Digital Dental Shade Matching Devices - A Review

Dhinesh Kumar Sanggaya

Saveetha Dental College,
Saveetha Institute of Medical and Technical Sciences,
Saveetha University, Chennai, India.

Type of manuscript: Review article

***Abstract*: Today's shade-matching technologies have been developed in an effort to increase the success of colour matching, communication, reproduction and verification in clinical dentistry, and, ultimately, to increase the efficiency of aesthetic restorative work within any practice. The tooth colour determination is a very important point during restorative dentistry procedures. Its clinical relevance needs to be considered before any treatment procedures in aesthetic dentistry. An alternative to visual colour assessment is using colour measuring instruments.**

Introduction

Appropriate colour evaluation is a vital factor in dental restoration procedures (1). Prosthetic dentistry will only provide satisfactory results if dental restorations are aesthetically appealing . Thus, an accurate determination of tooth colour is important for obtaining a definitive result. Most of the problems faced in dental aesthetic restorations are related to shade matching (2,3). In dentistry, achieving a colour match depends on a series of visual assessments that are usually discussed between two or more persons, mainly the clinician, patient, and technician. During restoration of a teeth in a dental, colour matching of dental restorative materials with the tooth is done using a shade guide. The shade guide is a standard model consisting of multiple shade tabs based on the colour distribution of natural teeth. The colour of the dental restorative material is based on the shade tabs of the shade guide. Visual colour determination with shade guides is the most commonly used shade-matching method in clinical practice (4,5,6). Because the accuracy of visual colour determination has been only 40~60% (also estimated by using shade tabs), there have been many issues in the communication between dentists, patients, and technicians (7,8). As a solution, electronic shade-matching devices have become more widespread in the field of dentistry. The most commonly used devices are colorimeters and spectrophotometers.

The tooth colour determination is a very important point during restorative dentistry procedures. Its clinical relevance needs to be considered before any treatment procedures in aesthetic dentistry. An alternative to visual colour assessment is using colour measuring instruments. Dental shade matching instruments, which was introduced in the late 1990s was aimed to lessen or overcome inconsistencies and imperfections of traditional shade matching. There are three primary categories of automatic shade selection devices. These shade matching instruments were introduced to the dental profession to overcome the limitations and inconsistencies of the manual, visual shade matching systems. Those instruments can be classified as colorimeters, spectrophotometers, and digital imaging. These devices basically consist of a detector and signal conditioner and software that has the signal to make the data usable in the laboratory or clinic. In the 1990s, there was great optimism due to the development of devices for measuring tooth shade. The frequently not so simple, visual determination of the shade of a tooth was to be done with the aid of a device which recognises the shade and describes it accurately by reference to a colour chart. However, the skepticism toward such devices was also great. It is known that the color effect frequently differs strongly when comparing a tooth from the shade guide with a metal ceramic crown, despite identical shade designation.Today's shade-matching technologies have been developed in an effort to increase the success of colour matching, communication, reproduction and verification in clinical dentistry, and, ultimately, to increase the efficiency of aesthetic restorative work within any practice.

Instruments for clinical shade matching includes spectrophotometers, colorimeters and imaging systems. Like any other device, benefits and limitations exist, and the clinician must consider how the technology relates to expectations and needs. Intra-oral colour measuring devices have been designed to primarily fit the needs of clinical dentistry, such as information on the corresponding shade tabs, tooth translucency, or information associated with colour communication, reproduction and verification. This, together with price limitation dictated by the dental market, resulted in having scientific aspects, such as providing reflectance values or colour formulation, less emphasised. Another significant difference compared to other, non-dental applications, are optical properties of human teeth—they are small, curved, multi- layered, translucent and exhibit colour transitions in all directions (gingival to incisal, mesial to distal and labial to lingual). This is why the accurate repositioning (measurement of the same area) is frequently of critical importance for either clinical and research use of dental colour matching devices.

Advances in electronic technology have provided solutions for many of the current problems in shade selection and colour matching in dentistry:

i. Colorimeters
ii. Spectrophotometer
iii. Digital cameras as filter colorimeters
iv.Spectrophotometers and spectroradiometers

All colour-measuring devices consist of, a detector, signal conditioner and a software that process the signal in a manner that makes the data usable in the dental operatory or laboratory. Because of the complex relationship between these elements, accurate colorimetric analysis is difficult at best.

These devices have been designed to aid clinicians and clinicians in the specification and control of tooth colour. The earliest colour measuring device designed specifically for clinical dental use was a filter colorimeter. The Chromascan (Sternogold Stamford, Connecticut) was introduced in the early 1980s but enjoyed limited success due to its inadequate design and accuracy. Further development was hindered primarily by lack of resources and commitment on industry's side—the market was too small. Now, with aesthetics as a major focus of dental marketing and with the availability of improved colour measuring optics, companies are willing to make the investment required to apply advanced technology to the challenge of shade control. Duane RD., et al. (1998) used the CIELAB colorimetric system to study the relationship between instrumentally measured colour differences and human observer assessment of colour differences in metal ceramic crown. The results indicated that dentist have lower tolerances to colour difference that result from variation in red chroma as compared with colour difference decreased from yellowness. Acceptability of shade difference depends on chromaticity. Observers were more sensitive and critical of crowns whose colour differed in redness than whose colour differed to the same extent in yellowness [6,19]. Correlations between instrumentally derived colour differences and visual assessments of perceptibility and acceptability were strong for crowns differing in yellow chroma, red, but weak for lightness. Threshold for acceptability were lower for metal crown differing in red chroma (1.1 Δεunits). Threshold for perceptibility (0.4Δε) were lower than acceptability for metal ceramic crown differing in their chroma.

Spectrophotometers

All instruments designed to produce the most accurate colour measurements. Spectrophotometers differ from spectroradiometers primarily because they include a stable light source. There are two types of basic designs commonly used for these instruments. The traditional scanning instrument consists of a single photodiode detector that records the amount of light at each wavelength [27]. The light is divided into small wavelength intervals by passing through a monochromator. A more recent design uses a diode array with a dedicated element for each wavelength. This design allows for the simultaneous integration of all wavelengths. Both designs are considerably slower than filter colorimeters but remain the tools that are required to examine and develop accurate colour-measuring devices.

Spectrophotometers are amongst the most accurate, useful and flexible instruments for overall colour matching and colour matching in dentistry. They measure the amount of light energy reflected from an object at 1–25 nm intervals along the visible spectrum. 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.

Colorimeters

Filter colorimeters generally use three or four silicon photodiodes that have spectral correction filters that closely simulate the standard observer functions. These filters act as analog function generators that limit the spectral characteristic of the light that strikes the detector surface. The inability to match the standard observer functions with filters while retaining adequate sensitivity for low light levels is the reason that the absolute of filter colorimeters is considered inferior to scanning device like Spectrophotometers and spectroradiometers. However, because of the consistent and rapid sensing nature, these devices can be precise with differential measurements. This is why they often are used for quality control.

Colorimeter measure tristimulus values and filter light in red, green and blue areas of the visible spectrum. Colorimeters are not registering spectral reflectance and can be less accurate than spectrophotometers (ageing of the filters can additionally affect accuracy).31 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. The blending of science and art is something the dental industry is primed for. Patients are demanding contemporary aesthetic dentistry, which has prompted the industry to continuously raise the bar with regard to aesthetic detail. Many factors can influence the perception of color; by taking advantage of today's shade-matching technology, the subjectivity of colour assessment can be minimised and accurate diagnosis of a restoration shade is more easily communicated.

Digital Cameras and Imaging Systems

The third classification of automated shade selection devices are the digital cameras and imaging systems. Digital cameras are based on the RGB color model in which the camera obtains red, green, and blue data that is used to produce the color image. In this additive color model red, green, and blue light are added together to generate a broad arrangement of colours. Digital cameras provide a basic approach to electronic shade selection and require a degree of shade selection with the human observer. The use in the dental practice of commercially available digital cameras can be very appealing to the clinician due to the cost, ease of use, and availability of digital cameras. Shade tab CIE LAB colours were predicted by applying the digital values into the calibration models and were compared to the measured CIELAB values. They determined that there is potential for the use in clinical dentistry of digital cameras combined with appropriate calibration protocols.

Conclusion

Both visual and instrumental systems of shade matching have greatly improved over the past years years. As previously mentioned, the manual, visual shade guide systems continue to be the most common means of shade selection in dentistry. The visual systems are much cheaper to obtain. However, shade selection is very subjective and is heavily influenced by ambient conditions. With the

addition of today's advanced colorimetry technology, qualitative and quantitative reliability more than double to approximately 70 percent of the true color range of natural dentition.
Close shade matching of dental restorative materials with natural teeth is vital to producing restorations that are biomimetic. Patients expect the modern dentist to restore missing and broken down teeth to and proper form and function with an acceptable aesthetic appearance. A better understanding of the physical and physiological processes involved in human color vision, color theory, and colorimetry is important.

References

[1] Sadowsky S.J. An overview of treatment considerations for esthetic restorations: A review of the literature. J. Prosthet. Dent. 2006;96:433–442. doi: 10.1016/j.prosdent.2006.09.018.

[2] Seghi R.R., Hewlett E.R., Kim J. Visual and instrumental colorimetric assessments of small colour differences on translucent dental porcelain. J. Dent. Res. 1989;68:1760–1764. doi: 10.1177/00220345890680120801.

[3] Paravina R.D., Westland S., Imai F.H., Kimura M., Powers J.M. Evaluation of Blending effect of composites related to restoration size. Dent. Mater. 2006;22:299–307. doi: 10.1016/j.dental.2005.04.022.

[4] Van der Burgt T.P., Ten Bosch J.J., Borsboom P.C., Kortsmit W.J. A comparison of new and conventional methods for quantification of tooth color. J. Prosthet. Dent. 1990;63:155–162. doi: 10.1016/0022-3913(90)90099-X.

[5] Chu S.J., Trushkowsky R.D., Paravina R.D. Dental color matching instruments and systems. Review of clinical and research aspects. J. Dent. 2010;38:e2–e16. doi: 10.1016/j.jdent.2010.07.001.

[6] Paravina R.D. Performance assessment of dental shade guides. J. Dent. 2009;37: e15–e20.
doi: 10.1016/j.jdent.2009.02.005.

[7] Okubo S.R., Kanawati A., Richards M.W., Childress S. Evaluation of visual and instrument shade matching. J. Prosthet. Dent. 1998;80:642–648. doi: 10.1016/S0022-3913(98)70049-6.

[8] Dagg H., O'Connell B., Claffey N., Byrne D., Gorman C. The influence of some different factors on the accuracy of shade selection. J. Oral. Rehabil. 2004;31:900–904. doi: 10.1111/j.1365-2842.2004.01310.x.