Accuracy of Two Electronic Dental Spectrophotometers

Ali A. Razooki Al-Shekhli[1]*, Isra'a Al Aubi[2]

1. Ph.D.; Acting Dean & Associate Prof, Restorative department at College of Dentistry, City University College of Ajman CUCA, UAE.
2. MSc; Lecturer, Restorative department at College of Dentistry, University of Science and Technology of Fujairah, UAE.

Abstract

The purpose of this in vitro study was to evaluate the accuracy of 2 dental electronic shade-matching instruments to recognize all individual tab shades of 3 visual shade guides.

Two electronic shade matching devices were selected to be evaluated in this study: Vita Easyshade Compact (Vita Zahnfabrik, Bad Sackingen,Germany) and ShadeStar (Dentsply-Germany). The two devices were calibrated according to manufacturer instructions. Three types of visual shade guides were also selected: Senator (Wright Health Group Ltd - Scotland, based on VITA shade guidelines), Ivoclar Vivadent and Ivoclar Vivadent Tetric N-Ceram (United States and Canada). Each shade tab from all the three visual shade guides was measured 10 times using both electronic devices. The measurements were done under simulated clinical conditions. Any reading was considered to be accurate if the device selected a shade that was identical to the shade tab measured. Accuracy was expressed as a percentage of measurements made with the device that were an exact match. Data was statistically analyzed by calculating the percentage of the accurate readings, mean of accurate readings, standard deviation, one way ANOVA and t-test at 5% level of significance.

Statistical analysis of the data with one-way ANOVA revealed that, there was a statistically significant difference between the 6 groups being tested in accuracy readings ($p \leq 0.05$). VITA Easyshade demonstrated the highest shade selection accuracy in this study.

The two electronic spectrophotometers showed a very high variability in accuracy reading percentages (23-88%). Easyshade spectrophotometer in general was more accurate than ShadeStar in our study and showed an accuracy reading percentages (74-88%) with the three different visual shade guide tabs.

Clinical significance: The most accurate shade selection devise achieves the highest aesthetic results.

Experimental article (J Int Dent Med Res 2021; 14(2): 554-558)

Keywords: Shade guides, Easyshade, ShadeStar, Spectrophotometers and shade measuring devices.

Received date: 08 March 2021 **Accept date:** 30 April 2021

Introduction

Esthetic dentistry is the marriage between the 'art and science of dentistry'. The simultaneous application of technical and artistic skills enables a practitioner to achieve outstanding esthetic and functional results. In the past 10 to 20 years, significant advances in restorative materials and devices have revolutionized aesthetic dentistry.[1] Technological improvements have taken place in response to the growing demand of the patients for esthetics and the consequent demand of clinicians for materials with similar optical characteristics to those of the natural teeth. Reproduction of the color and characteristics of natural oral structures is the ultimate goal for color specification measurement and shade matching.[2] Dental professionals have used shade guides for almost a century. It is the most widely used method for shade selection.[3,4]

A shade guide is a set of physical standards made of a certain material and arranged based on a specific criteria. They are used for visual shade matching of natural tooth structure or a restoration. [5] It is a low-cost, widely

Corresponding author:
Ali A. Razooki Al-Shekhli
Ph.D.; Acting Dean & Associate Prof, Restorative department at College of Dentistry, City University College of Ajman CUCA, UAE.
E-mail: alirazooki@yahoo.com

accepted, easy to use visual assessment tool, where hue and chroma can be relatively easy to match but matching value is more challenging. [6] As a matter of fact, incorrect value matching is responsible for 75% of improper shade selection [7], and a slight shift in value is more noticeable than a slight deviation in chroma or hue due to the human's eyes high sensitivity to brightness. Dental electronic color matching instruments and systems have potential advantage over visual shade matching due to their objectivity and ability to quantify differences in color and its dimensions compared to the closest match from different shade guides. Although hand-held color matching instruments are accurate and user-friendly, the role of dental professionals is still a decisive one—the more we know about instrument's features and limitations, the more useful they are for color matching, communication, reproduction, and verification. Instrumental and visual color matching methods complement each other and their combined use can lead toward predictable esthetic outcome.[8,9]

Thus, Shade Measuring Devices that are believed to be more accurate and reliable methods of shade selection have emerged; such as RGB devices, digital cameras[10], Spectrophotometers and colorimeters.[11]

Spectrophotometers measure reflectance throughout the visible spectrum.[12]The spectrophotometer measures colors based on reflectance by calculating the ratio of reflected wavelengths of the target object to the wavelengths reflected from a white standard reference at intervals of 5, 10, or 20 nm of the visible spectrum. They are more stable and are the instruments of choice for surface color measurements. They can be used for evaluation of color difference and absolute color measurements in addition to metamerism evaluation.[13] They have an advantage over spectroradiometers in that they include a stable light source.[14]

Spectrophotometry also offers a new method for the primary identification of changes in physical properties of photopolymer composite materials in comparison with features of reference samples.[15]

Two types of spectrophotometer were assessed in this study in terms of accuracy: VITA Easyshade compact and ShadeStar.

Materials and methods

Two electronic shade matching devices we selected to be used in this study; VITA Easyshade (Vita Zahnfabrik, Bad Säckingen, Germany), and ShadeStar (Dentsply-Germany) Figure 1. The two devices were calibrated according to manufacturer instructions. Each Device was used to measure all shade tabs from the three different Visual Shade Guides; Senator (Wright Health Group Ltd - Scotland, based on VITA shade guidelines), Ivoclar Vivadent Tetric N-Ceram (United States and Canada) and Ivoclar Vivadent and according to that, 6 groups were being evaluated in this study as summarized in Table 1. Each shade tab from the three visual shade guides was measured 10 times (n=10) using the two electronic shade matching devices.

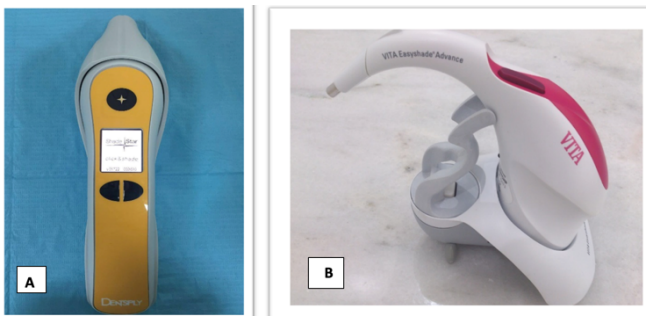

Figure 1. The Two electronic shade matching devices used in this study: Vita Easyshade Compact (A) and ShadeStar (B).

Group 1	Vita Easy X Senator
Group 2	ShadeStar X Senator
Group 3	Vita Easy X Tetric N-Ceram
Group 4	ShadeStar X Tetric N-Ceram
Group 5	Vita Easy X Ivoclar Vivadent
Group 6	ShadeStar X Ivoclar Vivadent

Table1. The six groups being evaluated in this study.

The Devices were calibrated as per the manufacturer's instructions. The VITA Easyshade was set to the Tooth Single Mode while the Shade Star was set to 3D Master Mode. The measurements were done under simulated clinical conditions. A measurement was considered to be accurate if the device selected a shade that was identical to the shade tab measured. Accuracy percentage was expressed as the total number of an exact match tabs shade (10 readings (n=10) X no. of shade tabs) divided by the total number of tabs per that specific

visual shade guide multiplied by 10. Data was statistically analyzed by calculating the percentage of the accurate readings, mean accurate readings, standard deviation, one way ANOVA and t-test at 5% level of significance.

Results

Accuracy percentage, mean accuracy readings, standard deviations of the six groups being tested in this study are presented in Table 2 & Figures 2 & 3. Figure (2) represents mean accuracy values of the six groups being tested in this study. One-way analysis of variance (ANOVA) tests for accuracy values of all the six groups revealed that, there were statistically significant differences (P≤0.05) as shown in Table 3.

Further analysis of the data with t-test indicated that, there was a statistically significant difference in accuracy values between all the 15 pairs of the six groups (p≤0.05) except between pair No. 2, 7, 9 and 14 that showed not significant differences (p≥ 0.05) between them as shown Table 4.

Data Summary					
Groups	N	Accuracy %	Mean	Std. Dev.	Std. Error
Group 1	15	82%	8.2	1.0823	0.2795
Group 2	15	23%	2.3333	3.0394	0.7848
Group 3	12	74%	7.4167	2.2747	0.6566
Group 4	12	40%	4.0833	4.757	1.3732
Group 5	16	88%	8.875	1.0247	0.2562
Group 6	16	38%	3.875	4.334	1.0835

Table 2. Data summary of six groups being evaluated in this study.

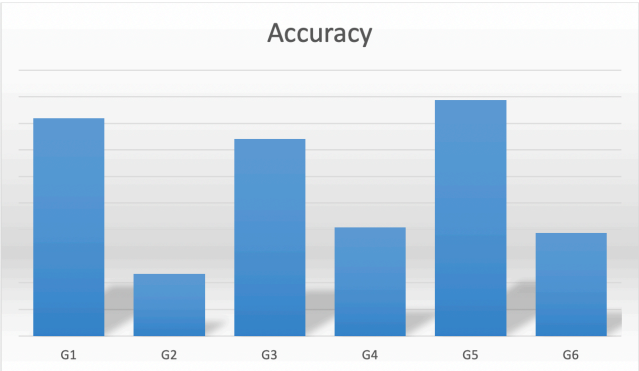

Figure 2. Mean values of the ACCURATE readings within the six groups.

ANOVA Summary					
Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	5	543.9627	108.7925	11.6189	0.00
Within Groups	80	749.0705	9.3634		
Total:	85	1293.0332			

Figure 3. One-Way ANOVA [Average ± Standard Deviation].

Pair No	Groups	t-value	p-value	Significant/ not significant
1.	G1xG2	7.04242	< .00001	significant
2.	G1xG3	1.18105	.124348	not significant
3.	G1xG4	3.26278	.001592	significant
4.	G1xG5	-1.78376	.042466	significant
5.	G1xG6	3.75312	.000389	significant
6.	G2xG3	-4.80867	.000031	significant
7.	G2xG4	-1.16164	.128176	not significant
8.	G2xG5	-8.13773	< .00001	significant
9.	G2xG6	-1.13933	.131945	not significant
10.	G3xG4	2.1899	.019712	significant
11.	G3xG5	-2.28427	.015382	significant
12.	G3xG6	2.56968	.008131	significant
13.	G4xG5	-3.93274	.000279	significant
14.	G4xG6	0.12076	.452407	not significant
15.	G5xG6	4.49089	.000049	significant

Table 4. t-test at 5% level of significance for each pair of the six groups individually being evaluated in this study.

Discussion

Accuracy refers to the ability of the device to provide a correct match for a given specimen. Devices have been developed to provide a technical, objective method for color measurement. They provide a more standardized objective method for color measurement that is not affected by changing conditions that can influence the visual color measurement method.[16] The advantages of using shade tabs are their similarity to natural teeth in size, contour, and color, as well as their availability. Other studies have used shade tab measurements to evaluate the accuracy of electronic shade-matching devices.[17]

However, performance of these devices may vary depending on the shade guide used.[18] This finding might explain the observed statistically significant difference in accuracy results (Table 3 & Figure 2) among the different shade guides examined in this study through examining the accuracy of the two electronic spectrophotometers: VITA Easyshade compact and ShadeStar. Accuracy measurements enable an evaluation of the validity of the shade output when measuring a shade tab of known color. The data of this study is totally agreed with findings of

Browning WD et al. [19] who found that, measurements of L* a* and b* are more accurate and precise using the spectrophotometer. The results are also in total agreement with another study done by Paul S. in 2002. [20]However, the spectrophotometer was found to show variations based on the method, the measuring geometry and the illuminant employed. The Data of this study indicated that, VITA Easyshade spectrophotometer was in general more accurate than ShadeStar in giving accurate shade matching readings (identical with the actual shade tabs) with all the three different visual shade guides as shown in groups 1,3,5 (Figure 2) with accuracy percentages 82%, 74% and 88% respectively. Our findings is in consistency with the findings of Kim-Pusateri (2009) [21], who achieved in his study the highest accuracy with VITA Easyshade (92.6%).

However, accuracy data for VITA Easyshade may be affected by the shade acquisition methodology that was followed as recommended by the manufacturer. The manufacturer recommends repeating shade measurements until 2 identical, consecutive measurements of the same tooth are achieved. In this study, measurements were repeated with Easyshade until two consecutive, matching measurements were made. Following this protocol allowed Easyshade more opportunities to correctly match the target shade tab, potentially leading to a shift towards greater accuracy. Another explanation for the greater accuracy of Easyshade involves the area of the shade tab measured by the devices tested. The Easyshade probe measures an area 5 mm in diameter in the central region of the tooth.

In this study, the average color of the shade tab was recorded. Software calculation of a single average shade for the entire shade tab may decrease shade measurement accuracy for ShadeStar compared to the single region measurement used by VITA Easyshade. An important limitation of this study involves potential variability of the shade guides regarding their indications for either composite or ceramic restorations. However, Easyshade spectrophotometer had successfully recognized the visual tabs at a high percentage in spite of this limitation. Shade tabs may vary between guides from same as well as from different manufacturers which can be considered as another variable affecting the general reading accuracy. Manufacturing variability among the shade tabs may be reflected as incorrect color readings. This potential variation was not evaluated in this study and might affected the accuracy of ShadeStar readings in a negative way since it had failed to recognize many shade tabs of the three visual shade guides and according to that, scored as zero number of correct readings for that specific shade tab. This error might be also due to the selection of 3D Master Mode instead of other mode options (four modes of measurement) that might if been selected like Vita Classic mode, the ShadeStar readings might be entirely changed (improved). In addition, the ease of use and degree of technique sensitivity are different for each device and were not evaluated in this study.

Conclusions

1- The two electronic spectrophotometers showed a very high variability in accuracy reading percentages (23-88%).
2- Easyshade spectrophotometer in general was more accurate than ShadeStar in our study and showed an accuracy reading percentages ranged (74-88%) with the three different visual shade guides.

Clinical Significance

The most accurate shade selection devise achieves the highest aesthetic results.

Declaration of Interest

The authors report no conflict of interest.

References

1- Mjör IA. Selection of restorative materials in general dental practice in Sweden. Acta Odontol Scand 1997; 55 (1):53-57.
2- Johnston, W. M. "Color measurement in dentistry." J Dent. 2009; 37 Suppl 1: e2-6.
3- Paravina, R. D. "Performance assessment of dental shade guides." J Dent 2009; 37 Suppl 1: e15-20.
4- Yoshida, A., L. Miller, J. D. Da Silva and S. Ishikawa-Nagai. "Spectrophotometric analysis of tooth color reproduction on anterior all-ceramic crowns: Part 2: color reproduction and its transfer from in vitro to in vivo." J Esthet Restor Dent 2010; 22(1): 53-63.
5- Paravina, R. D. and J. M. Powers. Esthetic Color Training in Dentistry, 1st ed.Elsevier Mosby 2004:17-37.
6- Chu, S. J. "The science of color and shade selection in aesthetic dentistry." Dent Today 2002; 21(9): 86-89.
7- Sagars, J. "Shade matching for today's dentistry." Dent Econ 2002; 1: 62-67.
8- Chu SJ, Trushkowsky RD, Paravina RD. Dental color matching instruments and systems. Review of clinical and research aspects. J Dent 2010; 38 s: e2–e16.

9- McLaren EA, Schoenbaum T. Combine conventional and digital methods to maximize shade matching. Compend Contin Educ Dent 2011; 32 (4):30–33.
10- Nasruddin Mf et al. A Comparison of Tooth Shade Selection between use of Visual Approach, Digital Cameras and Smartphone Cameras. J Int Dent Med Res 2021; 14(1): 99-104
11- Hammad, I.A. Intrarater repeatability of shade selections with two shade guides. J. Prosthet. Dent.2003, 89, 50-53.
12- Lehmann KM, Igiel C, Schmidtmann I, Scheller H. Four colormeasuring devices compared with a spectrophotometric reference system. J Dent 2010; 38 (suppl 2):e65–e70.
13- Paravina, R. D. and J. M. Powers. Esthetic Color Training in Dentistry, 2004, Elsevier Mosby.
14- Cal, E., P. Guneri and T. Kose. "Comparison of digital and spectrophotometric measurements of colour shade guides." J Oral Rehabil, 2006, 33(3): 221-228.
15- Kostenko S et al. Optimized Approach of Dental Composites Identification with The Use of Original Spectrophotometric Algorithm. J Int Dent Med Res 2018; 11(2): 403-8.
16- Miller, L. L. "Shade matching." J Esthet Dent 1993; 5(4): 143-153.
17- Dozic A, Kleverlaan CJ, El-Zohairy A, Feilzer AJ, Khashayar G. Performance of five commercially available tooth color-measuring devices. J Prosthodont 2007; 16:93-100.
18- Kim-Pusateri S, Brewer JD, Dunford RG, Wee AG. In vitro model to evaluate reliability and accuracy of a dental shade-matching instrument. J Prosthet Dent 2007; 98:353-8.
19- Browning, W. D., D. C. Chan, J. S. Blalock and M. G. Brackett. "A comparison of human raters and an intra-oral spectrophotometer." Oper Dent 2009; 34(3): 337-343.
20- Paul, S., A. Peter, N. Pietrobon and C. H. Hammerle. "Visual and spectrophotometric shade analysis of human teeth." J Dent Res 2002; 81(8): 578-582.
21- Kim-Pusateri S, Brewer JD, Davis EL, Wee AG. Reliability and accuracy of four dental shade-matching devices. J Prosthet Dent. 2009 Mar; 101 (3):193-9.