Short Communication

Comparing L*a*b* Color Coordinates for Natural Teeth Shades and Corresponding Shade Tabs Using a Spectrophotometer

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It was investigated whether $L^*a^*b^*$ values for teeth as well as shade tabs for one 3D-Master shade were similar to one another. Teeth were measured using Vita Easyshade and $L^*a^*b^*$ values and the closest 3D shade was then recorded. The shade-guide tabs were also measured using the same device. 3D-Master shades yielded different $L^*a^*b^*$ values for the teeth than for the tabs. L^* and a^* values, especially, were systematically different. Therefore, Easyshade $L^*a^*b^*$ values for teeth and tabs could not be directly compared. *Int J Prosthodont 2009;22:72–74*.

To explore coverage error of shade guides, color coordinates (CIE L*a*b* values; L* = lightness, a* = red/green, and b* = blue/yellow) of teeth and shade tabs must be compared.¹⁻³ Recent studies have measured both teeth and tab coordinates using the same device or used reference values provided by the manufacturer. Coverage error toward green was found, and a high mean coverage error for the 3D-Master shade guide (Vita Zahnfabrik) ($\Delta E = 6.15$) and coverage of only 37.45% for the Vita Lumin shade guide (Vident) were also documented.^{2,3} For the Vita Lumin, however, this may be the result of using extracted teeth. These differences were relatively high, but keep in mind that shade guides were originally conceived empirically and are meant to be used clinically.

From the literature, it remains unclear whether L*a*b* values of teeth and tabs can be directly compared. L*a*b* values may differ between instruments because of individual calibration processes. Moreover, teeth and tabs are physically different materials and measurement results may be material-dependent.

To investigate whether shade guides cover tooth colors of middle-aged (54 to 56 years) and old (73 to 75 years) patients, the anterior teeth of these age groups were measured using a clinically applicable spectrophotometer.⁴ Before coverage analysis, the hypothesis that measurement of shade tabs produces L*a*b* values that could be compared with values measured for natural teeth was investigated.

Materials and Methods

The hypothesis was tested using the 3D-Master shade guide since the shade-taking device used (Vita Easyshade, software version 11R[b]) automatically displays L*a*b* values and the corresponding 3D-Master shade. Preliminary data on natural tooth color for mainly the older cohort were used. Basic tooth color was measured in the "tooth single" mode with one measurement, leaving a minimum of 2 mm on the gingival edge and measuring above the region where the underlying dentin was assumed to be thickest, as recommended by the manufacturer. Natural anterior teeth

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3D-Master shade (no. of teeth)	Natural teeth			Shade tab						
	L*	a*	b*	L*	а*	b*	ΔL^*	Δa^*	Δb^*	$\Delta {\rm E_{ab}}$
3L1.5 (n = 7)	75.8 (1.7)	-1.2 (0.5)	19.6 (1.4)	71.2 (0.1)	1.8 (0.1)	20.4 (0.1)	4.6	-3	-0.8	5.5
3L2.5 (n = 14)	77 (1.1)	-0.4 (1.4)	26.7 (0.8)	72.7 (0.4)	2.1 (0)	26.4 (0.2)	4.3	-2.5	0.3	5
3M1 (n = 16)	75.6 (2)	-1.3 (1)	15.4 (1)	71.7 (0.2)	1.9 (0)	15 (0.1)	3.9	-3.2	0.4	5.1
3M2 (n = 2)	71.3 (6.1)	0.5 (0.1)	28 (4.3)	72 (0.3)	2.2 (0)	21.7 (0.2)	-0.7	-1.7	6.3	6.6
3M3 (n = 49)	79 (3.2)	0.1 (1)	31.9 (3.6)	72.3 (0.2)	2.9 (0)	29 (0.1)	6.7	-2.8	2.9	7.8
3R1.5 (n = 1)	77	2.5	21.1	73.2 (0.3)	2.9 (0)	18.7 (0.1)	3.8	-0.4	2.4	4.5
3R2.5 (n = 2)	76.2 (0.4)	3.3 (0.6)	27.4 (1.1)	72.5 (0.3)	3.5 (0)	27.2 (0.2)	3.7	-0.2	0.2	3.7
4L1.5 (n = 59)	68.9 (1.2)	-0.3 (0.7)	22.1 (1.5)	67.4 (0.2)	2.8 (0)	22.8 (0.1)	1.5	-3.1	-0.7	3.5
4L2.5 (n = 13)	67.4 (3.3)	0.1 (1)	28.7 (2.7)	66.7 (0.2)	3.9 (0.1)	29.8 (0.3)	0.7	-3.8	-1.1	4
4M1 (n = 38)	67.3 (2.8)	_0.6 (0.8)	17.4 (2.4)	67.1 (0.2)	2.5 (0)	16.8 (0.1)	0.2	-3.1	0.6	3.2
4M2 (n = 13)	68.8 (1.1)	1.4 (0.9)	26.2 (1)	67.7 (0.2)	3.4 (0.1)	24.5 (0.2)	1.1	-2	1.7	2.8
4M3 (n = 70)	70.3 (2.5)	4.3 (1.5)	35.8 (2.6)	66.8 (0.2)	4.3 (0.1)	29.8 (0.1)	3.5	0	6	6.9
4R1.5 (n = 4)	69.1 (1)	1.5 (1.7)	22.4 (1.7)	67.4 (0.1)	3.9 (0)	20.7 (0.1)	1.7	-2.4	1.7	3.4
4R2.5 (n = 25)	68.4 (1.1)	4.2 (1)	30.8 (2.1)	68.2 (0.2)	5.2 (0.1)	29.2 (0.3)	0.2	-1	1.6	1.9

Table 1L*a*b* Values (SD) of Natural Teeth and Shade Tabs of the Same 3D-Master Shade. Differences Between L*, a*,and b* Values (Δ L*, Δ a*, Δ b*), and Δ E_{ab}

in the maxilla and mandible were only included if they were not overlapping a tooth-colored filling and the probe tip could be placed correctly. For every tooth, the L*a*b* values and the closest 3D-Master shade were recorded. For further analysis, only teeth with a shade in value groups 3 and 4 and without inbetween shades (eg, 3.5M2) were considered (n = 313 teeth). Value group 2 was infrequent and value groups 1 and 5 only have "M" shades. Mean L*a*b* values were calculated for every 3D-Master shade.

The shade tabs of the 3D-Master shade guide were measured three times with the same device in the "tooth single" mode, the only mode providing L*a*b* values, and means were calculated.

Mean L*a*b* values of teeth for the respective 3D-Master shade were compared with values for the 3D-Master shade tab. For example, for shade 3M2, the mean L*a*b* values of 3D-Master tab 3M2 were compared with mean L*a*b* values calculated from measurement of teeth for which the device had chosen 3M2 as the closest shade.

Results

Mean values for one shade of the 3D-Master differ between tooth color measurements and measurements for the tabs (Table 1, Figs 1 and 2). The same 3D-Master shade therefore gave different L*a*b* values for the different materials. Systematic differences were observed for L* and a* values, especially. The L* value was higher, and therefore lighter, for natural teeth; tooth a* values were more toward –a* (green spectrum) than those of tab measurements.

 ΔE_{ab} gives the color difference, ie, the Euclidian distance between 2 L*a*b* coordinates (L*₁a*₁b*₁ to L*₂a*₂b*₂). It is obtained from the formula:

$$\Delta \mathsf{E}^*_{ab} = \sqrt{(\mathsf{L}_1 - \mathsf{L}_2)^2 + (\mathsf{a}_1 - \mathsf{a}_2)^2 + (\mathsf{b}_1 - \mathsf{b}_2)^2}$$

The color distance (ΔE_{ab} , Table 1) between the means for tabs and teeth for one shade was greater than or equal to the threshold for the largest color difference with no mismatches observed, as described in a study by Johnston et al,⁵ for 9 of the 14 different shades ($\Delta E_{ab} = 3.7$).

Discussion

The hypothesis had to be rejected. The algorithm used by the shade-taking device to determine which L*a*b* value corresponded to which 3D-Master shade was devised empirically. Therefore, for the human eye, there seemed to be a good match between tab and tooth, but the instrument furnished different values. Although shade tabs had comparable shades and imitated dentin and enamel layers, Easyshade L*a*b* values for tabs should not be compared directly with those of teeth. This could lead to unjustified conclusions. For example, the systematic shift of tab measurements toward +a* (red) could lead to the assumption that the shade guide does not cover the "greener" tooth colors.

Confounding variables of the results might be the specular reflection (gloss) and translucency of the incisal regions of the teeth.² However, this is qualified with the measurement of basic color, not including those at the incisal site, and according to the developers of Easyshade, with the design of the fiberoptic probe, which does not allow for specular reflections to influence the measurement. Translucency, in contrast, does affect the L* measurement. Another limitation of the study is the restricted color gamut examined; this was in a darker and more saturated color region because of the elderly participants.



Fig 1 Comparison of the positions of shade tab and natural tooth for one 3D-Master shade in value group 3.

Conclusion

Bearing in mind the limitations of the study, it is concluded that Easyshade L*a*b* values for teeth and shade tabs cannot be used for direct comparison. A correspondence factor between measurements of these physically different materials should be worked out before investigating coverage of natural tooth color with the shade guide. Further research should be conducted for other devices.

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Fig 2 Comparison of the positions of shade tab and natural tooth for one 3D-Master shade in value group 4.

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