre third of the shade tab tooth surface.[28][30] [35]

j) Smart Apps and Dental Shade Matching:

I. Smartphones with high-resolution camera technology and interactive apps offer a promising alternative for matching tooth shades. Smartphones provide a convenient, portable, affordable, quicker, and simpler way to record audio.[36]

Choose two shades that closely match the tooth value prior to the color-to-grayscale conversion (Vita Toothguide 3D-Master; Vita North America).

Click the camera icon to turn on the smartphone camera (iPhone 4; Apple Inc.). To convert colour to grayscale, choose the colour conversion tool and click the "Mono" section.

With this setting, contrast the shade tabs with the suggested tooth shade to find the most similar value. Be aware that the stems will differ slightly with other smart phones.

Comparing the value of the shade tab and the dental prosthesis using the color-to-grayscale conversion function.

use the color-to-grayscale conversion function to help match shades with external stains.

can result ingrayscale images that are perceptually acceptable.(Figure – 2)[37]

I. A smartphone camera and an SVM classification technique were utilised to achieve shade tab matching.Workflow methodology: -

a) The system, as shown in, was divided into four main components: SVM classification, feature vector building, feature vector calculation, and cropping of the shaded content.

b) Shade colour features were combined to create feature vectors for the feature vectors construction.[38]

c) The results show how training sample sizes affect the outcomes of shade classification. [39][40]

Conclusion :

• Understanding the fundamentals of colour theory can help dentist to develop and use colour palettes more effectively by allowing you to start parsing the logical structure of colour for themselves.

There are many tools available to help with the matching process, however regardless of the kind of shade guidance system employed, determining visual shade is highly subjective. The appearance (metamerism) is influenced by the light source used to determine the shade, and this light source may also introduce inaccuracy.

It is advised that researchers and software businesses determine the needs of professionals and develop suitable technologies to enhance and speed up performance in colour selection for both physicians and dental workers.

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