Reliability of Two Electronic Shade-Matching Devices

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Abstract

The purpose of this in vitro study was to evaluate the reliability of 2 dental electronic shade-matching devices o 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 (n=10) using both electronic devices. The measurements were done under simulated clinical conditions. To measure reliability, each shade tab from each visual shade guide was measured 10 non-consecutive times by both electronic spectrophotometers. Repeated measurements were considered to be reliable if they were similar, even if they did not match the shade tab itself. Data was statistically analyzed by calculating the percentage of the reliable readings, mean of reliable 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 reliability readings ($p \leq 0.05$). VITA Easyshade and shadeStar spectrophotometers in general demonstrated variable high reliability percentages in this study.

In general, the two electronic spectrophotometers showed a high and comparable reliability reading percentages. Easyshade spectrophotometer showed true high reliability percentage while ShadeStar spectrophotometer showed false high reliability percentage.

Clinical significance: The most reliable shade selection devise results in more consistent readings but might not achieve a correct shade matching.

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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]

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It is a low-cost, widely 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 as discussed earlier, 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 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.[5] They have an advantage over spectroradiometers in that they include a stable light source.[13]

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.[14]Two types of spectrophotometer were assessed in this study in terms of reliability: 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-Germany) and ShadeStar (Dentsply-Germany) Figure 1.

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

The two devices were calibrated according to manufacturer instructions. Each Device was used to measure shades from 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.

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.

Each shade tab from the three visual shade guides was measured 10 times (n=10) using the two electronic shade matching devices. 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. To measure reliability, each shade tab from each shade guide type was measured 10 non-consecutive times by each instrument. Repeated measurements were considered to be reliable if they were similar, even if they did not match the shade tab itself. Reliability percentage was expressed as the total number of repeated readings per each shade tab (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 reliable readings, mean reliable readings, standard deviation, one way ANOVA and t-test at 5% level of significance.

Results

Reliability percentage, mean reliability values, standard deviations of the six groups being tested in this study are presented in Table 2 & Figures 2 & 3. Figure (2) represents mean reliability values of the six groups being tested in this study.

One-way analysis of variance (ANOVA) tests for reliability 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 reliability values between all the 15 pairs of the six groups (p≤0.05) except between pair No. 2, 3, 5, 10 and 12-15 that showed not significant differences between them as shown Table 4.

Data Summary					
Groups	N	Reliability %	Mean	Std. Dev.	Std. Error
Group 1	15	82%	8.2	1.0823	0.2795
Group 2	15	65%	6.5333	1.8848	0.4866
Group 3	12	79%	7.9167	1.505	0.4345
Group 4	12	85%	8.5	1.6787	0.4846
Group 5	16	88%	8.875	1.0247	0.2562
Group 6	16	85%	8.5	2	0.5

Table2. Data summary of six groups being evaluated in this study.

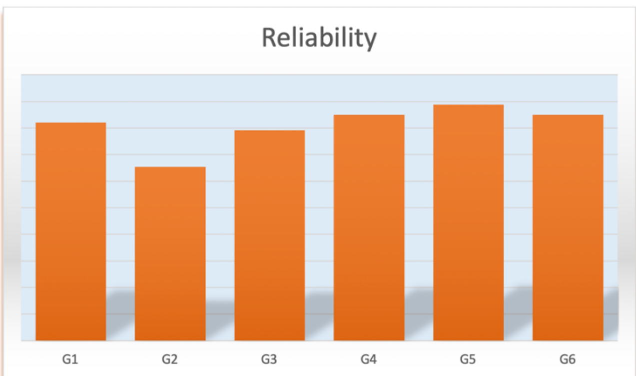

Figure 2. Mean values of the RELIABLE readings within the 6 groups.

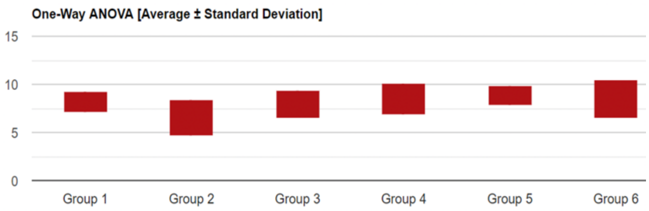

Figure 3. One-Way ANOVA [Average ± Standard Deviation].

ANOVA Summary					
Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	5	51.4572	10.2914	4.1624	0.0021
Within Groups	80	197.7976	2.4725		
Total:	85	249.2549			

Table 3. One-Way ANOVA summary of six groups being evaluated in this study.

Pair No	Groups	t-value	p-value	Significant/ not significant
1.	G1xG2	2.96994	.003025	Significant
2.	G1xG3	0.56906	.287196	not significant
3.	G1xG4	-0.56254	.289378	not significant
4.	G1xG5	-1.78376	.042466	Significant
5.	G1xG6	-0.51428	.305477	not significant
6.	G2xG3	-2.06698	.024619	Significant
7.	G2xG4	-2.82572	.00457	Significant
8.	G2xG5	-4.33594	.00008	Significant
9.	G2xG6	-2.8131	.004358	Significant
10.	G3xG4	-0.89626	.189909	not significant
11.	G3xG5	-2.00658	.02765	Significant
12.	G3xG6	-0.84524	.202845	not significant
13.	G4xG5	-0.73232	.235263	not significant
14.	G4xG6	0.	.5	not significant
15.	G5xG6	0.66749	.25478	not significant

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

Discussion

Reliability refers to the consistency of the device in matching the same 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. [15] 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.[16]

However, performance of these devices may vary depending on the shade guide used.[17] This finding might explain the observed statistically significant difference in reliability results (Table 3 & Figure 2) among the different shade guides examined in this study through examining the reliability of the two electronic spectrophotometers: VITA Easyshade compact and ShadeStar. Reliability measurements enable an evaluation of the consistency of the shade-matching device in making repeated measurements of the same shade tab. The reliability of the electronic shade-matching devices ranged between 65% and 88% (Table 2). The Data of this study indicated that, VITA Easyshade spectrophotometer was in general more truly reliable than ShadeStar in giving accurate reliable 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 reliability percentages 82%, 74% and 88% respectively.

Our findings is in consistency with the findings of Kim-Pusateri (2009)[18], who mentioned in his study that, the VITA Easyshade had achieved a high reliability percentage (94.4%). The reliability percentage of ShadeStar in combination with Senator visual shade guide (G2) was significantly much lower (65%) than that of all other groups being tested in this study (Table 2). The ShadeStar device has failed to give consistent readings with some specific tabs of the senator visual shade guide even if they were false and not matching the actual shade tab. Reliability measurements provide a means of measuring the predictability of the device.

In this part of the study, no distinction was made as to whether the devices correctly identified the color of the shade tab. The outcome measured was how consistent the devices were, regardless of accuracy. VITA Easyshade was able to give true reliability readings since most of its reliable readings were accurate while ShadeStar gave false reliability readings since most of its reliable readings were inaccurate. ShadeStar device that produces reliable measurements would likely perform more predictably than a device that is inconsistent. ShadeStar has failed to recognize many shade tabs of the three visual shade guides and according to that, scored as 10 in a false way by repeating the incorrect shade registration of that specific shade tab and to be recorded as a reliable readings. This error might be 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).

Conclusions

1- In general, the two electronic spectrophotometers showed a high and comparable reliability reading percentages.
2- Easyshade spectrophotometer showed true high reliability percentage while ShadeStar spectrophotometer showed false high reliability percentage.

Clinical Significance

The most reliable shade selection devise results in more consistent readings but might not achieve a correct shade matching.

Declaration of Interest

The authors report no conflict of interest.

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