Review Article

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Colour Matching in Dentistry.

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ABSTRACT

The success of dental treatment is evaluated according to functional and aesthetic results. To achieve aesthetics, four basic determinants are required in sequence; viz., position, contour, texture and colour. The knowledge of the concept of colour is essential for achieving good aesthetics. Colour matching is influenced by several factors, and if not performed properly, it can it can have unsatisfactory results for both the clinician and the patient This review discusses colour science, factors associated with colour perception, and colour matching techniques.[1]

Keywords : Colour scheme, Chroma, hue, value, shade matching, shade selection,

INTRODUCTION

An understanding of the nature of light and how the eye perceives and the brain interprets light as colour is important for successful aesthetic restorations, particularly when metal-ceramic or all-ceramic restorations are being made.[2] Colour and shape determine the aesthetics of both restored and natural teeth . The importance of colour research in dental science has improved significantly over the last decades . To provide aesthetic prosthesis, the dentist should consider the colour's scientific basis as well as the artistic aspects of colour matching . Because of the great variety of natural teeth colour, obtaining a close colour match of a prosthesis with the natural teeth is a complex procedure. The dentist needs an understanding of colour, light, and characteristics of resin and porcelain in addition to the ability to communicate with the technicians to achieve a natural-looking prosthesis.[3] The understanding of the light's nature, how the eye perceives the light, and how the brain interprets light as colour is essential for a favourable aesthetic prosthesis.[4] Colour can be described by three primary attributes of colour which are hue, Chroma, and value. To facilitate communication with the technician, the dentist should be thoroughly familiar with these terms and their definitions . Colour determination and replication are the greatest challenging parts of dental aesthetic.[5] Tooth colour is determined using either instrumental or visual methods The most common technique for colour matching is the visual method using a shade guide.[6] Shade guides have been used to determine and communicate the colour of tooth and prosthesis to obtain an optically satisfying prosthesis but misunderstanding could often happen since every human-eye is not capable to perceive it in a standardized way.[7,8] Additionally, visual colour matching relies on many subjective elements such as translucency, surface structure, lighting conditions, and the optical character of the material used.[9] Since visual colour matching relies on an individual assessment, which is subjective and consequently a clinically challenging procedure. So, this is one of the causes of developing standards for communicating shades and instruments. That make it easier to measure them.[10] However, instrumental colour matching is concerned to be useful and reliable in obtaining colour for clinical colour matching in dentistry . The recommended protocol for visual and instrumental colour matching should be followed for a better understanding of the difficulties involved in it.[11]

RATIONALE

Dental shade-matching instruments have been brought to market to reduce or overcome imperfections and inconsistencies of traditional shade matching. The most commonly used shade-matching method is the visual method, whilst Vitapan Classical (Vita Zahnfabrik, Bad Säckingen, Germany) and its derivations are probably the most commonly used shade guides. The coloured tabs of distinctive shades organize the empiric-based Vita chart.[12-15] In addition, unequivocal findings were reported on colour consistency amongst shade guides from the same manufacturer.[16,17]

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Introduction of evidence-based Vitapan 3D-Master shade guides, Tooth guide, Bleach guide and particularly Linear guide by the same manufacturer correspond to colour of human teeth and therefore increase chances for successful shade matching.[18,19]

COLOUR

Colour is a property of light. Objects have no colour of their own; they just reflect a particular wavelength from the colour spectrum. For example a blue object absorbs all of the wavelengths, except for blue. The remaining wavelengths enter our eyes and this is what we see.

BASIC COLOR SCHEMES

The colour wheel or colour circle is the basic tool for combining colours. The first circular colour diagram was de- signed by Sir Isaac Newton in 1666. Over the years, many variations of the basic design have been made, but the most common version is a wheel of 12 colours, the primary colours being red, yellow and blue. Three secondary colours (green, orange and purple) are created by mixing two primary colours. Six tertiary colour are created by mixing the primary and secondary colours. The colour circle can be divided into warm and cool colours. Warm colour are vivid and energetic, and tend to advance in space. Cool colours give an impression of calm, and create a soothing impression. White, black and grey are considered to be neutral.[1]

MUNSELLS COLOUR SYSTEM

Prof. Albert D. Munsell presented a colour wheel that contains the dimension of Value, Chroma, and Hue at the beginning of the 20th century.[20] The colour quality that differentiates one colour from another is called hue. Hue is the name of a colour, e.g. red, orange, or yellow.[21] Hue is represented on the Vita Classic shade guide by A, B, C, or D. Chroma define as the strength, intensity, or saturation of the hue.[22] On the Vita Classic Shade Guide, the higher numbers represent increased chroma.[23] Value is the colour relative lightness or darkness or the object's brightness . According to Munsell, value is described as a black to white grayscale.[24] Often the most important dimension of colour is the value, as the value decreased, the chroma is increased; value and chroma are inversely related .

DESCRIPTION OF COLOUR

The most popular method for describing colour is the Munsell system. The three attributes of colour in this system are called Hue, Chroma and Value.

Hue: It is defined as the particular variety of a colour. "Hue" is the quality that distinguishes one family of colour from another. It is specified as the dominant range of wave- lengths in the visible spectrum that yields the perceived colour, even though the ex- act wavelength of the perceived colour may not be present. Hue is a physiologic and psychologic interpretation of a sum of wavelengths. Hue is rep- resented by A, B, C or D on the commonly used Vita Classic shade guide.[25]

Chroma: "Chroma" is the saturation, intensity or strength of the Hue.[24] If any dye (say red) is added into a glass of water and the same dye is added again and again, the intensity increases, but the colour remains the same (hue). As more dye is added, the mixture appears darker; thus, the increase in chroma has a corresponding change in value. As chroma is increased, the value is decreased; chroma and value are inversely related. Higher numbers on the Vita Classic shade guide represent increased chroma.[26]

Value: "Value," or brightness, is the amount of light returned from an object . Munsell described value as a white-to- black grey scale. Bright objects have lower amounts of grey and low-value objects have larger amounts of grey and will appear darker.[27] The brightness of a crown is usually increased in two ways: by lowering chroma or by increasing the reflectivity of the surface. Lowering value means less light returns from the illuminated object and the remaining light is being absorbed or scattered elsewhere.

There are two types of colour, additive and subtractive.[28]

Additive Colour: These are the colour obtained by emitted light and are associated with television and computer displays. The primary additive colours are Red, Blue and Green and the secondary additive colours are Cyan, Yellow and Magenta. When additive primary colours are combined they produce White.

Subtractive Colour: These are the colours associated with reflected light and are used in pigments for making paints, inks, fabrics etc. The primary subtractive colours are Red, Yellow, and Blue and the secondary subtractive colours are Green, Violet and Orange. When subtractive primary colours are combined they produce Black.

COLOUR PRECPTION

Eyes can't see alone. Our eyes and brain have to work together to make a sense of light and colour. Light goes through the pupil and splashes on the rods and cones of the retina. There, the light causes a chemical reaction. The optic nerve connects eyes to the brain. It understands the chemical reaction and carries a message to the brain. There the colour perception takes place.

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Eyes: The initial process occurs in the retina of the eye. The retina contains millions of cells called photoreceptors that are sensitive to light. There are two types of photoreceptors, some shaped like rods and some like cones. These photoreceptors process light into nerve impulses and pass them along to the cortex of the brain via the optic nerve. 120 million RODS in the outer edges of the retina help eyes adjust when one enters a dark room. They are good for detecting motion and for seeing in low light-levels. At low light levels, the rods of the human eye are more dominant than the cones and colour perception is lost. As the brightness becomes more intense, colour appears to change (BEZOLD-BRUCKE EFFECT).[29] There are 6 million CONES in each eyeball which are sensitive to colour. There are three types of cone cells, each sensitive to the long, medium or short wavelength of light (red, blue and green colour respectively).

SHADE SELECTION

Quality of Light: Energy distribution of a light has definite effects on the type of colour being perceived. The clinician should try and use a source of light that contains full spectrum of rays without the dominance of any wavelength; because when an object is viewed under lights dominating in particular wavelengths (colour bands), that specific colour becomes dominant to the observer. There are three types of light sources.[30]

1. Incandescent Light: Emits high concentration of yellow waves. It is not suitable for shade matching. It has low Colour Rendering Index (CRI).
2. Fluorescent Light: Emits high concentration of blue waves. It is not suitable for shade matching. It has CRI of 50-80.
3. Natural Daylight: Northern daylight is considered the best because it is closest to emitting the full spectrum of white light. It is used as the standard by which to judge other light sources. It has CRI close to 100.

Most dental offices are fitted with incandescent and fluorescent lights.[30]

Colour Rendering Index: Northern daylight, which can be close to full-spectrum white light and often, is used as the "normal" standard for judging light from other sources. It has a colour rendering index (CRI) close to 100. The colour rendering index, on a scale of 1 to 100, indicates how well a particular light source renders colour as compared to a specific standard source.

Although daylight is often used as the standard against which other light sources are compared, never use direct sunlight to take tooth shade. The distribution of light waves from the sun depends on the time of day and on humidity and pollution. Morning and evening incident light has shortened blue and green waves scattered and only the longer waves penetrate the atmosphere. Therefore daylight at dawn and dusk is rich in yellow and orange but is lacking in blues and greens. Northern daylight around the noon hour on a bright day is considered ideal, because the incident daylight is most balanced within the Visible Light Spectrum.

Metamerism: Another aspect of lighting is the subject of metamerism. Two objects may appear to be identical Colours under a certain kind of light, yet under another kind of light they may appear totally different. This is called metamerism. The problem of metamerism can be avoided by selecting a shade and confirming it under different lighting conditions (e.g., natural daylight and fluorescent light).[31]

Guidelines for Shade Selection

1. Teeth to be matched should be cleaned of all debris and stains. Prophylaxis should be done before shade selection.
2. Brightly coloured lipstick/makeup should be removed (strong red lipstick next to the tooth will fatigue the red receptors while the blue and green receptors remain fresh and fully stimulated. This makes the tooth that looks blue- green) and bright clothing should be draped with grey napkin. The operatory walls should be painted grey.
3. Patient should be viewed at eye level and at arms length, so the most sensitive part of the retina will be used.[32]
4. Shade comparisons should be made under different lighting conditions. Initial shade may be taken under a colour corrected fluorescent light and then 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 when they are dry because of desiccation.
6. Shade comparisons should be made quickly (5 seconds), with shade tabs placed just under the lip and adjacent to the teeth to be matched.
7. Look at a gray walls or patient's napkin between each shade evaluation.

Types Of Shade Guide

The most popular shade guides currently used for dental shade matching are[33]

- Vita Classic (Vita Zahnfabrik, Bad Sackingen, Germany)
- Vitapan 3D-Master (Vita Zahnfabrik, Bad Sackingen, Germany)
- Chromascop (Ivoclar – Vivadent, Schaan, Liechtenstein)
- Custom or specific chroma and value guide

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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 colour differences [34,35]

Vita toothguide 3d-master

It comprises 26 tabs separated into five groups depending on the lightness of the colour. 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 (om1, 0m2, and 0m3) indicate more lightness, three levels of chroma, and middle hue. The major contrast between the vita classical and vi 3d-master is that the vita classical sh back guide is built on the colour hue and the to vita 3d-master characterizes the colour top value. The vita 3d-master shade guide is considered superior to the vita classical shade guide. It contains enhanced light- ness spectrum and additional chromatic tabs. The hue latitude is expanded against the reddish spectra. Further, the shade tabs are evenly distributed and group di- vision is improved. [36-38]

Chromascope

Chromascope uses a numbering system to identify shades. It is organized into groups depending on the hue (100 = white, 200 = yellow, 300 = orange, 400 = grey, 500 = brown) and within the groups as chroma increases from 10 to 40. [39]

Custom shade guide

The standard shade guide cannot encompass the entire range of hue and chroma values of human dentition. It is useful for 85% of the colour 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 coloured pencils may be used to reproduce the minute variations between shades, analogous translucency, and denominating colours[40]

Dentin and Extended Shade Guide

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 coloureda die materials corresponding to the dentin shade are used, which allows the technician to appraise the aesthetics of the restoration [41]. 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. [42]

COLOUR MEASURING INSTRUMENTS

Colorimeter

A colorimeter measures colour (hue, chroma, and value) as perceived by a human eye. It can only measure colour 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.[43]

Spectrophotometer

Spectrophotometers are commonly used to analyse surface colours. They measure the amount of spectral reflection from the body. It is a photometer that can measure intensity based on colour, 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[44]. 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[45]

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 colour 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[46,47]

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[48]

Limitations of digital shade guide

The limitations of digital shade guide include the following: (a) the phenomenon of edge loss affects the accuracy of colour

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measurement; (b) translucent mapping is inadequate for all systems; (c) placement of the probe or mouthpiece seems to be important for the repeatability of the measurement; (d) no digital shade guide is sufficiently advanced to operate in a formulation mode; (e) the laboratory must have up-to-date systems for the successful application of this approach; (f) this approach requires a relatively expensive setup[49]

Causes of errors in colour matching

- Poor quality lighting.
- Using non-evidenced-based shade guides: Classic is subjective versus 3D, which is objective.
- Taking too long to select the shade: We're physiologically programmed that if we stall or stare too long, it will cause errors in our judgment.
- Mixing and matching restorative materials: If we don't understand the reduction requirements for the materials that we're selecting it will cause failure.
- Not using photography: Photography is critical not only for patient education and treatment planning, but also for communication to our laboratory.
- Taking shades at the end of the appointment: This is a big problem; our eyes are tired; the teeth are dehydrated, etc.
- Not using optoelectric devices.
- Oversaturated backgrounds: What's going on in the background is going to significantly impact what you're looking at when selecting a shade. If you're using pastel coloured bibs or if your chair is burnt orange, it can really impact shade selection.
- Using a single modality: This is the most important thing. Simply using just one modality is going to get you into trouble
- Using old shade guide: With today's infection control, we disinfect our shade guides. Over time, we're actually stripping of the glaze layer off of the shade guide so what you're using in your office doesn't match what your technician has[51]
- Colour blindness: Colour blindness is the inability to distinguish the differences between certain colours. This condition results from an absence of colour-sensitive pigment in the cone cells of the retina. Humans are born colour blind because the cones do not begin functioning until a baby is about four months old. One male in twenty suffers from some form of colour blindness, but only one in several hundred females are colour blind. Colour blindness is usually inherited, that is, a genetic defect.

CONCLUSION

Patients expect the broken down and missing teeth to be restored with proper form, function, and an aesthetic appearance. To provide an aesthetic restoration to the patient, the dentist must have a full understanding of the science of colour and colour perception.[50] Colour matching forms an important part in producing aesthetics prosthesis. The tooth colour determination and replication is a challenging task for every dentist. Understanding the science of colour, colour perception, colour matching instrument usage, and limitations, and communication between technicians and dentists are essential for successful aesthetics treatments. Accurate colour matching that allows the prosthesis to match the natural teeth positively influences the appearance and aesthetic self-confidence of the patient.[51]

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