Egyptian Prosthodontic Association (EPA Newsletter)

Combining Digital and Visual Shade Matching in Fixed Prosthodontics

Electronic Newsletter

Volume 5. Issue 5

May 2026

The ever-increasing patients' demand for high esthetics and natural-looking dental restorations has led to preferential use of tooth-colored all ceramic restorations [1,2]. The reproduction of the esthetic outcome anticipated by patients has been considered as a prime determinant of the treatment esthetic success [3].

Shade matching is one of the most essential and important clinical procedures in fixed prosthodontic treatments. Color reproduction, translucency, and surface texture present key factors in determining the esthetic success of fixed restorations [4]. Even though the development of highly esthetic dental ceramics, namely glass ceramics, have enabled dentists and dental ceramists to produce the life-like appearance [5], one of the greatest hurdles clinicians face is to determine not only the shade needed, but also the degree of translucency the final fixed restoration needs to reproduce to mimic surrounding dentition.

Technological advancements have gone a long way since the first shade guide was developed by Dr. E.B. Clark in 1931 [6]. These advancements have led to a quantum leap in the understanding and clinical steps of dental shade matching. From the numerously available dental shade guides, clinical dental practice has adopted the use of digital devices and artificial intelligence to improve the accuracy of dental shade matching. This has resulted in a paradigm shift from subjective to objective shade matching.

Factors affecting visual shade matching:

Numerous external and internal factors contribute to the outcome of visual shade matching in clinical dental practice [7]. The multiple elements that affect artificial tooth shade matching are the source of light, the object perceived, and the observer's skills and angle of observation [8,9].

Figure (1): SpectroShade® Micro II clinical spectrophotometer device

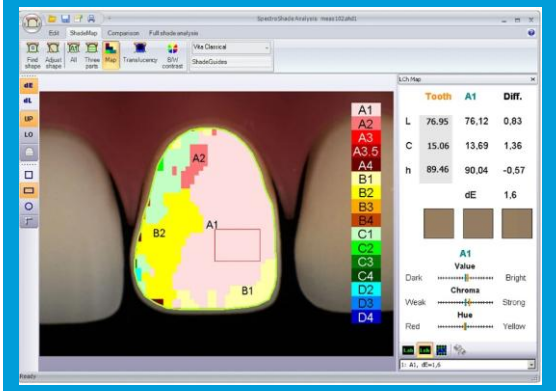

Figure (2): Color mapping using the Spectroshade Micro spectrophotometer device

Nonetheless, the heavy influence of ambient light and other phenomena such as metamerism on the final shade matching process were sometimes unavoidable in clinical dental practice. The subjectivity and lack of quantification of the visual method of shade matching has led to the increased demand for objective color assessment and was at the core of the development of digital methods for shade selection.

It also worth mentioning that the color vision of the observer, whether a clinician or a dental laboratory technician add to the complexity and subjectivity of the visual method for shade matching. The subjectivity of color "perception" - how different the perception of a specific color may vary between individuals- is not the only compromise of the conventional method. Color blindness and other color vision-related disorders are often pass undiagnosed. A dental professional with impaired color vision can have an inherent vision-related error which will always interfere with their ability to select the best shade match between a tooth and a dental restoration. All of these limitations have led to the derive to develop digital shade matching devices that can be reliable and accurate.

Digital shade matching and the shift to objective methods:

Although color is reliant on psychophysical sensation [10], quantification of color has been proposed by the Commission Internationale de l'Eclairage (CIE) by the introduction of their CIELab color system in 1976 [11].

Digital color measurement:

Instrumental color measurement is the most reliable method for quantification of color and measurement of color coordinates numerically, these instrumental measurements allow for a more uniform and precise communication of translucency and color [12]. Several devices are used for this instrumental measurement including spectrophotometers, spectroradiometers, colorimeters, and some imaging processing techniques [13].

Digital clinical Spectrophotometers:

A spectrophotometer is a sophisticated device, designed to measure the amount of light energy reflected from an object at 1 to 25 nm intervals along the visible light spectrum which ranges from 400 to 700 nm [12], and convert measured spectral reflectance values into CIELab color coordinates [11]. Spectrophotometers have a built-in light source and are provide a contact-type color measurement [11].

Figure (3): Vita® Easyshade clinical spectrophotometer device

Figure (4): Shade matching tool in Trios IOS by 3Shape®

Figure (5): The exposure triangle in photography

Clinical spectrophotometers, such as the Vita® Easyshade V, have been used for many years to help clinicians determine the shade of both a natural tooth and/or a fixed dental restoration in a more predictable manner with numeric expression of the CIELab coordinates along with its conversion to a specific shade number expressed in either the classical or the 3D master shade numbering system [14,15].

Vita® Easyshade V and SpectroShade devices:

The SpectroShade®, (Figure 1) which was developed in Switzerland by MHT Optic Research, is a clinical spectrophotometer developed for use that combines digital imaging with spectrophotometric analysis. The unit consists of a high-intensity halogen light source that is directed to the tooth through fiber-optic bundles and lenses to uniformly illuminate the field at a 45° angle. This allows the device, through light transmission and reflection to quantify light and analyze the shade of the tooth being measured (Figure 2).

One the other hand, the Vita® EasyShade (Figure 3) is a handheld spectrophotometer for tooth shade determination. The fiber optic tip of the Easyshade is approximately 5 mm in diameter and contains nineteen 1 mm diameter fiber-optic fibers. The Easyshade device had different modes of measurement including the tooth mode -which is primarily used to match the shade of a natural tooth that's being measured- and the restoration mode -which is used to confirm the shade of a restoration received from the dental laboratory-.

Intraoral Scanners (IOS) and shade matching:

The use of intraoral scanners (IOS) is at the heart of the digital dentistry revolution. The increased popularity of these recent dental "gadgets" has captured the attention of the dental research society and clinical practice alike. Recently, intraoral scanners have been updated to utilize their high-definition cameras for the purpose of shade matching. This is advantageous to clinicians as it combines impression making and shade selection in one tool (Figure 4). Different studies have been conducted to assess the accuracy and repeatability of intraoral scanners when used for shade matching. However, findings and conclusions varied significantly [16].

Several studies [17-19] concluded that intraoral scanners should be supplemented with additional methods to determine the appropriate shade. This might be due to the several factors influencing the shade matching capability of an intraoral scanner. The choice of shade guide when setting up the scanner for shade matching was one of the most commonly reported influencing factors [20-22], with the Vita 3D Master settings resulting in improved accuracy in most studies.

Ambient light, speed of scan, distance between the scanner and tooth surface, the angle of the scanner relevant to the tooth surface and the area from which tooth shade is being analyzed are all seem to have an influence on the accuracy of the shade matching capability of an i **Digital photography and dental shade matching:**

A digital camera is the most basic form of an electronic shade-matching device. The explosive use of smartphones and digital cameras in the dental office has allowed dental practitioners to rely on digital technologies in their daily practice. Digital applications have not only simplified the shade selection procedure but also allows active participation of the patient, thereby reducing patient satisfaction and subjective esthetic failure rates.

Digital photography -when used properly- aids in transferring not just the shade of the tooth, but helps both dentists and dental technicians alike see with their own eyes the interaction between different colors and layers of a natural tooth and the optical phenomena within a specific tooth [23].

Surface texture is yet another variable that influences how a tooth/restoration treats the incident light, controlling both the light reflected back from the restoration and the light scattered from the surface. Both phenomena of light reflection and scattering are well documented to have a decisive influence on the perception of how this restoration may look to an observer [13].

Unlike the visual method of shade matching which focuses on transferring the code of a shade to be used when fabricating a dental restoration from a specific ceramic material, digital photographs - when captured well and are both calibrated and balanced- can not only aid in shade matching, they can also transfer numerous data about the tooth photographed regarding other “optical properties” such as amount of incisal translucency, intrinsic stains distribution, and surface texture along with other structural/anatomical distinctive features, such as craze lines, white spots, and cracks [24].

When taking clinical digital photographs, the settings of the camera and the ambient conditions during photography play a key role in the accuracy of the image captured. Shutter speed, aperture size, ISO -light sensitivity of the sensor-, are commonly known as the "exposure triangle" of a digital photography (Figure 5).

Camera settings, flashlight, ambient illumination, and distance between the camera and object all play a role in the reliability of the captured photograph. Unreliable light conditions and illumination in addition to variant object-camera distance render these digital images greatly questionable [25].

The use of standardized digital photographs taken under standardized illumination and ambient conditions can be a highly efficient and reliable shade matching strategy [26]. Various studies have suggested different protocol for shade selection by digital photographs. Hein et al. proposed the use of reflective cross-polarized light digital photographs with a standardized white balance Grey card.

It is a good clinical practice for a dental clinician to combine both visual and digital shade matching techniques for optimal results. Visual shade matching puts on the human perception and individualized touch to the final esthetic outcome of a restoration, enabling clinicians to avoid the potential errors of devices that may oversee a certain measurement. However, it is wise to adopt the more recently introduced technologies developed to equip practitioners with the instruments aimed at overcoming the inherent limitations of the visual method of shade matching.

References

1. Ghodsi S, Jafarian Z. A review on translucent zirconia. Eur J Prosthodont Restor Dent. 2018 May; 26(2):62-74.

2. Karci M, Demir N. Effect of home bleaching on the translucency of CAD/CAM systems. J Prosthodont. 2019 Mar; 28(3):310-4.

3. Basso GR, Kodama AB, Pimentel AH, Kaizer MR, Bona AD, Moraes RR, Boscato N. Masking colored substrates using monolithic and bilayer CAD-CAM ceramic structures. Oper Dent. 2017 Jul/Aug; 42(4):387-395.

4. Baldissara P, Llukacej A, Ciocca L, Valandro FL, Scotti R. Translucency of zirconia copings made with different CAD/CAM systems. J Prosthet Dent. 2010 Jul; 104(1):6-12.

5. Walczak K, Meißner H, Range U, Sakkas A, Boening K, Wieckiewicz M et al. Translucency of zirconia ceramics before and after artificial aging. J Prosthodont. 2019 Jan; 28(1): 319-24.

6. Agrawal V., Kapoor S. Color and Shade Management in Esthetic Dentistry. Univ Res J Dent. 2013 Dec; 3(3): 120-7.

7. Abu-Hossin S, Onbasi Y, Berger L, Troll F, Adler W, Wichmann M, Matta RE. Comparison of digital and visual tooth shade selection. Clin Exp Dent Res. 2023 Apr;9(2):368-74.

8. Jouhar R. Comparison of Shade Matching Ability among Dental Students under Different Lighting Conditions: A Croess-Sectional Study. Int. J. Environ. Res. Public Health 2022;19:1892.

9. Udiljak, Z.; Illeš, D.; Zlataric´, D.K.; C´ elic´, R. Effect of Clinical Experience on the Shade Matching Accuracy in Different Dental Occupational Groups. Acta Stomatol. Croat. 2018;52:132–9.

10. Bachhav VC, Aras MA. The effect of ceramic thickness and number of firings on the color of a zirconium oxide based all ceramic system fabricated using CAD/CAM technology. J Adv Prosthodont. 2011 Jun; 3(2):57-62.

11. Joiner A, Luo W. Tooth colour and whiteness: A review. J Dent. 2017 Dec; 67:3-10.

12. Papageorgiou-Kyrana A, Kokoti M, Kontonasaki E, Koidis P. Evaluation of color stability of preshaded and liquid shaded monolithic zirconia. J Prosthet Dent. 2018 Mar; 119(3):467-72.

13. Paravina RD et al. Color difference thresholds in dentistry. J Esthet Restor Dent. 2015 Apr; 27:1-9.

14. Kurtulmus- Yilmaz S., Ulusoy M. Comparison of the translucency of shaded zirconia all-ceramic systems.JAdv Prosthodont. 2014 Oct; 6(5):415-22.

15. Tabatabaian F. Color in zirconia-based restorations and related factors: A literature review. J Prosthodont. 2018 Feb; 27(2):201-11.

16. Akl MA, Mansour DE, Zheng F. The Role of Intraoral Scanners in the Shade Matching Process: A Systematic Review. J Prosthodont. 2022;1–8.

17. Rutk¯unas V, Dirs˙e J, Bilius V. Accuracy of an intraoral digital scanner in tooth color determination. J Prosthet Dent. 2020;123:322-9.

18. Brandt J, Nelson S, Lauer HC, et al. In vivo study for tooth color determination—visual versus digital. Clin Oral Investig. 2017;21:2863-71.

19. Yoon HI, Bae JI, Park JM, et al. A study on possibility of clinical application for color measurements of shade guides using an intraoral digital scanner. J Prosthodont. 2018;27:670-5.

20. Liberato WF, Barreto IC, Costa PP, et al. A comparison between visual, intraoral scanner, and spectrophotometer shade matching: a clinical study. J Prosthet Dent. 2019;121:271-5.

This Issue is Prepared by:

Dr. Ahmed Mohamed Leithy

Associate Professor of Fixed Prosthodontics, Faculty pf Dentistry, Al-Azhar University.

Egyptian Prosthodontic Association (EPA)

Address: 15 Ahmed Abo El-Ela St. – 8th district Nasr City, Cairo Egypt.

Mobile : 010 28203484 (Calls & Whatsapp) Phone: 02 26705035