New Shade Guide for Evaluation of Tooth Whitening—Colorimetric Study

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ABSTRACT

Statement of the Problem: Available shade guides lack colorimetric uniformity, which compromises the validity of visual evaluation of tooth whitening efficacy.

Purpose: The objective of this study was to perform a colorimetric analysis of a new shade guide designed primarily for the visual evaluation of tooth whitening efficacy and to compare this shade guide with two commercial shade guides.

Materials and Methods: Color ranges and color distribution of three shade guides (prototype of the new Vita Bleachedguide 3D-Master [BG, Vita Zahnfabrik, Bad Säckingen, Germany], value scale of Vitapan Classical [VC, Vita], and color-ordered Trubyte Bioform porcelain shade guide [TB, Dentsply International, York, PA, USA]) were analyzed ($N = 3$). A circular area ($d = 1.7$ mm) on the middle of the labial surface of the tab, excluding the cervical portion, was measured with a spectroradiometer (D65, 2). Whiteness and yellowness indices were computed. Data were analyzed by analysis of variance and Fisher's PLSD test at a 0.05 level of significance.

Results: The range of color difference (ΔE^*) from the lightest to the darkest tab was 33.8 (BG), 17.1 (VC), and 23.2 (TB). Mean values of ΔE^* among pairs of adjacent tabs were 3.0 (BG), 4.2 (VC), and 3.3 (TB). BG exhibited the highest R^2 values between color coordinate pairs and between whiteness and yellowness indices with the respective color coordinates.

Conclusions: BG exhibited the widest color range and had the most consistent color distribution as compared with the two commercial products. Extension of the lightness range of BG toward higher L^* values (bleach shades) was confirmed.

CLINICAL SIGNIFICANCE

A dental shade guide that is colorimetrically uniform might increase the reliability of visual comparisons of tooth whitening efficacy, whereas the inclusion of realistic bleaching shades in the shade guide will complement contemporary esthetic dentistry.

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INTRODUCTION

The public interest and demand for esthetic dental procedures has never been greater—a beautiful smile became a kind of a business card of modern times. Being relatively efficient, long-lasting, painless, and affordable, tooth whitening (bleaching) is probably the most popular contemporary esthetic procedure.[1] Although tooth whitening has been practiced and described as early as the 1890s,[2] a significant professional and public interest for this procedure occurred almost 100 years later upon publication of a paper on nightguard vital bleaching in 1989.[3] A plethora of bleaching products available nowadays are classified into three huge groups: over-the-counter home-use bleaching products, dentist-dispensed home-use bleaching products, and professional in-office bleaching products.[4–7]

Besides just visualizing bleaching-related changes in tooth color, dentists need guidelines[8–10] and tools for objective, comparable, and routine evaluation of the efficacy and longevity of tooth whitening products. Instrumental evaluation, depending on the device and method, is relatively objective[11–13] but limited to the very small percentage of dentists and institutions that possess these devices. Visual evaluation, using dental shade guides arranged according to decreasing brightness (from the lightest to the darkest tab, "value scale," and "color-ordered" shade tabs), is subjective but widely used.[14] The Vitapan Classical shade guide (VC, Vita Zahnfabrik, Bad Säckingen, Germany) and Trubyte Bioform (TB, Dentsply International, York, PA, USA), with the tabs arranged in this manner, are popular tools for the visual evolution of tooth whitening efficacy. However, these shade guides were not primarily designed for this purpose, starting from the fact that they do not include tabs with bleaching shades (shades lighter than B1 and B59 in VC and TB, respectively). To overcome this deficiency and to be able to record whitening-related differences in color upon usage of contemporary products, artificial thresholds are sometimes used in study designs, including only patients whose teeth were A3 (sometimes A2) or darker before whitening. Visual comparisons among whitening-related color differences are usually expressed in shade guide units (sgu), whereas both visual and instrumental changes can be recorded in color change units (ccu).[8–10] Lack of colorimetric uniformity within shade guides results in the inaccuracy of results recorded utilizing visual comparison with dental color standards.[1] In addition, the "overlapping" of similar shades has led to visually, probably correct, but colorimetrically unrealistic findings on changes of 10+ sgu.

Vitapan 3D Master (Vita) is an advanced shade guide as compared to the VC and some other dental color standards;[15,16] however, its three-dimensional tab arrangement is not convenient for the evaluation of bleaching efficacy. Relatively huge lightness differences among groups of Vitapan 3D Master tabs were found to be an additional concern.[14] Therefore, a new Vita Bleachedguide 3D-Master (BG, Vita) (Figure 1), derived from the Vitapan 3D Master, was designed and developed primarily for the visual evaluation of tooth whitening efficacy. The objective of this study was to perform a colorimetric analysis of a new shade guide and to compare this shade guide with two commercial shade guides, VC and TB. The null hypotheses were that there was no difference in color ranges and color distribution among the evaluated shade guides.

METHODS

Colorimetric evaluation of the three shade guides [prototype of the new BG (15 tabs), value scale of VC (16 tabs), and color-ordered TB porcelain shade guide (24 tabs) ($N = 3$)] was performed by means of a PR-705 spectroradiometer (Photo Research, Chatsworth, CA, USA). The spectroradiometer was calibrated to a reflectance standard (Labsphere, Inc., North Sutton,

Figure 1. Vita Bleachedguide 3D-Master (Vita Zahnfabrik, Bad Säckingen, Germany).

NH, USA) under controlled illumination (Model 66904 lamp housing and Model 69911 power supply, Thermo Oriel Instruments, Stratford, CT, USA) using a 45°/0° optical geometry (illumination/observation geometry). Upon removal of the metal tab holders, shade tabs were positioned in focus on a custom-made, clear acrylic stand and measured with no backing. A holder enabled accurate repositioning of shade tabs. The x-positions of the left and right edges of the shade tabs were noted, and the average x-position of these edges was defined as the center x-position (reset to zero) of tab. After determining the y-position of the center of the tab, all readings of each shade guide tabs were made at an x-position of 0 mm and with the unchanged y-position. A circular area ($d = 1.7$ mm) on the middle of the labial surface of the tab, excluding the cervical portion, was measured. Spectral reflectance values of each shade tab were computed into the Commission Internationale De l'Eclairage, (International Commission on Illumination [CIE]) XYZ and CIELAB values (D65, 1931 CIE standard observer).[17,18]

CIELAB color differences (ΔE^*) were calculated as follows:[19]

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \qquad (1)$$

where ΔL^*, Δa^*, and Δb^* are differences in lightness (achromatic coordinate), green-red coordinate, and blue-yellow coordinate, respectively. Chroma (C^*) and hue (h) values were calculated from the a^* and b^* values.

CIE Whiteness Index (WI), an optimized form of the CIE Whiteness Index (WIO), and the E313 yellowness index (YIE313) were evaluated using the following equations:[20–22]

$$WI = Y + 800(xn - x) + 1.700(yn - y) \qquad (2)$$

$$WIO = Y + 1.075.012(xn - x) + 145.516(yn - y) \qquad (3)$$

$$YIE313 = 100(1 - 0.847Z/Y) \qquad (4)$$

where Y is the relative luminance (Y tristimulus value) and xn, yn, x, and y are the chromaticity coordinates of the reference white and the specimen, respectively.

The means and SDs were determined for the CIELAB values. R^2 values were determined in order to evaluate the interdependence among the pairs of evaluated parameters using a spreadsheet application (Microsoft Excel, Microsoft, Redmond, WA, USA). Analysis of variance (ANOVA) (StatView, SAS Institute, Cary, NC, USA) was used to analyze the data. Fisher's PLSD intervals (StatView) for comparison of means were calculated at the 0.05 level of significance.

RESULTS

Means and SDs of L^*C^*h for the evaluated shade guides are listed in Table 1. ANOVA showed

TABLE 1. CIELAB COLOR COORDINATE VALUES OF EVALUATED SHADE GUIDES.

Vita Bleachedguide 3D-Master				Vitapan Classical				Trubyte Bioform			
Tab	*L**	*C**	*h*	Tab	*L**	*C**	*h*	Tab	*L**	*C**	*h*
0M1	81.5 (0.8)	6.1 (0.1)	97.3 (0.3)	B1	74.4^{a} (0.7)	13.3 (0.2)	98.1 (0.9)	B59	75.4 (0.8)^{a}	15.3 (0.5)^{n}	96.4 (0.9)
0.5M1	79.9 (0.3)	8.9 (0.1)	95.2^{e} (0.2)	A1	74.6^{a} (0.4)	14.5^{g} (0.1)	93.7^{n} (0.6)	B51	75.1 (0.8)^{a}	17.8 (0.8)^{o,p}	94.3 (0.8)^{A}
1M1	76.4 (0.5)	11.7 (0.2)	93.3^{f} (0.5)	B2	73.1^{b} (0.2)	18.1^{h} (0.2)	93.0^{n} (0.3)	B91	71.5 (0.1)^{b,c,d}	14.6 (0.3)^{n}	91.3 (0.7)^{A}
1M1.5	77.6^{a} (0.2)	14.7 (0.1)	94.4^{e} (0.1)	D2	68.7^{c} (0.8)	14.4^{g} (0.5)	90.3^{o} (0.6)	B62	71.9 (0.8)^{b,c}	17.0 (0.2)^{o}	92.1 (0.2)^{y,z}
1M2	77.4^{a} (0.1)	16.6 (1.4)	92.9^{f} (1.4)	A2	73.3^{b} (0.5)	18.7$^{h.i}$ (0.3)	88.0^{p} (0.5)	B66	71.3 (0.7)^{c,d}	19.3 (0.6)^{q}	92.1 (0.3)^{y,z}
1.5M2	75.5 (0.2)	17.7 (0.4)	91.3 (0.2)	C1	69.2^{c} (0.0)	14.8^{g} (0.4)	90.4^{o} (0.6)	B52	72.4 (0.5)^{b}	18.5 (0.6)^{p,q}	92.7 (0.3)^{y}
2M2	72.7 (0.0)	18.7^{d} (0.0)	88.7 (0.1)	C2	67.5^{e,f} (0.6)	19.1^{i} (0.3)	89.5 (0.3)	B53	70.3 (0.4)^{d,e,f}	20.5 (0.4)^{r}	89.4 (0.5)^{B,C}
2.5M2	71.8 (0.3)	19.3^{d} (0.6)	87.8 (0.6)	D4	67.1^{f} (0.3)	21.4^{k} (0.7)	90.7^{o} (0.1)	B92	70.4 (1.4)^{d,e,f}	17.0 (0.5)^{o}	91.8 (1.2)^{z,A}
3M2	68.2^{b} (0.1)	20.6 (0.3)	85.1^{g} (0.1)	A3	69.9 (0.7)	21.0^{j,k} (0.3)	86.4^{r} (0.4)	B63	71.6 (0.3)^{b,c}	20.6 (0.2)^{r}	88.3 (0.1)^{D,E}
3.5M2	67.6^{b} (0.8)	21.5 (0.4)	84.4^{g} (0.6)	D3	67.3^{e,f} (0.4)	18.1^{h} (0.0)	86.3^{r} (0.6)	B54	70.6 (0.7)^{d,e}	21.9 (0.3)^{s,t}	87.4 (0.2)^{F,G,H}
4M2	64.5 (0.3)	22.8 (0.2)	81.5 (0.2)	B3	68.5^{c,d} (0.5)	24.0^{l,m} (0.1)	87.4^{p,q} (0.2)	B65	70.0 (0.4)^{e,f,g}	23.0 (0.1)^{t,u}	87.4 (0.2)^{F,G,H}
4.5M2	63.2 (0.2)	23.9 (0.6)	80.6 (0.3)	A3,5	67.0^{f} (0.4)	24.5^{m} (0.2)	83.9^{s} (0.1)	B93	67.6 (0.8)^{h}	21.1 (0.3)^{r,s}	87.6 (0.5)^{E,F,G}
5M2	59.9^{c} (0.4)	25.9 (0.1)	78.0^{h} (0.1)	B4	68.0^{d,e} (0.2)	25.8 (0.7)	86.9^{q,r} (0.4)	B55	70.3 (0.3)^{d,e,f}	24.6 (1.1)^{v,w}	90.0 (0.6)^{A,B}
5M2.5	61.5 (0.8)	28.9 (0.1)	79.0^{i} (0.2)	C3	64.5 (0.1)	20.6^{j} (0.5)	87.6^{p,q} (0.3)	B69	67.0 (0.4)^{h,i}	22.9 (0.6)^{t,u}	87.0 (0.3)^{G,H}
5M3	60.4^{c} (0.1)	32.0 (0.8)	78.4$^{h.i}$ (0.1)	A4	63.0 (0.4)	23.7^{l} (0.7)	81.8 (0.2)	B94	65.8 (0.5)^{j}	22.1 (1.2)^{s,t}	89.5 (0.5)^{A,B}
				C4	59.9 (0.3)	21.2^{j,k} (0.4)	83.3^{s} (0.3)	B95	66.3 (0.2)^{i,j}	19.4 (0.8)^{q}	88.0 (0.3)^{D,E,F}
								B67	69.2 (0.7)^{g}	24.9 (0.7)^{v,w}	88.7 (0.3)^{C,D}
								B56	69.4 (0.8)^{f,g}	24.7 (0.5)^{v,w}	86.6 (0.3)^{H}
								B77	67.8 (0.2)^{h}	24.8 (0.7)^{v,w}	86.9 (0.2)^{G,H}
								B81	64.5 (0.7)^{k}	25.2 (0.1)^{w}	83.9 (0.2)^{I}
								B96	62.0 (0.5)^{m}	23.9 (1.5)^{u,v}	83.2 (0.1)^{I}
								B83	66.2 (0.3)^{i,j}	26.7 (0.5)^{x}	83.7 (0.2)^{I}
								B84	63.5 (0.1)^{k,l}	26.7 (0.6)^{x}	81.3 (0.4)^{J}
								B85	63.0 (0.2)^{l,m}	34.1 (0.0)	81.2 (0.3)^{J}

CIE = Commission Internationale De l'Eclairage; *L** = lightness; *C** = chroma; *h* = hue.
Means marked with the same superscript letters within each shade guide separately were not statistically different ($p = 0.05$).

significant differences in L^*C^*h values within pairs of tabs of each of the shade guides ($p < 0.0001$, power = 1.0). Fisher's PLSD intervals ($p = 0.05$) for comparisons of L^*C^*h values among tabs of the BG shade guide were 0.7, 0.8, and 0.8, respectively. Corresponding values were 0.7, 0.7, and 0.8 for VC and 1.0, 1.1, and 0.8 for TB, respectively.

Means and SDs of differences between the first and the last tab in the evaluated shade guides are listed in Table 2 as ranges of lightness, chroma, and hue (ΔL_R, ΔC_R, Δh_R) and color-difference ranges (ΔE_R). Fisher's PLSD intervals ($p = 0.05$) for comparisons of ΔL_R, ΔC_R, Δh_R, and ΔE_R values were 1.7, 1.2, 1.6, and 1.6, respectively. Color distribution and uniformity within shade guides are presented in Table 2 as mean differences among pairs of adjacent tabs (ΔL_A, ΔC_A, Δh_A, ΔE_A). Means marked with the same superscript letter within each column were not statistically different ($p = 0.05$).

Mean lightness (ΔL^*), chroma (ΔC^*), hue differences (Δh), and color differences (ΔE^*) among adjacent tabs and all possible combinations of tab distances from 2 to 14 tabs apart for BG (original tab arrangement), from 2 to 15 tabs apart for VC (value scale), and from 2 to 23 tabs apart for TB (color-ordered) are shown in Figure 2.

CIE WI ranged from 28 (0M1) to –169 (5M3) for BG, from –27 (B1) to –110 (C4) for VC, and from –35 (B59) to –168 (B85) for TB.

TABLE 2. RANGES OF LIGHTNESS, CHROMA, AND HUE (ΔL_R, ΔC_R, ΔH_R) AND COLOR DIFFERENCE RANGES (ΔE_R), AND MEAN DIFFERENCES (SD) AMONG PAIRS OF ADJACENT TABS (ΔL_A, ΔC_A, ΔH_A, ΔE_A) OF VITA BLEACHEDGUIDE 3D-MASTER (BG), VALUE SCALE OF VITAPAN CLASSICAL (VC), AND COLOR-ORDERED TRUBYTE BIOFORM SHADE GUIDE (TB).

Shade Guide	ΔL_R	ΔC_R	Δh_R	ΔE_R	ΔL_A	ΔC_A	Δh_A	ΔE_A
BG	21.2 (0.9)	25.9 (0.9)	18.9 (0.3)	33.8 (0.8)	1.5[b] (1.7)	−1.9 (1.0)	1.3[d] (1.4)	3.0[e] (1.2)
VC	14.5 (0.9)	7.9 (0.3)	14.8[a] (0.8)	17.1 (0.9)	1.0[b] (2.6)	−0.4[c] (3.0)	0.5[d] (3.0)	4.2 (1.6)
TB	12.4 (0.7)	18.9 (0.5)	15.2[a] (1.1)	23.3 (0.8)	0.5[b] (2.1)	−0.8[c] (2.7)	0.7[d] (1.9)	3.3[e] (1.6)

Corresponding values of WIO ranged from 46 to −81 for BG, from 16 to −43 for VC, and from 12 to −74 for TB, while corresponding YIE313 values ranged from 17 to 59 for BG, from 31 to 43 for VC, and from 36 to 49 for TB.

R^2 values among L^*C^*h values and tab arrangement of BG (tabs 1–15), value scale of VC (tabs 1–16), and

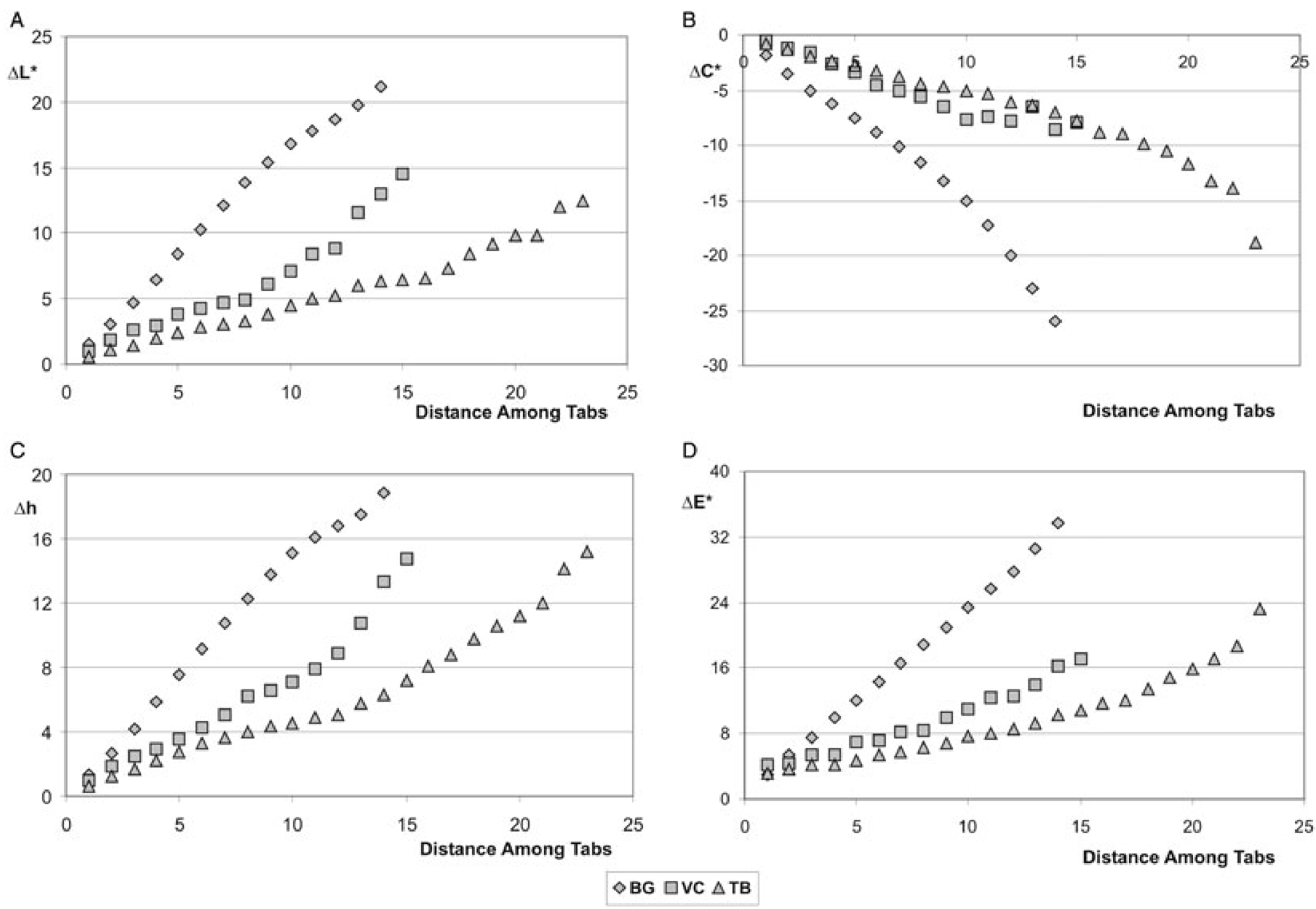

Figure 2. Difference in color parameters among adjacent tabs and all possible combinations of tab distances from 2 to 14 tabs apart for Vita Bleachedguide 3D-Master (BG), from 2 to 15 tabs apart for Vitapan Classical (VC), and from 2 to 23 tabs apart for Trubyte Bioform (TB). A, *Lightness differences (ΔL^*).* B, *Chroma differences (ΔC^*).* C, *Hue differences (Δh).* D, *Color differences (ΔE^*).*

color-ordered TB shade guide (tabs 1–24), and R^2 values among pairs of color parameters are presented in Table 3.

DISCUSSION

BG was designed to enable a relatively consistent visual evaluation of tooth whitening efficacy as opposed to the present findings obtained using VC and TB. Because the original tab arrangement of Vitapan 3D Master was, to a certain extent, cumbersome for the evaluation of tooth whitening, it was redesigned into a linear shade guide (a form that dentists are familiar with), whereas interpolations were included to bridge huge ΔL^* gaps among groups. The lightest part of the BG and its subtle color gradation are other big differences as compared with the other two evaluated shade guides.

In all three shade guides, L^* and h values decrease, whereas C^* values increase from the lightest to the darkest tab. Tables 1 and 2 provide information on color ranges and color distribution of the three shade guides. When the first tabs (the "lightest" ones) of the three shade guides were compared, 0M1 was lighter and less chromatic than B1 and B59 (ΔL^* of 6.9 and 6.1, respectively; ΔC^* of –7.2 and –9.2, respectively). These differences recommend BG as a shade guide of choice for patients with initially very light teeth and for the evaluation of very efficient tooth whitening products. In addition, BG exhibited the widest L^*C^*h and ΔE^* ranges (from the "lightest" to the "darkest" tab) among the evaluated dental color standards.

Another issue is color distribution. BG had the fewest tabs that were essentially duplicates in terms of either L^*C^*h values (Table 1) or color-difference values among adjacent tabs (Table 2). The greatest L^*C^*h differences among pairs of adjacent tabs, and yet the smallest color difference among these pairs, present additional confirmation that the color distribution of BG is more uniform than the other two products. Figure 2 and the R^2 values in Table 2 additionally emphasize the differences in color distribution among the evaluated products.

Differences in the L^* coordinate values among BG tabs were relatively consistent except for the 1M1–1M2 and 5M2–5M3 transitions in which C^* differences predominated. However, this was not treated as a shortcoming. First, the inclusion of 5M2.5 and 5M3 to BG comply with the concern that dental shade guides lack redder shades,[1] thus enabling better representation of tooth color space and better representation of the original product, Vitapan 3D Master. Second, ΔE^* values were relatively consistent throughout BG, which corresponds to the American Dental Association (ADA) recommendation that the degree of overall

TABLE 3. R^2 VALUES AMONG L^*C^*H VALUES AND TAB ARRANGEMENT (TA) OF VITA BLEACHEDGUIDE 3D-MASTER (TABS 1–15), VALUE SCALE OF VITAPAN CLASSICAL (TABS 1–16), AND COLOR-ORDERED TRUBYTE BIOFORM SHADE GUIDE (TABS 1–24), AND R^2 VALUES AMONG PAIRS OF COLOR PARAMETERS.

Parameter	Vita Bleachedguide 3D-Master	Vitapan Classical	Trubyte Bioform
L^*/Tabs	0.97	0.79	0.81
C^*/Tabs	0.96	0.65	0.78
h/Tabs	0.97	0.78	0.84
L^*/C^*	0.89	0.31	0.54
L^*/h	1.00	0.60	0.81
C^*/h	0.89	0.56	0.72
L^*/WI	0.95	0.72	0.80
L^*/WIO	0.97	0.77	0.83
b^*/YIE313	0.99	0.16	0.08

WI = whiteness index; WIO = optimized whiteness index; YIE313 = yellowness index.

color change should be considered clinically important.[8–10,14] Visual (sgu, VC) and instrumental (ΔE^*) change of 3, 4, and 5 ccu are the ADA threshold of clinical success for over-the-counter home-use tooth whitening products, dentist-dispensed home-use products, and professional in-office bleaching products, respectively.[8–10] The ADA recommendations also specify that color change must be in the direction of higher L^* and lower b^* values, which is in accordance with the literature.[13]

Whiteness is defined as the attribute of color perception by which an object color is judged to approach the preferred white, whereas whiteness index is a number that indicates the degree of departure of an object color from that of a preferred white.[22] Yellowness is defined as the attribute of color perception by which an object color is judged to depart from colorless or a preferred white toward yellow. Accordingly, the yellowness index, YI, is a number that indicates the degree of departure of an object color from colorless or from a preferred white toward yellow.[22] As both increase in lightness and decrease in yellowness are expected after successful tooth whitening, whiteness and yellowness indices were evaluated in this study. CIE WI was compared with a modified version of this index, WIO, developed in order to provide better fit to the visual evaluation of teeth and shade guides.[20,21] This study demonstrated that WIO enabled better fit with the instrumental color measurements as well. R^2 values between L^* and both WI and WIO were the highest for BG, followed by TB and VC, respectively (Table 3). Because teeth become less yellow (and less chromatic) after whitening, the R^2 value between b^* and YIE313 for BG (0.99) appears to be a significant advantage as compared with the corresponding R^2 values for VC (0.16) and TB (0.08).

Corresponding color differences as compared to the "lightest" tab were evaluated for each of three shade guides (up to tab 15 for all shade guides because BG has only 15 tabs). The ratio of ΔE^* values was BG:*T = 1:1.9 and BG:TB = 1:2.4. These relationships mean that it is possible to compare the visual BG finding (sgu) with the visual VC and TB findings from previous studies by multiplying the BG sgu value by approximately 2.0. The opposite conversion is not recommended because of the relatively flawed order of VC and TB.

CONCLUSIONS

Within the limitations of this study, the null hypotheses were rejected—BG exhibited the widest color range and had the most consistent color distribution as compared with the two commercial products. Extension of its lightness range toward higher L^* values (bleach shades) was confirmed.

DISCLOSURE AND ACKNOWLEDGMENTS

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COMMENTARY

NEW SHADE GUIDE FOR EVALUATION OF TOOTH WHITENING—COLORIMETRIC STUDY

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Claims for the efficacy of tooth whitening products are often based on studies utilizing the relative whitening compared to tooth tabs from various dental shade guides. Not all evaluators have access to more accurate instrumental evaluation. The shade guides used may have no correlation to each other, vary in the color differentiation between shade tabs next to each other in their own systems, may or may not be arranged in a value-ordered system, and may not have bleaching shades in their ranges. Shade guides also darken when sterilized multiple times, so new units need to be used to minimize internal variation. Therefore, because of the limitations of the shade guides used, manufacturers' claims are impossible to differentiate from each other, and because of this, it is impossible to do a valid comparison between products from different manufacturers based on study results.

The authors of this study evaluate a new shade guide for assessing tooth whitening, which has been developed to address the previously mentioned shortcomings of current shade guides when used in comparative data for shade whitening results. This shade guide is compared to the value scale of the Vitapan Classical (Vita Zahnfabrik, Bad Säckingen, Germany) and the color-ordered Trubyte Bioform (Dentsply International, York, PA, USA) porcelain shade guide. The new bleaching shade guide has a larger range of lightest to darkest shades. It has a more even distribution of color between shade tabs, with a delta E of 3 among pairs that is discernible to the eye. The even distribution eliminates shade tabs that may be essentially duplicates in lightness, hue, and chroma. It also includes bleaching shades that are missing from some of the shade guides in use today. This author believes that this is a significant step forward in creating a standard reference that can be used in comparison studies when evaluating the effectiveness of whitening products used clinically.

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