International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2024: 7.101

Shade Selection in Clinical Dentistry - A Literature Review

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Short Title: *Shade Selection – Literature Review*

Abstract: ***The accuracy in tooth shade selection has always been a challenging task in restoring the natural appearance of the teeth. For good esthetic outcome we need to have sound knowledge about the concept of shades and its selection protocol. To obtain optimal esthetics precise position, shape, surface texture and shade are the four necessary critical elements. This article throws light on various aspects of color, shade, optical properties and the factors contributing to shade selection. This article also discusses visual and instrumental methods used in shade determination.***

Keywords: Color dimensions, optical properties, color perception, shade selection

1. Introduction

In clinical dentistry, success is to choose the accurate shade of a tooth, select and apply the most closely matched quality material, and finally, communicate precisely with the lab technicians to achieve good esthetic results. To achieve aesthetics, four basic determinants are important: position, contour, texture and color. Knowledge of the concept of color is essential for achieving good aesthetics. It is imperative to have a sound knowledge about the concept of shades and its selection protocol for obtaining good esthetics outcomes.

The effect of tooth shade is achieved by the combination of intrinsic and extrinsic colorations. Intrinsic coloration is related to the light scattering and properties of absorption of the enamel and dentine. Extrinsic coloration is linked with material absorption (e.g., red wine, tea, iron salts and chlorhexidine,) onto the surface of enamel and, specifically, the pellicle coating that eventually causes extrinsic stain. The most challenging procedures in restorative dentistry are to match the artificial teeth with the natural teeth. Natural teeth vary greatly in color.[2] Recreating the natural color of teeth using restorative material requires perfect control of shade matching ability.

The use of shade guides in dentistry is a subjective procedure and plenty of variables may also influence the outcomes: the encircling illumination, the perspective of view of the enamel and the tab, clothing, makeup and, of course, the chromatic notion of the dentist.

Three Color Dimensions:
Selection of shades has not always been easy to define perfectly and communicate verbally. In the Munsell system, hue, value and chroma are the three variables that are applied to distinguish the acuity of light, which reflects from the surface of a tooth.

Value -indicates the lightness or darkness of a tooth shade's hue.
Chroma - quality that distinguishes the hue's grade of brightness.
Hue - defines the leading shade of the teeth, such as more reddish or yellowish.

Hue
Hue is a particular variety of colour , Hue differentiates color from one family to another. It is that quality by which we distinguish one color family from another, as red from yellow, green from blue, or purple. It is a physiological and psychological interpretation of a sum of wavelengths.[2]

It is denoted by
A (reddish brown),
B (orange yellow),
C (greenish gray)
D (pinkish gray) on the commonly used shade guide of Vita Classic

Value
Value measures light or dark shades or the brightness of a tooth color. The brightness of any object is directly responsible for the status of energy of light for which the object reflects or transfers. Bright items are less gray, but low-value objects include more gray and appear darker. Lowering the value means a lesser amount of light reflects from the lightened object and the extra light absorbs or is dispersed somewhere else. Value is inversely related to age.[7]

Chroma
The saturation, intensity or power of a color is referred to as chroma. Chroma and value have a converse relation, if chroma is increased, the value is decreased or vice versa.

Optical phenomenon in natural teeth:

Translucency[2]
Human teeth can be categorized by variable grades of translucency, such as gradient between opaque and transparent. Usually, increasing the crown translucency consequently decreases its value because a smaller amount of light reflects towards the eye[2]. With augmented translucency, light passes through the surface and is dispersed inside the restoration.

Demineralization alters the physiological reflectivity of composition. Demineralization alters the physiological reflectivity of the enamel, and the difference in RI between the healthy enamel and the demineralized area generates color alterations.

Semitransparency of a crown lowers the value so less light returns to the eye. In exaggerated semi – transparency, light can pass and scatter within the restoration. It is also dependent on perspective of incidence, surface texture, luster, wavelength and stage of dehydration[6].

Fluorescence[6]

A material that has absorbed light or other electromagnetic waves will emit light when it has exceedingly longer wavelength[6]. It is a type of luminescence. Because there is a higher concentration of organic material in the dentin of a human tooth, this condition predominately occurs in dentin . Therefore, the chroma is lower and more the dentin luminesces.

Opalescence [26]

Opalescence is the optical property of a material in which it seems to be of one color upon the reflection of light, while on transmission of light, it appears to be another color. This distinctive impact is most frequently seen in enamel, which improves the brightness, liveliness and depth perception of teeth.

Surface texture [28]

This affects the esthetics of a tooth by determining the quantity and path of light that are reflected off the facial surface. Natural teeth may have various categorizations with lobes, stippling, striations and ridges. These characterizations are seen more in young enamel [6].

Metamerism [2]

When two colors appear to match under specific lighting conditions yet have differing shadow-like reflectance, known as metamers, the phenomenon is known as metamerism, and the entire process is considered to be metamerism. By selecting a shade and authenticating it in general lighting conditions, such as fluorescent light and natural daylight, the problem of metamerism may be avoided or disregarded.

Factors influencing Color perception [17]

The perception of color, which depends on three entities:
1) Illumination – the type and quality of illumination significantly impacts color perception. Different light sources alter the color perception.
2) The environment – the immediate surroundings like patient's skin tone, lip color , make up, clothing color, room color and lighting can influence color perception.
3) The viewer – color perception can vary between individuals gender differences, age related changes and fatigue of color receptors.

Guidelines for clinical shade selection [4]

Shade-matching devices are also called shade guides. The order of shade selection is first selecting the value, chroma, and lastly hue. Color matching should be done in a systematic way that ensures accuracy, uniformity, predictable results which are absolutely important in esthetic dentistry.

Operating Site Lighting

Sunlight is the traditional source .The mid of the day is considered optimal for shade selection, as this exposure contains an almost equal blend of all wavelengths of light compared to morning and evening exposures, which are richer in reddish and yellow wavelengths. In clinics that do not have proper access to sunlight, artificial light should be used to simulate sunlight. Although no artificial light lamp can perfectly duplicate sunlight, it is adequate for clinical purposes. Prior to shade selection, the light to which the patients are most exposed to in their daily routine must be ascertained. The commercially available demeteron shade light and rite lit are handheld portable lamps which significantly reduces the influence of surrounding colors. [11]

Environment

Bright-colored surroundings should be avoided as they interfere with proper color matching by influencing the colors in the reflected light. A drape can be used to mask undesirable colors in the patient's clothing and jewelry. Lipstick should be removed so that it does not affect color perception. A very light grey color provides the ideal background for color matching. Surfaces with high gloss produce disturbing glares and should be avoided.

Condition of the Teeth

The tooth of interest and its adjacent teeth should be free of plaque and other deposits and surface stains. The tooth should be moist with saliva as dehydration results in a different shade which is lighter in appearance without surface gloss. The tooth becomes dryer after application of the rubber dam, and therefore, color matching should be performed before rubber dam application[7].

Distance of the Operator from the Tooth

A distance of 61 cm (2 feet) to 183 cm (6 feet) distance from the oral cavity is considered ideal for shade matching. The patient should be positioned in the dental chair such that the patient's teeth are at the level of the operator's eyes. The operator should stand directly in front of the patient, with light focused on the teeth. Shade selection and shade matching should be performed by the dentist preferably in the morning, when eye fatigue is minimal.

Squint Test for Restricting Light[7]

The squint test enables shade selection by restricting the light entering the eye. It is performed by bringing the eyelids closer and then looking at the shade guide and the natural tooth. The color that fades from view first is the one that is least conspicuous in comparison with the tooth color.

There are two types of shade selection methods:
- The conventional method
- The use of color measuring instruments

Visual shade guide

The conventional method of shade selection is the use of visual shade guides which are the most famous and convenient way in selecting tooth shades. They are cost-effective and readily available; they also proficiently match the color of the dentition with a standardized reference shade guide. The selection of tooth color by the shade tab method completely depends on human eye observation.

Paper ID: SR25707044717 DOI: https://dx.doi.org/10.21275/SR25707044717

The currently available shade guides are Vita classical (Bad Säckingen, Germany: VITA Zahnfabrik H. Rauter GmbH & Co.), Vita Toothguide 3D Master shade guide (Bad Säckingen, Germany: VITA Zahnfabrik H. Rauter GmbH & Co.), and Chromascop (Buffalo, NY: Ivoclar Vivadent Inc.).

Vita Classical Shade Guide

Based on the hue, 16 tabs are arranged into four groups and within the groups corresponding to the chroma. Since there are some limitations with Vita classical shade guide, Vita 3D-Master shade guide is the most commonly used among the commercially available shade tabs. It provides superior and standardized color differences.

Vita Toothguide 3D-Master

It comprises 26 tabs separated into five groups depending on the lightness of the color. The numbers (1, 2, 3, 4, and 5) in front of the letters represent the group number and lightness level; a lower number indicates a higher lightness. The numbers (1, 1.5, 2, 2.5, and 3) below the group number represent the level of the chroma; the more chromatic tabs are indicated by larger numbers. Three bleaching shades (0M1, 0M2, and 0M3) indicate more lightness, three levels of chroma, and middle hue. The major contrast between the Vita classical and Vita 3D-Master is that the Vita classical shade guide is built on the color hue and the Vita 3D Master characterizes the color value. The Vita 3D-Master shade guide is considered superior to the Vita classical shade guide. It contains an enhanced lightness spectrum and additional chromatic tabs. The hue latitude is expanded against the reddish spectra. Further, the shade tabs are evenly distributed, and group division is improved.

Chromascop

Chromascop uses a numbering system to identify shades. It is organized into groups depending on the hue (100 = white, 200 = yellow, 300 = orange, 400 = gray, 500 = brown) and within the groups as chroma increases from 10 to 40.

Custom Shade Guides

The standard shade guide cannot encompass the entire range of hue and chroma values of human dentition. It is useful for 85% of the color selection, and its alteration or preparation of custom shade tabs is necessary for the remaining 15%. Composite resin, ceramic, or acrylic materials are used to fabricate custom-made shade guides. Shade guide modifications can be performed using surface colorants or by surface abrasion using aluminum oxide. Fine line markers and colored pencils may be used to reproduce the minute variations between shades, analogous translucency, and denominating colors.

Dentin and Extended Shade Guides

Dentin system can be used for the fabrication of translucent all-ceramic crowns and veneers. This shade guide helps in communicating a specific shade to the dental laboratory. Specially colored die materials corresponding to the dentin shade are used, which allows the technician to appraise the esthetics of the restoration. The extended shade guide comprises the tabs of all materials used to fabricate the restoration. It may also be utilized to expand the choice of shade.

Disadvantages of shade guides [30]

The disadvantages of shade guides are described as follows:
1) The colors in shade guides differ for each manufacturing company.
2) Porcelain used for restoration may not be identical to that used in a guide.
3) Shade guides are unable to direct the fabrication of porcelain restorations.
4) The shades in a guide are not logically organized and do not cover the volume of color space that exists in natural dentition.
5) A standard shade tab is made using synthetic resin and has greater thickness than that of a crown.
6) A shade guide tab reflects and transmits light, creating translucency and an appearance of vitality. However, for a restoration, light is reflected and is less likely to be transmitted, which makes the restoration appear dense and opaque.

Color measuring instruments [7]

All color-measuring devices comprise three parts: a detector, signal conditioner, and software that converts the signal into data that can be used in the dental laboratory or operatory.

The following are examples of color measuring instruments:
1) Colorimeters
2) Spectrophotometers
3) Digital cameras
4) Hybrid devices
5) Spectroradiometers.

Colorimeter

A colorimeter measures color (hue, chroma, and value) as perceived by a human eye. It can only measure color by measuring tristimulus values under fixed illumination and observer conditions. The light source, integrating sphere, and detector (three or four filters) are the key optical elements.

Spectrophotometer

Spectrophotometers are commonly used to analyze surface colors. They measure the amount of spectral reflection from the body. It is a photometer that can measure intensity based on color, or more specifically, wavelength.

The optical elements consist of a light source, monochromator, and detector. In general, light sources are diffracted. Several wavelengths are passed through the entrance slit and test sample to be tested. Different wavelengths of light are selectively absorbed by the sample. The light then passes through another slit, called the exit slit, and strikes the detector. The detector converts the intensity of light at a certain wavelength into an electrical signal, which is then amplified and displayed on a screen or plotted on a chart. It is advisable to use a spectrophotometer to accurately measure color. A colorimeter provides an overall measure of the light absorbed, while a spectrophotometer measures the light absorbed at varying wavelengths. Briefly, colorimeters measure the amount of light absorbed overall, while spectrophotometers measure the amount of light absorbed by a specific wavelength. Spectrophotometers are reliable and accurate over time.

Digital Cameras

A digital camera is the most basic form of an electronic shade-matching device. In contrast to film cameras, this device records images using charge-coupled devices (CCDs), which comprise thousands or even millions of minute light-sensitive elements known as photosites. It provides a thorough and precise picture of the tooth surface and is also useful for color mapping. There is a flashcard that records all memories and allows the recording of voice feedback that can be sent directly to the lab without the need for a computer. The data can be downloaded onto a computer system for easy shade and translucency mapping.

Hybrid Devices

SpectroShade provides a combination of digital imaging and spectrophotometric analyses. It uses ClearMatch software system (Hood River, OR: Smart Technology) and is a hardware-independent product developed for use on all personal computers having the Windows platform and almost any digital camera.

Spectrophotometers and Spectroradiometers

These instruments allow the most precise color measurements. A spectrophotometer differs from a spectroradiometer in that it mainly contains a steady source of light. Two different basic designs have been employed for these instruments. The conventional scanning device comprises a single photodiode detector that records the quantity of light at each wavelength. The latest design utilizes a diode array with a dedicated element for each wavelength. This design allows the simultaneous integration of all wavelengths at the same time. Both designs operate significantly slower than filter colorimeters but remain important for research on the development of precise color-measuring devices.

Limitations of digital shade guide [30]

The limitations of digital shade guide include the following:

1) The phenomenon of edge loss affects the accuracy of color measurement
2) Translucent mapping is inadequate for all systems
3) Placement of the probe or mouthpiece seems to be important for the repeatability of the measurement
4) No digital shade guide is sufficiently advanced to operate in a formulation mode
5) The laboratory must have up-to-date systems for the successful application of this approach
6) This approach requires a relatively expensive setup.

2. Discussion

Understanding the influence of different variables in shade selection from light illumination to the teeth' hue, value and chroma and how the eye interprets this can assist in this selection. 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. 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 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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