Consistency in color parameters of a commonly used shade guide

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Abstract Objective: The use of shade guides to assess the color of natural teeth subjectively remains one of the most common means for dental shade assessment. Any variation in the color parameters of the different shade guides may lead to significant clinical implications. Particularly, since the communication between the clinic and the dental laboratory is based on using the shade guide designation. The purpose of this study was to investigate the consistency of the $L^*a^*b^*$ color parameters of a sample of a commonly used shade guide.

Materials and methods: The color parameters of a total of 100 VITAPAN Classical Vacuum shade guide (VITA Zahnfabrik, Bad Säckingen, Germany) were measured using a X-Rite ColorEye 7000A Spectrophotometer (Grand Rapids, Michigan, USA). Each shade guide consists of 16 tabs with different designations. Each shade tab was measured five times and the average values were calculated.

Results: The $\Delta E$ between the average $L^*a^*b^*$ value for each shade tab and the average of the 100 shade tabs of the same designation was calculated. Using the Student $t$-test analysis, no significant differences were found among the measured sample.

Conclusion: There is a high consistency level in terms of color parameters of the measured VITAPAN Classical Vacuum shade guide sample tested.

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1. Introduction

Since the beginning of last century, the problems of color in dentistry so eloquently described by Clark (1931) remains to be a challenge. Although tremendous advances have been made in the field, the reliance on subjectively assessing the shade of natural tooth, remains a commonly used practice today (Paravina, 2009; Brewer et al., 2004). The selection of an appropriate shade is normally made from a range of porcelain tabs supplied by the porcelain manufacturer in the form of a shade-guide (Smith and Wilson, 1998). Shades are selected...
according to closeness of match between tab and the natural teeth (Behle, 2001). Shade selection intrarater repeatability was found to be high using two different shade guide systems (Hammad, 2003).

It has been reported that the color difference between the fabricated shade and the intended shade could range between 2.50 and 3.84 ΔE units (Fazi et al., 2009). This finding can be a source of problems for the clinician since most likely the resultant restoration will not be clinically acceptable. Similarly, the selected shades and the obtained shades were spectrophotometrically measured using three different porcelain systems by Omar et al. (2008). The difference in the shades varied between 1.21 and 1.56 ΔE units.

The inadequacies of different shade guide systems have been reported previously in the literature (O’Brien et al., 1991). However, very few studies have examined the amount of variation in the color parameters of existing shade guides. One recent study by King and deRijk (2007) has closely examined the interchangeability of a commonly used shade guide. The results indicated that the differences observed between shade guides were larger than the variations induced by the experimental method used in their study. Therefore, they concluded that the shade guides should not be considered interchangeable.

Therefore, the objective of this study was to attempt to provide baseline information regarding the consistency of the L*a*b* color parameters in a sample of a commonly used shade guide system using the ΔE color difference method.

2. Materials and methods

The L*a*b* color parameter of a randomly selected sample of 100 new VITAPAN Classical Vacuum shade guide (VITA Zahnfabrik, Bad Säckingen, Germany) were measured. The samples were obtained from the manufacturer’s local distributor and were given serial numbers from 1 to 100.

All color measurements were obtained by using a X-Rite ColorEye 7000A Spectrophotometer (X-Rite, Grand Rapids, Michigan, USA). This instrument is a bench top reference spectrophotometer which uses a dual beam pulsed xenon light source and is calibrated by NIST (National Institute of Standards and Technology) tiles. The spectral range is 360–750 nm with a wavelength interval of 10 nm. Reflectance measurements were made at 45° with illumination at 0°. The measurement aperture size used for the shade guide samples was Small Area View (SAV) which measures 0.75 cm by 1.0 cm. Fig. 1 shows a sample shade guide tab placed in the sample holder of the spectrophotometer (Fig. 1). The black colored trap latch of the sample holder acted as a backing for all the samples. All samples of the new shade guides were wiped with a clean lint-free cloth before placement for measurement. Since there were 100 shade guides, each consisting of sixteen tabs which were each measured five times to obtain an average for each tab; the total number of measurements was 8000 (100 × 16 × 5 = 8000).

The ΔE between the average L*a*b* value for each shade tab and the average of the 100 shade tabs of the same designation was calculated using the following formula:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}.$$  

Statistical analysis was performed using the Student t-test to determine if there was any significance (α = 0.05). All computations and statistical analysis were done using Excel software (Microsoft® Office Excel®, Redmond, Washington, USA).

3. Results

The average L*a*b* values for 100 tabs of each of the 16 designations of the shade guide, standard deviation and average ΔE value between each shade guide tab and the average of the 100 tabs along with the calculated t-test and p-value are shown in Table 1. No significant differences were found between any of the measured samples. Figs. 2–5 illustrate the average ΔE value between each shade guide tab and the average of the 100 tabs with the standard deviation in each group of four shade groups (A, B, C and D).

Figure 1 Shade guide sample placed in the aperture of the spectrophotometer.
4. Discussion

A close inspection of the overall average $L^*a^*b^*$ measurements of the shade guide studied shows lower values in the $L^*$ as compared to the findings reported by O’Brien et al. (1991, 2002). This could be attributed to the influence of the backing of the samples during measurement. All sample tabs measured by O’Brien were coated with barium sulphate prior to being measured. This action yielded a consistent white background to all the samples. The rationale being that it will prevent any of the incident light to be allowed to pass through the measured specimen. In the present study, no particular backing was made on the shade tabs prior to measurement. The black plastic coating of the latch trap of the measurement aperture served as the background which may have contributed to the lowering of the general value of the sample. However, since this potential influence was consistent, its impact would be constant on the whole sample. Consequently, it would not influence the results.

The very small color differences ($\Delta E$) between the shade guide tabs measured which are reported in this study are the basis for the claim of high consistency in color parameters. Although the findings of King and deRijk (2007) indicate that there was a high range of variability between different shade guides, however, their experimental method was different than the present study. After establishing the reproducibility of their experimental method by one shade guide measured 10 times, the authors then established the range of variation for 25 different shade guides by using the calculated $E$ value and treating the observed changes in it as $\Delta E$ values. In contrast, in this study, the $\Delta E$ values were used directly to make comparisons between each shade guide and the average of all 100 shade guides.

With regard to the manufacturing of the shade guides, there is no requirement to label each shade guide with an identifying

<table>
<thead>
<tr>
<th>$L$</th>
<th>$a$</th>
<th>$b$</th>
<th>St. Dev.</th>
<th>$\Delta E$</th>
<th>$t$-test for 0.5</th>
<th>$p$-value</th>
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Figure 2  Histogram of the average $\Delta E$ value between each shade guide tab and the average of the 100 tabs with the standard deviation in the A group of shade tabs.
Figure 3  Histogram of the average $\Delta E$ value between each shade guide tab and the average of the 100 tabs with the standard deviation in the B group of shade tabs.

Figure 4  Histogram of the average $\Delta E$ value between each shade guide tab and the average of the 100 tabs with the standard deviation in the C group of shade tabs.

Figure 5  Histogram of the average $\Delta E$ value between each shade guide tab and the average of the 100 tabs with the standard deviation in the D group of shade tabs.
batch or lot number. Consequently, it is not possible to verify whether the measured shade guides used in this study were actually manufactured together or at different production times. The 100 shade guides used in the study were ordered and delivered by the local distributor of the manufacturer. It may be assumed that they were all manufactured simultaneously. It may be possible that the results might differ if the measured shade guides of the same manufacturer were collected from different sources or were selected by the manufacturer to be of different production batches.

5. Further recommendation

Even though the sample in this study was relatively large in terms of the number of shade guides used, however, it could still be useful to repeat such a study design with shade guides obtained from different manufacturers. Further measurements of the color parameters of a sample of shade guides obtained from different batches are recommended.

6. Conclusion

Within the limitations of the design of this study, the following conclusion can be drawn:

It appears that the VITAPAN Classical Vacuum shade guide is manufactured with high consistency with regard to the color parameters.

References