

VISUAL VERSUS INSTRUMENTAL SHADE SELECTION TECHNIQUES

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ABSTRACT

Statement of Problem: Visual shade selection is a subjective process depending on the skill of operator, eye fatigue, lightening conditions along with many other factors.

Purpose: To test the difference between the visual and the instrumental shade selection techniques.

Materials and methods: Shade selection of maxillary right central incisor of 32 randomly-chosen students was performed visually by comparing to VITA 3D-Master Linearguide (VITA Zahnfabrik H), and instrumentally using an intraoral spectrophotometer (Vita Easyshade Compact). Color Difference (ΔE) was calculated according to the equation: $\Delta E = [(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2]^{1/2}$. ΔE values more than 2.7 were considered clinically unacceptable.

Results: High ΔE values mean values (9.65) between visual and instrumental techniques, resulted in clinically unacceptable results.

Conclusion: Color difference between human-eye and computerized color matching was perceivable under clinical settings, as delta E values were higher than the acceptability threshold.

Clinical Implications: Further advancements are needed in both the shade guide ranges and the instrumental shade measuring devices to get more accurate close results.

KEYWORDS: Spectrophotometer, Easyshade, Visual, Acceptability threshold, Delta E.

INTRODUCTION

Looking back in history you can see how generations of women have used some interesting ways to make themselves beautiful. Dental esthetics has been based for a long on theories, where the restored or replaced teeth had to match the face

shape in respect to sex, age and the personality of the patient. Patients in need of restorations in the anterior region look for both esthetics and function. Restoring esthetics depends on outline form, surface texture, translucency and colour.¹ With the new available dental materials, achieving

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superior esthetics became easier and applicable.² Nevertheless, the dentist's ability to assess color and the laboratory technician's ability to reproduce color remain a confusing procedure.³

Color measurement has been classified and specified in several ways. Two of the most widely used systems for describing color are the "Munsell System" and the International Commission on Illumination (CIE) color/order system.⁴ The *Munsell System* compares the perceived color of an object with a standardized and orderly arranged color chips. It describes colors in a three-dimensional coordinate system of *hue*, *value*, and *chroma*.⁴

Unlike the Munsell system, the *CIE color system*, developed in 1931 as the international standard for color perception, is based on the concept that all colors can be matched by some kind of mixture to specify relative amounts of three light primaries, namely, red (X), green (Y), and blue (Z), that are required to match the color of a sample.⁵ The tri-stimulus values (X, Y, Z) are transformed into $L^*a^*b^*$ color coordinates.⁶ L^* refers to the lightness coordinate and its value ranges from 0 (perfect black) to 100 (perfect white). The values of a^* and b^* are the chromaticity coordinates in red-green axis and yellow-blue axis, respectively. Positive a^* values indicate the *red* color range, and negative values indicate the *green* color range. Similarly, positive b^* values indicate the *yellow* color range, whereas negative value indicate *blue* color range. CIE $L^*a^*b^*$ color difference values (ΔE) are then calculated to determine color perception.⁷

However, the literature is not in agreement with respect to color difference perception of the human eye. ΔE values less than 1 are regarded as not appreciable by the human eye. ΔE values between 1 and 2 are appreciable by non-skilled careful individuals, and are therefore, considered clinically acceptable. ΔE values, however, more than 2 are appreciable to non-skilled regular individuals, and are therefore, considered not clinically acceptable.⁸

Shade selection was conventionally made by a visual mean of comparing a target tooth to a shade guide.^{9,10} However the presence of certain discrepancies in shade guides such as: insufficient shade range that cover all the colors of natural teeth and incomplete coverage of the color space of the natural teeth^{9,11}, in addition to the observer's state of exhaustion, aging, and different lighting environment¹² made it a subjective procedure.

For the sake of decreasing the errors, standardizing the results, and improving the communication between the dentist and the laboratory technician, numerous electronic devices are now available in the market such as colorimeters, spectrophotometers, spectroradiometers, and digital cameras.^{13,14,15} Although these devices improved the shade selection procedure and made it easier, some dentists found it accurate and effective while others found it changeable and unpredictable. Several studies showed mixed results regarding these color measuring devices.^{16,17,18}

The dilemma is whether the professional eye can serve alone to determine the tooth color accurately disregarding the available technology or even the most skilled practitioners need sometimes the aid of these color measuring devices.

The aim of this study was to compare the colour matching ability of a spectrophotometer (VITA Easyshade) with a conventional visual colour matching technique by the use of VITA 3D-Master Linearguide (LG; VitaZahnfabrik) in order to determine which method provided the most reproducible colour matching in the clinical environment.

MATERIALS AND METHODS

Shade selection was performed to the middle third of the maxillary right central incisor of 32 randomly-chosen students in the outpatient dental clinic at the Faculty of Dentistry, Beirut Arab University. Inclusion criteria for those teeth were as follows:

- (a) Absence of any type of restorations
- (b) No observable carious lesions or stains
- (c) No history of orthodontic treatment
- (d) No malformed or excessively rotated teeth
- (e) No previous bleaching treatment

Measurements were done between 10 AM and 12 PM. The light source was natural daylight only, and a gray bib was used on all individuals. Shade selection was performed by two techniques: visual and instrumental.

Visual shade selection:

Color determination was made using the VITA 3D-Master Linearguide. It was placed next to the maxillary right central incisor and, in order to simulate the clinical situation, the shade was determined only once for each tooth.

Instrumental shade selection:

Color determination was done by the use of Easyshade following the manufacturer's instructions. Definitely, the spectrophotometer was calibrated before each shade selection, using the calibration method provided by the manufacturer. Deviation in the quantity of illumination output from the internal light source is compensated by the calibration process¹⁹. The head aperture of the spectrophotometer was positioned on the facial surface of the tooth to determine its shade. Instrumental shade determination was done three consecutive times for each of the thirty two incisors.

The spectrophotometric readings of each object were recorded and the color of the measured tooth was identified in CIE L* a*b* colour parameters²⁰. The shade-guide tabs chosen by the visual shade selection were also measured using the same device²¹. (Figure 1)

The data was coded and entered using the statistical package SPSS version 15. The data was



Fig. (1) Shade registering using Easy Shade.

summarized using descriptive statistics: mean, standard deviation, minimum and maximum values for quantitative variables. Statistical differences were tested using paired sample t test repeated measurement ANOVA with post Hoc Bonferroni test for quantitative normally distributed variables. Inter-rater agreement was tested using Intraclass Correlation Coefficient. P-values less than or equal to 0.05 were considered statistically significant.

The collected CIE L*a*b* data was tabulated and analyzed. Color differences (ΔE) for the average L*, a*, and b* color parameters between every pair of subgroups were calculated. The ΔE values were inspected to identify if any difference was greater than 2.7 according to Ragain and Johnston (2000)²².

RESULTS

The mean of the L instrumental showed higher values (86.05) than that of the L visual (shade tab) (77.83) and therefore lighter. Tooth a* values were more toward -a*(-0.99) (green spectrum) than those of tab measurements (0.38). The mean value of the b* color coordinate of the tooth (instrumental) was (18.49) whereas that of the shade tab measurements was (18.39). The minimum value of the b* instrumental was (5.50) whereas that of the visual (shade tab) was (10.30); that is tab values were more toward the yellow spectrum.

TABLE (I)

	Minimum	Maximum	Mean	Std.Deviation
L instrumental (Easyshade)	67.40	93.00	86.05	5.53
L visual (Shade tab)	72.60	81.10	77.83	3.35
a instrumental (Easy shade)	-2.60	3.70	-0.99	1.21
a visual (Shade tab)	-0.70	3.40	0.38	1.04
b instrumental (Easyshade)	5.50	29.10	18.49	5.85
b visual (Shade tab)	10.30	27.90	18.39	4.87
ΔE	3.88	17.89	9.65	3.05

	t	df	p-value
Pair 1: L Instrumental Shade Selection (Easyshade) for upper right central – L EasyShade readings of selected shade tab (visual)	10.561	31	0.000
Pair 2: B Instrumental Shade Selection (Easyshade) for upper right central - B EasyShade readings of selected shade tab (visual)	0.153	31	0.880

	A EasyShadereadings of selected shade tab (visual) - A Instrumental Shade Selection (Easy shade) for upper right central
Z	-4.901
Asymp. Sig. (2-tailed)	0.000

ΔE gives the color difference, ie, the Euclidian distance between 2 $L^*a^*b^*$ coordinates ($L_1^*a_1^*b_1^*$ to $L_2^*a_2^*b_2^*$). It is obtained from the formula:

$$\Delta E = [(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2]^{1/2}$$

The color distance (ΔE Table 1) between the tabs and teeth (9.65) was greater than the threshold for the largest acceptable color difference.

DISCUSSION

Correct tooth shade selection and communication are essential to success of a restoration. There are two methods of shade determination: comparison with shade tabs and shade measurement with electronic devices. These two methods have gone under great improvement during last decades and their combination increases esthetic success. By taking

advantage of combination of visual methods and technology-based instrumentation the subjectivity of visual color assessment can be minimized and accurate color analysis for restoration's shade is more easily communicated and predictable esthetic outcome can be achieved. Routine clinical shade match, the method of comparing the tooth with shade tabs is subjective with not always quite controlled conditions and methods. Color matching is complicated by individual differences in color perception of even those dentists with normal color vision. The frequency of red-green color vision deficiency is reported 6-14% among dentists and dental students.

The VITA 3D-Master Linear guide enables the quick determination of precise tooth shades and uses the same scientific principles and 29 shades found in the VITA 3D-Master shade guide. The Linearguide features a, linear design that makes the process of precise shade determination faster and easier. In two steps the final shade is achieved, first by selecting from five value tabs, then by choosing the proper mix of chroma and hue within the selected value range. The only method of transferring the chosen tooth shade from any shade guide into physical color coordinates (L^*, a^*, b^*) that can be compared numerically with that of a colorimeter is by measuring the selected shade tab by the colorimeter itself.

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 compared²³. But in this paper, we ignored that difference because it is the same in all our comparisons.

Della Bona, et al, found that a significantly higher visual-instrumental shade agreement was demonstrated by the clinically experienced dentists, regardless of shade guides and lighting conditions²⁴.

In addition, Yilmaz and Karaagaciloglu (2008) in comparing visual shade determination and an intra-oral dental colourimeter found that the repeatability of instrumental (intra-oral dental colourimeter) and visual shade determinations were acceptable²⁵.

Whereas on the opposite side, Okubo et al (1998) found that shade determination by visual means was inconsistent. Accuracy of a new colorimeter in matching porcelain shade guide teeth was only slightly better²⁶. Also Yap et al (1999) found that color difference between human-eye and computerized color matching is perceivable under clinical settings, as delta E values are greater than 3. There is a need for correction factors in the formal specification of the color-matching software due to the discrepancy between human-eye and computerized colorimetric color matching²⁷. Further researches are needed to enable more improvement of both visual and instrumental shade guide to better precision and patient service.

CONCLUSIONS

Color difference between human-eye and computerized color matching was perceivable under clinical settings, as delta E values were higher than the acceptability threshold.

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