DOI: 10.18044/MEDINFORM.2025121.1990 ISSUE 1, 2025

Different methods of color determination in dental medicine. Literature review

Ilia Liondev, Rangel Todorov

Department of Prosthetic Dental Medicine, Faculty of Dental Medicine, Medical University – Sofia

Abstract

Aim: The aim of this study is to evaluate the effectiveness of various shade-matching methods, comparing their accuracy, and highlight the growing importance of digital tools in modern dental medicine.
Materials and Methods: The research relied on Google Scholar and PubMed publications.
Results: Methods for color determining can be divided into two categories: objective (device-based) and subjective (visual). Visual assessment using shade guides remains the most commonly employed method in clinical practice, yet it is highly dependent on individual assessment and lighting conditions. Research indicates that spectrophotometers enhance accuracy by 33% and provide objective compliance of 93.3%. The workflow process between the laboratory and the dentist is objectified by the eLab system. Digital tools such as intraoral scanners and advanced colorimeters, including Optishade, have demonstrated superior repeatability and accuracy. Significant differences regarding accuracy have been observed in studies comparing various devices; spectrophotometers and digital colorimeters frequently outperform conventional visual approaches.
Conclusion: For increased accuracy and dependability, the results highlight the necessity of a hybrid approach to shade selection that incorporates both conventional and digital methods. Accuracy and efficiency should be further improved in the future with the use of cloud-based data storage and AI-driven shade-matching systems. In order to maximize patient satisfaction and improve aesthetic results, digital dental medicine will continue to evolve.

Keywords: EasyShade V, spectrophotometer, intraoral scanner, Optishade, digital dental medicine, shade matching

Introduction

Color determination plays a crucial role in modern prosthetic dental medicine, which is increasingly focused on aesthetics. Accurate shade selection is key to making restorations indistinguishable from the patient's natural teeth, ensuring both functional and aesthetic success.
Over the years, various methods of color determination have emerged, ranging from traditional hue matching to specially devices such as spectrophotometers.
While visual methods are subjective and depend on the dentist's perception, new technologies offer objective, consistent, and reproducible results. Digital color recording instruments, spectrophotometers, and colorimeters are revolutionizing the field by providing clinicians with greater accuracy and precision. This publication aims to evaluate the effectiveness of color determination technologies, compare their accuracy, and emphasize the growing importance of digital tools in modern dental medicine.

DOI: 10.18044/MEDINFORM.2025121.1990 ISSUE 1, 2025

Aim

The article reviews available literature on color determination methods, equipment, and their effectiveness on both natural teeth and dental ceramics.

Results

Color determination in prosthetic dental medicine can be divided into two main categories: subjective also known as visual and objective – device based. Visual color determination by comparison of a patient's tooth with a different shade guides is the most frequently used method in clinical practice (1). Color evaluation through visual comparison has proven to be unreliable due to variations in how different observers perceive color. This type of assessment relies on the observer's physiological and psychological reactions to the stimulation of radiant energy (2,3).

Compared to the conventional observational method, spectrophotometers improve accuracy by 33% and enhance objective compliance by 93.3%. (4).

Research has proven that the superior performance of the Vita 3D Master may be attributed to several factors. It includes more tabs—26 compared to the 16 in the Vita Classical system. Shade matching with the Vita 3D Master involves a three-step process (brightness, intensity, and shade), whereas the Vita Classical system requires only one step. However, drawbacks include potential bias from the person conducting the measurement and the need to learn to differentiate subtle color variations. As a result, the selection process remains subjective and open to debate, rather than being grounded in objective data (5).

Spectrophotometers are capable of delivering accurate results and objective measurements based on the CIE Lab* system, such as with SpectroShade 2.20, or using shade guides like the VITA EasyShade V (6).

An intraoral scanner can create a digital scan in place of a traditional impression, offering a more convenient way to store data while being more environmentally friendly. Its color comparison accuracy is comparable to that of spectrophotometers, making it an appealing alternative (7,8).

Mohammed A. Akl et al. (2022) found a statistically significant difference when comparing the gold standard in color determination, namely the spectroradiometer, with two clinical spectrophotometers – Vita EasyShade V and SpectroShade. Between the spectroradiometer and Vita EasyShade V, the ΔE00 values showed a statistically significant difference, while the ΔE00 values between the spectroradiometer and SpectroShade did not show a statistically significant difference (9).

Seungyee Kim-Pusateri et al. (2009) conducted a comparative study of four clinical spectrophotometers: SpectroShade, ShadeVision, VITA Easyshade, and ShadeScan. The study was carried out on three different shade guides (Vitapan Classical, Vitapan 3D-Master, and Chromascop). Most devices exhibited similar high reliability (over 96%), indicating predictable shade values from repeated measurements (10).

Massimo Del Fabbro et al. (2017) conducted a study on the repeatability, accuracy, and ergonomics of three dental color measurement devices: Easyshade, Spectroshade, and Rayplicker (Borea Dental). The authors have performed a spectrophotometric analysis of the buccal surfaces of 50 freshly extracted teeth placed on gypsum models. Measurements were repeated by three different operators under three different light sources. To assess accuracy, an in vitro protocol was followed using 60 metal-ceramic crowns. SpectroShade and Rayplicker demonstrated identical results and outperformed Vita Easyshade in terms of repeatability and accuracy. Rayplicker has a significant advantage regarding ergonomics and more user-friendly features. It has a small working tip and low weight. There is no need for calibration, color capture is quick, and only one measurement is required. Additionally, it offers an important advantage concerning infection control, as it has a simultaneously sterilizable tip and protective sheath. Rayplicker can facilitate

DOI: 10.18044/MEDINFORM.2025121.1990 ISSUE 1, 2025

interaction with the laboratory, as it can share the obtained data not only via email, as other devices do, but also directly to the virtual cloud (11).

Susana Dias et al. (2023) conducted an in vitro study to determine color using two different methods: spectrophotometric analysis with the SpectroShade device and the eLAB system, which is based on CIELAB and designed for tooth color measurement using a standardized dental photography protocol. This study aimed to compare the Lab* values of the VITA Classical and VITA Toothguide 3D-MASTER shade guides. Two distinct digital methods were employed: the SS spectrophotometer and the eLAB photograph/software measuring system, to evaluate the tooth color of the two shade guides. The results showed significant differences in Lab* values and corresponding ΔE00 between the tested methods for both shade guides (12).

Sascha Hein et al. believed that the eLAB system objectivizes communication between the dentist and the laboratory (13).

In modern dental practice, communication between the dentist and the dental technician through photographs is becoming increasingly common due to the ability to provide information regarding the color of the tooth surface, shape, and characteristic features (14).

Camila S. Sampaio et al. conducted a comparative study on color determination through photography. The research team found that the combination of a camera and a cross-polarizing filter showed the highest accuracy for obtaining digital images, as it demonstrated the lowest ΔE value compared to the use or non-use of a gray reference card (15).

Photography offers a vast amount of color data; however, it lacks consistent color precision. The colors in digital images are affected by various technical elements, including lighting conditions, the medium of output, the camera used, and the settings during capture (16).

Utilizing dental photography and eLab aids in the digital assessment and selection of composite resin systems and shades. By employing a white balance reference card alongside cross-polarized photography, it can lead to more predictable results when using the stratification technique with resin composites (17).

The digital colorimeter – OptiShade (StyleItaliano, Genoa, Italy) provides information based on color coordinates, resorting to the L*a*b* scales, which consider lightness, red-green, and yellow-blue scale positions. Jordi Manauta et al. conducted that the incorporation of OptiShade measurements with the CompoShade layering recipe calculation represents a major step forward in attaining accurate color matching for anterior composite restorations (18).

Martínez Marugán, Alicia investigates the repeatability of two color measurement devices from the German company Vita: the Vita EasyShade V and the OptiShade from StyleItaliano. A total of 32 artificial teeth were used, taken from 2 different Vita shade guides. Both OptiShade® from StyleItaliano and VITA® Easyshade® V demonstrate high repeatability. Only the b* values showed satisfactory agreement, while the L* and a* values displayed low compatibility (19).

N. Kutkut et al. also investigated the accuracy and reliability of a shade-matching colorimeter (Optishade), a spectrophotometer (VITA Easyshade V), and visual shade matching under simulated clinical conditions. The colorimeter demonstrated the highest accuracy, followed by the spectrophotometer, and then the visual shade selection method. Both digital methods examined in this study exhibited comparable reliability (20).

A comparison between visual shade selection and one of the latest digital colorimeters – OptiShade, was conducted in 2024 by Menini and colleagues. The study was carried out with the participation of 70 dental students and specialists in the field. The StyleItaliano colorimeter showed a 100% match in results, while the visual method achieved only 78% accuracy. A statistically significant difference was observed between the two methods (21).

V. Rutkunas and colleagues conducted a study to evaluate the accuracy of an intraoral digital scanner in tooth shade determination. The investigated scanner was the TRIOS 3 intraoral digital scanner, compared to the Spectroshade spectrophotometer. A total of 120 anterior maxillary teeth were examined. The authors

DOI: 10.18044/MEDINFORM.2025121.1990 ISSUE 1, 2025

found that the TRIOS 3 did not match the Spectroshade precisely in determining tooth color, and therefore, the use of additional methods is recommended. The accuracy of the TRIOS 3 was higher when the shade was recorded using Vita 3D Master values rather than Vita Classical (22).
Farhad Tabatabaian et al (2022) Studies show that intraoral scanners demonstrate unacceptable shade matching accuracy. Intraoral scanners indicate acceptable shade matching precision (23).
A comparison was made between the classic visual method and the color registration method using the TRIOS intraoral scanner based on the VITA Toothguide 3D-MASTER. The repeatability of each observer and the intraoral scanner was recorded for each color dimension (hue, chroma, and value). The intraoral scanner again showed better results with 86% accuracy, while the manual method demonstrated 75% (24).
Rizwan Jouhar's study concluded that shade matching scores were significantly higher when using correcting lights compared to clinical lighting. Additionally, both clinical and non-clinical students showed a notable improvement in shade matching skills under a correcting light source as opposed to standard dental operatory lighting. Moreover, students with clinical experience performed better in shade selection than those without clinical experience (25).
Visual shade matching is inherently subjective, posing a challenge for clinicians. To enhance accuracy and achieve better esthetic outcomes, various measurement devices have been developed to assist in tooth color selection. The use of a light-correcting device in combination with visual shade guides led to an improvement in interrater agreement (26).
As digital dental medicine continues to evolve, emerging technologies such as AI-driven color analysis, real-time shade-matching algorithms, and cloud-based data storage are expected to improve the accuracy and efficiency of color determination.
Additionally, the integration of intraoral scanners with AI-powered shade analysis is anticipated to enhance predictability in shade selection (27).

Conclusion

This study evaluates the effectiveness of various shade matching methods, including visual assessment and digital photography. While traditional visual methods using shade guides remain widely employed, they can be subjective and susceptible to errors influenced by factors such as lighting conditions and the clinician's perception.
The results underscore the importance of combining different methods to optimize shade matching outcomes. By leveraging the strengths of both visual and digital techniques, clinicians can improve the predictability of shade selection, leading to more satisfactory restorations that seamlessly blend with the natural tooth structure. Ongoing research and innovations in shade matching methodologies will play a pivotal role in elevating standards of dental aesthetics and enhancing patient care in restorative dental medicine.

ACKNOWLEDGEMENTS

This study was supported by GRANT No. 131/29.05.2024, from The Council of Medical Science at the Medical University in Sofia, Bulgaria.

DOI: 10.18044/MEDINFORM.2025121.1990 ISSUE 1, 2025

References

1. van der Burgt TP, ten Bosch JJ, Borsboom PC, Kortsmit WJ. A comparison of new and conventional methods for quantification of tooth color. J Prosthet Dent. 1990;63(2):155-162
2. McPhee ER. Light and color in dentistry. Part I--Nature and perception. J Mich Dent Assoc. 1978;60(11):565-572.
3. Judd DB, Wyszecki G. Color in business, science and industry. 3rd ed. New York: John Wiley; 1975. p. 5-90.
4. Lagouvardos PE, Fougia AG, Diamantopoulou SA, Polyzois GL. Repeatability and interdevice reliability of two portable color selection devices in matching and measuring tooth color. J Prosthet Dent. 2009;101(1):40-45.
5. Hammad IA. Intrarater repeatability of shade selections with two shade guides. J Prosthet Dent. 2003;89(1):50-53.
6. Klotz AL, Habibi Y, Corcodel N, Rammelsberg P, Hassel AJ, Zenthöfer A. Laboratory and clinical reliability of two spectrophotometers. J Esthet Restor Dent. 2022;34(2):369-373.
7. Tabatabaian F, Beyabanaki E, Alirezaei P, Epakchi S. Visual and digital tooth shade selection methods, related effective factors and conditions, and their accuracy and precision: A literature review. J Esthet Restor Dent. 2021;33(8):1084-1104.
8. Mehl A, Bosch G, Fischer C, Ender A. In vivo tooth-color measurement with a new 3D intraoral scanning system in comparison to conventional digital and visual color determination methods. Int J Comput Dent. 2017;20(4):343-361.
9. Akl MA, Sim CPC, Nunn ME, Zeng LL, Hamza TA, Wee AG. Validation of two clinical color measuring instruments for use in dental research. J Dent. 2022;125:104223.
10. Kim-Pusateri S, Brewer JD, Davis EL, Wee AG. Reliability and accuracy of four dental shade-matching devices. J Prosthet Dent. 2009;101(3):193-199.
11. Fabbro, Massimo Del et al. “Repeatability , Accuracy and Ergonomics of three devices for tooth color measurement Short title : Tooth shading evaluation.” (2017).
12. Dias S, Dias J, Pereira R, Silveira J, Mata A, Marques D. Different Methods for Assessing Tooth Colour-In Vitro Study. Biomimetics (Basel). 2023;8(5):384. Published 2023 Aug 23.
13. Hein S, Modrić D, Westland S, Tomeček M. Objective shade matching, communication, and reproduction by combining dental photography and numeric shade quantification. J Esthet Restor Dent. 2021;33(1):107-117.
14. Jarad FD, Russell MD, Moss BW. The use of digital imaging for colour matching and communication in restorative dentistry. Br Dent J. 2005;199(1):43-33.
15. Sampaio CS, Atria PJ, Hirata R, Jorquera G. Variability of color matching with different digital photography techniques and a gray reference card. J Prosthet Dent. 2019;121(2):333-339.
16. Ramsthaler F, Birngruber CG, Kröll AK, Kettner M, Verhoff MA. Über die Farbdetailtreue in der digitalen forensischen Fotografie [True color accuracy in digital forensic photography]. Arch Kriminol. 2016;237(5-6):190-203.
17. Ntovas P, Papazoglou E. Digital selection of composite resin shade using cross polarized photography and a standardized white balance gray reference card. J Clin Exp Dent. 2021;13(10):e1061-e1066.
18. Manauta, J., Almeida, G., Kovacs-Vajna, Z. M., Vervack, V., Shaalan, O., Devoto, W., Faccoli, M., Falacho, R. I., & Putignano, A. (2024b). Precision layering techniques: Integrating digital tools for accurate color matching and realistic try-ins in anterior composite restorations. Journal of Esthetic and Restorative Dentistry, 36(12), 1638–1650.

DOI: 10.18044/MEDINFORM.2025121.1990 ISSUE 1, 2025

19. Martínez Marugan, Alicia. "Estudio sobre la concordancia y repetibilidad de Optishade® de Styleitaliano® y VITA Easyshade® V de VITA®." (2023).
20. Kutkut N, Jordi M, Almalki A, Conejo J, Anadioti E, Blatz M. Comparison of the Accuracy and Reliability of Instrumental Shade Selection Devices and Visual Shade Selection: An in Vitro Study. J Esthet Restor Dent.
21. Menini M, Rivolta L, Manauta J, Nuvina M, Kovacs-Vajna ZM, Pesce P. Dental Color-Matching Ability: Comparison between Visual Determination and Technology. Dent J (Basel). 2024;12(9):284.
22. Rutkūnas V, Dirsė J, Bilius V. Accuracy of an intraoral digital scanner in tooth color determination. J Prosthet Dent. 2020 Feb;123(2):322-329.
23. Tabatabaian, Farhad, et al. "Accuracy and precision of intraoral scanners for shade matching: A systematic review." The Journal of Prosthetic Dentistry (2022).
24. Reyes, Juan, Pamela Acosta, and Dalina Ventura. "Repeatability of the human eye compared to an intraoral scanner in dental shade matching." Heliyon 5.7 (2019).
25. Jouhar R. Comparison of Shade Matching Ability among Dental Students under Different Lighting Conditions: A Cross-Sectional Study. Int J Environ Res Public Health. 2022;19(19):11892.
26. Liberato WF, Barreto IC, Costa PP, de Almeida CC, Pimentel W, Tiossi R. A comparison between visual, intraoral scanner, and spectrophotometer shade matching: A clinical study. J Prosthet Dent. 2019;121(2):271-275.
27. Shetty S, Gali S, Augustine D, Sv S. Artificial intelligence systems in dental shade-matching: A systematic review. J Prosthodont. 2024;33(6):519-532.

Corresponding author:
Ilia Liondev
Faculty of Dental Medicine, Medical University Sofia
Georgi Sofiiski 1, 1000, Sofia
Tel.: +359 893424979
e-mail: i.lyondev@fdm.mu-sofia.bg

Liondev I, Todorov R, Different methods of color determination in dental medicine. Literature review, Medinform 2025; 12(1):1990-1995.