



SHADE MATCHING-A SYSTEMATIC AND SIMPLIFIED APPROACH

Dental Science

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ABSTRACT

Measurements of the color of restorative craniofacial and dental materials have many important applications to clinical practice and research. In modern aesthetic dentistry, as well as the patients, have very high demands on the final aesthetic appearance of the dental restoration. A perfect reproduction of the natural dentition shades have a great influence on patient's satisfaction with final restoration. There are different possible techniques used in color selection and most of them are subjective and dependent on surrounding conditions and dentist's abilities. The paper has tried to systematize different techniques of colour matching to simplify the procedure to achieve the perfect aesthetic result with prosthetic crowns, bridges, inlays, veneers, removable partial dentures, complete dentures and composite restorations.

KEYWORDS:

Color, Colorimeters, Digital, Shade

INTRODUCTION

The tooth color is complex as teeth are small, curved, multilayered, and exhibit color transitions in all directions –gingivo-incisally/occlusally, mesio-distally, and labio/bucco lingually. In addition, color of permanent teeth changes throughout the lifetime and always interacts with other appearance attributes such as translucency, opacity, gloss, fluorescence, opalescence and iridescence, and with appearance attributes of surrounding tissues. Numerous variables regularly associated with the light-object-observer triplet certainly bring further complexity to the color matching and reproduction in dentistry.¹ Advances in technology, computers, the internet, and communication systems have greatly affected and shaped modern society. Commensurate with these strides are the advances in contemporary dentistry.

During the past half-decade, the dental profession has experienced the growth of a new generation of technologies devoted to the analysis, communication and verification of shade. Shade determination for direct and indirect restorations has always been a challenge for the esthetic dentist. In 1931 Clark described this in the Color Problems in Dentistry.²

The late 1990s marked the birth of a new industry in dentistry, commercially available instrument-based color measurement systems, with the development of the ShadeScan system (Cortex Machina, Montreal, Canada)³ This was the first effort toward a shade analysis system for complete tooth surface measurement. Prior literature published by several authors described limited area measurement instruments, with an optical diameter of 3–5 mm, in the analysis of shade.⁴⁻⁶ Today's shade-matching technologies have been developed in an effort to increase the success of color matching, communication, reproduction and verification in clinical dentistry, and, ultimately, to increase the efficiency of esthetic restorative work within any practice. The aim of this paper is to provide a comprehensive review of the current state of shade **Shade Matching Devices**

Shade Matching Devices

Currently, there are several electronic shade-matching instruments available for clinical use. These devices can be classified as

spectrophotometers, colorimeters, digital color analyzers, or combinations of these.

1) SPECTROPHOTOMETER

Spectrophotometers are amongst the most accurate, useful and flexible instruments for color matching in dentistry.^{7,8} They measure the amount of light energy reflected from an object at 1–25 nm intervals along the visible spectrum.^{9,10} A spectrophotometer contains a source of optical radiation, a means of dispersing light, an optical system for measuring, a detector and a means of converting light obtained to a signal that can be analysed. The data obtained from spectrophotometers must be manipulated and translated into a form useful for dental professionals. The measurements obtained by the instruments are frequently keyed to dental shade guides and converted to shade tab equivalent.¹¹ Compared with observations by the human eye, or conventional techniques, it was found that spectrophotometers offered a 33% increase in accuracy and a more objective match in 93.3% of cases¹²

TYPES

1.1) SpectroShade Micro (MHT Optic Research, Niederhasli, Switzerland) is an imaging spectrophotometer. It uses a digital camera/LED spectrophotometer combination. It has an internal computer with the analytical software. The tooth positioning guidance system, shown on the LCD touch screen, is used during color measurement. Images and spectral data can be saved on the internal memory and transferred to a computer¹³

1.2) Crystaleye (Olympus, Tokyo, Japan) combines the benefits of a traditional spectrophotometer with digital photography. Through the development of optical and image processing technology, this product allows the practitioner to match tooth shade and color more accurately and simply compare with the traditional spectrophotometer.¹⁴ The significant benefit of this system is that 'virtual shade tabs' in the computers database can be cross-referenced and superimposed visually onto the natural tooth image to be matched giving the technician the ability to visualize the correct shade tabs. The digital image produced by the Crystaleye uses a 7-band LED light source, which results in a more precise depiction of color than the conventional systems used with digital cameras. Moreover, the

image produced by the Crystaleye is taken from inside the oral cavity and consequently is devoid of the external light that can cause discrepancies.

1.3) Vita Easyshade Compact (Vita Zahnfabrik, Bad Sauckingen, Germany) is cordless, small, portable, cost efficient, battery operated, contact-type spectrophotometer that provides enough shade information to aid in the color analysis process. Different measurement modes are possible with Easyshade Compact: tooth single mode, tooth area mode (cervical, middle and incisal shades), restoration color verification (includes lightness, chroma and hue comparison) and shade tab mode (practice/training mode).¹⁵

1.4) Vita Easyshade Advance 4.0 digital shade matching system from Vident is the fourth generation of Easyshade technology with the new VITA Easyshade Advance 4.0. with cutting edge measurement technology and durable LED components, VITA Easyshade Advance 4.0 offers precision that is twice as effective as that of the human eye. A new "average" mode in the Easyshade Advance 4.0 allows users to measure up to 30 shades on a single tooth and arrive at an overall average shade, making the determination of a base shade on tricky anteriors, even simpler. The user no longer has to worry about placing the probe tip precisely perpendicular to the tooth surface. The shade measure button can be depressed prior to placement and the Easyshade Advance 4.0 will automatically measure when proper placement is achieved and using bluetooth, the measurement data can be wirelessly transferred to the VITA Assist communication software on operatory computers. The results are displayed in both international shade standards for VITA classical A1-D4 and VITA 3D-MASTER. VITABLOCS shades can also be specified.¹⁶

1.5) Vita Easyshade V. The new fifth generation of Easyshade is even more innovative and precise, offering new applications for every day use. To start, a new ergonomic design and user-oriented operating concept is enhanced by an intuitive touch-screen,

color LED display. The durable and long-lasting battery can be charged wirelessly through an inductive charging base. The VITA Easyshade V gives both dentists and technicians complete shade control, from the determination of tooth shade to the final restoration. This new generation of Easyshade verifies fabricated restorations as early as after initial firing, and provides tips on possible optimization measures for achieving the target tooth shade and supports the planning process for professional tooth bleaching through digital documentation of the current and planned tooth shade during the tooth-bleaching process. The innovative software allows you to instantly prescribe VITA Classical A1-D4 and VITA 3D-Master shades at the push of a button. The VITA Assist software (Android App coming soon) allows for the combination of Easyshade V shade data via Bluetooth with a patient photo for better shade communication between dentist and technician.¹⁷

1.6) ZFX is a color measuring instrument consists of a spectrophotometer controlled by a Linux machine and is user-friendly and compatible with Microsoft Windows. The spectrophotometer is equipped with LED lighting; for each measured wavelength another LED type is used. If the measuring button is pressed, the light source illuminates the entire spectrum of the visible light at short intervals. The colors are guided along a light conductor which divides into two light conductors and can thus bring together the symmetrical light on the measuring object. The image of the measuring object, illuminated by the colored light, is then reflected onto a special black and white CCD sensor which is located at the end of the optic. This CCD sensor measures the data in the visible area from 400 to 700 nm.¹⁸

1.7) Shade-X (X-Rite, Grandville, MI) is also compact and cordless "spot" measurement" spectrophotometer with 3-mm probe diameter, and keyed to the majority of popular shade guides. Shade-X have two databases to match the color of the dentin (more opaque)

and the incisal tooth regions (more translucent)¹⁹

2) COLORIMETERS

Colorimeters measure color tri stimulus values from light reflectance of a specimen after the light source has passed through a series of filters. Colorimeters are useful in quantifying color differences between specimens. These devices measure tri stimulus values according to CIE illuminant and observer conditions. Colorimeters use photodiode filters to control light reaching the specimen. The light reflected from the specimen is then measured by a sensor. Colorimeters are easier to use and are less expensive than spectrophotometers. However, repeatability may be poor due to aging of filters, and object metamerism can be a challenge to their accuracy.²⁰

2.1) ShadeVision (X-Rite, Grandville, MI) is an imaging colorimeter. Complete tooth image is provided through the use of three separate databases: for gingival, middle and incisal third. Virtual try-in feature enables virtual testing of color reproduction during fabrication.²¹

3) DIGITAL CAMERAS AND IMAGING SYSTEMS

Most consumer use video or digital still cameras which acquire red, green and blue image information that is utilized to create a color image. The RGB color model is an additive model in which red, green and blue light are added together in various ways to reproduce a broad array of colors. Digital cameras represent the most basic approach to electronic shade taking, still requiring a certain degree of subjective shade selection with the human eye. Various approaches have been used to translate this data into useful dental color information.

Intraoral digital cameras (Nikon Coolpix 990, Kodak, Nikon D-50, Olympus) enable to record tooth shade variations and provide quick and more detailed prescription of the selected color in Comparison Methods Used in Tooth Colour Selection 67 a form of digital data or printed photographs sent to the dental laboratory. It provides the transfer of subtleties in shade transition, craze marks, translucency, occlusal groove stains, incisal haloes, texture and gingival body color to a dental technician, which is impossible while using traditional analogous cameras or photos. The use of photos processed traditionally might not be a perfect manner of direct color communication, as there is a great variability among cameras and printers that can make the obtained images different from the actual tooth color. The extra oral digital camera is comparable to the intraoral camera tool, helpful in tooth shade assessment, but more time consuming and with less precise data transfer²²⁻²³. Digital camera imaging systems are more reliable in tooth color quantification than colorimeters and spectrophotometers, which are designed for flat, bigger surfaces (edge-loss effects), rather than curved, small, semi translucent surfaces found on the teeth²⁴

3.1) ClearMatch (Smart Technology, Hood River, OR) is a software system that uses high-resolution digital images and compares shades over the entire tooth with known reference shades. Similar to the software associated with color measuring devices, ClearMatch contains the color database of industry-standard shade guides.²⁵

4) Polarization dental imaging modality (PDIM)

Polarization dental imaging modality (PDIM) and image analysis methods address the limitations of the currently available methods. Unlike colorimeters, optical spectrometers, and digital color cameras, PDIM provides both quantitative and qualitative information on tooth color and minimizes motion artifact during image acquisition. PDIM provides glare-free tooth color images by utilizing the principle of cross-polarization. It mainly consists of a digital color camera (Canon EOS 450D; Canon Inc., Tokyo, Japan) and a ring-shaped white LED light (HW321A; Siretech, Sungnam, Korea) around the camera. Two linear polarizers (Model A45-669; Edmund Industrial Optics, Barrington, NJ, USA) are mounted perpendicularly in front of the camera and the light source to enable cross-polarization. Its primary advantage is to provide tooth color

images that eliminate specular reflection from the tooth surface

5) Interpretation and application of shade analysis data

Complete tooth surface measurement [CTSM] devices give a color map of the gingival, body and incisal shades for the fabrication of direct or indirect restorations. These systems give a virtual shade overlay of the proposed tab onto the digital image on the computer screen of the tooth measured for visual reference and assessment by the clinician and/or technician. CTSM spectrophotometers, such as Crystaleye and Spectro-Shade, provide shade tab designation and the respective DE*values compared to shade tab values in the memory. However, these mappings are two dimensional and they do not necessarily take into account the shape, texture, thickness of the restoration, type of abutment and different core material (metal or ceramic).²⁷

In addition, they 'average out' color data over the complete tooth surface or larger defined areas which can lead to inaccurate shade information.

Limited area measurement devices provide 3–5mm diameter areas of the tooth being measured. Therefore several areas of the tooth should be considered to obtain a representative evaluation of tooth shade. At a minimum, a limited area measurement of the gingival, body and incisal areas of the tooth [total of 3 measurements] should be assessed and recorded for the technician if an indirect restoration is prescribed. It was found that decreasing the window size when examining extracted teeth with a spectrophotometer and spectroradiometer resulted in lower CIE L*a*b* values.²⁸ Small-window tooth color measurement may cause edge loss of the light due to a tooth's translucency.²⁹

CONCLUSION

The tooth color assessment is a very complex process with many factors such as lightening conditions, human eye and brain influencing the overall perception of tooth shade. The measurement of tooth color is possible via many different methods including visual assessment with shade guides and instrumental techniques based on spectrophotometry, colorimetric and computer analysis of digital images. Each of these methods has its advantages and disadvantages that can limit its use in certain cases. The choice of method is up to the clinician and sometimes it's better to use two different techniques to obtain an objective and satisfying aesthetic result in dental rehabilitation. New modern techniques introduced to dentistry simplify and make more objective the process of tooth shade selection, however the price of the equipment can still limit its use in dental practice. We can expect that the further development of this branch of electronics industry will result in more precise and better devices available for clinician in the nearest future.

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