Applied Medical Informatics
Original Research Vol. 30, No. 1 /2012, pp: 49-54

Visual versus Colorimetric Data Analysis for Color Determination in Resin Veneers

Raluca DIMA

University of Oradea, Faculty of Medicine and Pharmacy, Department of Dental Medicine, Piața 1 Decembrie, No. 10, 410068 Oradea, Bihor, Romania.
E-mail: razdima@gmail.com

* Author to whom correspondence should be addressed; Tel.: +4-0742121351

Received: 6 December 2011 /Accepted: 15 February 2012 / Published online: 10 March 2012

Abstract
The color of natural teeth depends on their capacity to modify the incident light (to change the wave length of incident light). Mainly two types of observation modes are used: diffuse illumination 0% and 45%; the angles represent incidence of illumination and observation on the surface of the object whose color is determined. The patients have been properly selected to receive direct resin veneers on their frontal maxillary incisors. Visually we observed and determined color directly using natural incident light between 10 am and 16 pm, the observer was positioned away from patient so the tooth to examine was at the level of observer's eye (incidence angles were mainly similar). Vita Easy Shade colorimeter was used to establish the color of the restoration before and after it was performed. The Expanded Visual Rating Scale for Appearance Match (EVRSAM) supplied statistically comparable data as the literature; the comparison between visual and colorimetric data makes us suppose that visual color determination is a necessary but not sufficient tool for the esthetic success of any veneer restoration.

Keywords*:* Visual color analysis; Vita Easyshade colorimeter; Resin veneers.

Introduction

Color shade or the color sensation that can be produced by natural teeth is mainly a combination of the light reflected by the natural enamel and the light scattered by the deeper dentin layers.

The main characteristics of the light transmittance through various shades of resin composites were thoroughly evaluated by various authors and they concluded that light transmittance characteristics play an important role in the appearance of a resin restoration [1].

Although human observation is the most common way to assess the aspect of a veneer, several problems can interfere in color description, whether is human observation or colorimetric analysis.

The translucency of a resin veneer will transmit, or not, if properly masqued by an opaquer, all the underlying tooth color [2].

The visual observation is dependent on various external factors such as: previous eye exposure to light and the physical and color characteristics of the object to observe, the color and the wave length of the illuminant and its position relative to the observers eye.

Various persons can determine a different color for the same object depending on the time of observation and characteristics of the illuminant due to metamerism [3].

Judgments of appearance matching by means of visual criteria established by the United States

Public Health Service (USPHS) used for the clinical evaluation of color match of any restorative material, have been established in 1971 and readjusted in 2005 by Cvar and Ridge [4,5].

The observer determines the color of a restoration by visual comparison between a restoration and the tooth structure, but he can only determine the degree of correspondence in color. This determination gets a rating: A – corresponds to a perfect match, B – corresponds to a mismatch, within an acceptable range; C – a total mismatch in both color shade and translucency. It has been reported, that human observer usually detects colour differences of 1 Δ E unit under some standardized laboratory conditions.

In the human oral cavity, a match for compared teeth was reported having an average of 3.7 Δ E units, [6]. This article concerns shade rendering; it is important to emphasize that matching the hue and chrome is sixth or seventh in importance on the list of things to match, when constructing a prosthetic tooth replacement [7].

The distance from which you can observe subtle differences in color should be very small; yet shape, surface texture, lustre and opacity disparities can be seen from four or five meters away.

Not rendering conformity and unique characteristics of the tooth will cause an unwanted proheminence of the veneers, [8].

Instrumental colorimetry produces color parameters that depend on the degree of illumination and various physical characteristics of the colorimeter such as: the wave length of the illuminant light, the diameter of the sensor, the diameter of the observation path.

Two major geometries are used in colorimetric analysis for reflectance spectrophotometry: diffuse 0% and 45% where the angles are the angles of illumination and observation path from a normal axis to the objects [3].

The purpose of this study was to assess a relationship between USPHS visual criteria and expanded visual rating scale for appearance match EVRSAM and instrumental colorimetry for color determination of dental composite veneers.

Material and Method

We selected 42 veneers, from the ones we performed over a 5 years period. The veneers were made of diacrilic composite resin, using a total of three nanocomposite resins (Table 1).

Table 1. Resin used for veneers

Name	Producer
Gradia	GC
Charisma	Hereus Kultzer
Empress Direct	Ivoclar Vivadent

The veneers were placed on the upper central incisors (CI) and lateral incisors (LI), canines (C) and bicusps (BC), the selection criteria were among the usual criteria in placing direct composite veneers: moderate discromia, good dental tissue support (not extended approximal fillings), acceptable oclusal features (moderate over bite, no bruxism), patients with good dental hygiene.

The dental tissue reduction for each tooth receiving a veneer, had a medium depth of 0.7 mm. We used a preparation in tampered chamfer following the gingival contour and also a tampered chamfer at the aproximal contact [4].

The visual assessment of the colour shade was performed on the tooth in question and also on the adjacent teeth, if the tooth to prepare was heavily stained or had a large previous restoration.

The veneers were performed by the same practitioner, using different resin shades in a layering technique. We used a silicon key in the cases that involved a contact point removal, or an additional wax up when we enhanced the length of the frontal teeth.

The visual assessment of colour consisted in two stages color detection.

The assessment of color involves one stage of chromatic analysis and another stage of determining: shade, saturation, luminosity, opalescence, translucidity and degree of fluorescence.

If translucency effects, used mainly in the incisal third, are to be reproduced, the degree of translucency must be determined previously [7].

We assessed color shade by visual observation using natural light between 10 am and 4 pm. The viewer was positioned away from the patient so the tooth to examine was approximately at the examiners eye level. The distance between the eye and the tooth to examine was standard reading distance, 25 – 33 cm. The shade sample was positioned close to the tooth and did not cover the adjacent tissues.

We held the shade tab incisal edge to the incisal margin of the tooth, because this effectively isolates the shade tabs from the teeth, so they don't reflect onto each other, reducing after images. The time for the examination was 5 seconds and after the viewer rested his eyesight on a blue surface because orange and blue are complementary colors.

The key we used was Vitapan Classical (Vita), which is most commonly used by dentists and dental technicians.

A spectrophotometric analysis was made before and after the restorations were done, using the Vita Easyshade® (Vita Zahnfabrik Germany), following the manufacturers instructions.

Devised to provide CIE L a b values, the Vita Easyshade is an intraoral dental spectrophotometer consisting in a base unit, a fibber optic cable and a hand piece.

The illumination provided by the halogen bulb located in the base unit is aimed at the tooth surface, from the periphery of the probe tip to the hand piece.

A study comparing shade matching stated that Vita Easyshade has both reliability and accuracy values grater than 90% (96.4% for reliability and 96.4% for accuracy) [9].

Extended visual rating scale for appearance match (EVRSAM) was used to assess the change in color and also the USPHS criteria, at three different time points: at the placement point, after six months and after twelve months, for each restoration, by the same examiner (Table 2).

Table 2. Extended Visual Rating Scale For Appearance Match (EVRSAM)

Rating	Description
0	Perfect match, or one so closed that the restoration can be delineated only with difficulty
2	Slight mismatch with esthetics good to very good
4	Mismatch but within an acceptable range for most patients
6	Poor esthetics on the borderline of acceptability
8	Very poor esthetics unacceptable for most patients
10	Totally unacceptable esthetics

The assessment of color using Vita Easyshade was also performed at setting time, at six months and twelve months.

The colorimetric recordings were taken in the mid facial location on each restoration and tooth. The color parameters in terms of CIE (1978 and 1985) tristimulus values were recorded. All parameters (visual or colorimetric) were than statistically averaged for each recording at each time period.

Color differences were than averaged between pairs by means of equation CIE (1978):

$$\Delta E\ (L^*a^*b^*) = [(L_c^* - L_r^*)^2 + (a_c^* - a_r^*)^2 + (b_c^* - b_r^*)^2]^{1/2}$$

where ΔE = color difference according to CIE (Commission internationale de l'éclairage 1978); L* = CIE 1976 psychometric lightness; a* = Red(+) - Green(-) axis; b* = Yellow(+) - Blue(-) axis; c = the average color parameter of the compared tooth and r = average color parameter of the resin veneer restoration.

The analysis of variance was performed for all restorations and teeth and also a correlation test was made to assess the ΔE in both visual and colorimetric analysis.

A correlation test was used to assess any relationship between the ranks of the EVRSAM and ΔE values.

We also exemplified some of the ratings we obtained in the EVRSAM compared to the USPHS and colorimetric analysis (Table 3).

Table 3.USPHS criteria: color match

Rating	Description
Alpha (A)	No difference in color, form and translucency between restoration and adjacent teeth
Bravo (B)	A slight mismatch between restoration and teeth in the range of one Vita Shade, acceptable form and translucency
Charlie (C)	Major mismatch more than one Vita shade, also difference in form and translucency

Results

Using the USPHS criteria we obtained 91 A results and 79 B results and no C results in any of the patients we examined.

We used the more translucent shades of composites for veneers in the frontal zone and the opaque ones in the buccal area (Table 4).

Table 4. Distribution of nanocomposites by location (mean values)

Material	CI (%)	LI (%)	C (%)	BC (%)	Total (%)
Gradia	6 (14.28)	1 (2.38)	0 (0)	0 (0)	7 (16.66)
Empress Direct	22 (52.38)	4 (9.52)	1 (2.38)	1 (2.38)	28 (66.66)
Charisma	3 (7.14)	2 (4.76)	1 (2.38)	1 (2.38)	7 (16.66)
Total	31 (73.80)	7 (16.66)	2 (4.76)	2 (4.76)	42 (100)

CI = central incisors; LI = lateral incisors; C = canines; BC = bicusps

The correlation coefficient for the relation between EVRSAM and that of colorimetric analysis was 0.403 ($p<0.001$).

An analysis of variance (ANOVA) concerning the color differences and a correlation test was performed, to obtain the correlation data between the two types of color analysis for the ΔE calculated. Associated with ANOVA, we performed a correlation test to assess any relationship between the ranks of EVRSAM and USPHS rating and we used a level of confidence of 95%.

Table 5. The relationship between EVRSAM and USPHS

Source of Variation	Degrees of freedom	Mean square	F-ration	p
USPHS categories	1	226596.2	262.17	<0.001
Error	163	846.3		

EVRSAM = Extended Visual Rating Scale for Appearance Match; USPHS = United States Public Health Screening Criteria

In Table 6, we exemplify a few of the observations obtained in EVRSAM ratings.

Table 6. Color differences and visual appearance ratings EVRSAM

Patient	No Tooth	Composite or natural tooth	L*	a*	b*	ΔE	USPHS	EVRSAM	Time (months)
Patient A	11	composite	55.6	-1.3	-2.9	2.2	A	2	6
	21	composite	56.0	-3.1	-3.1	2.1	A	2	6
	11	composite	53.8	-1.4	-0.8	3.8	B	4	12
	21	composite	57.2	-2.2	-0.9	3.8	B	4	12
Patient B	14	composite	54.2	-1.4	-4.7	4.4	A	2	0
	24	composite	56.7	-4.1	-2.0	4.4	A	2	0
	14	composite	52.5	-1.7	-5.0	6.1	B	4	12
	24	composite	57.8	-3.1	-2.5	6.1	B	4	12

L* = CIE 1976 psychometric lightness; a* = Red(+) - Green(-) axis; b* = Yellow(+) - Blue(-) axis; ΔE = color difference according to CIE (Commission internationale de l'éclairage 1978); USPHS = United States Public Health Screening Criteria: A = No difference in color, form and translucency between restoration and adjacent teeth; B = A slight mismatch between restoration and teeth in the range of one Vita Shade, acceptable form and translucency; C =Major mismatch more than one Vita shade, also difference in form and translucency; EVRSAM = Extended Visual Rating Scale for Appearance Match; 2 = Slight mismatch with esthetics good to very good; 4 = Mismatch but within an acceptable range for most patients

Discussion

From the data of this study we can observe that for all the teeth appearance match observation, the minimum color difference calculated from the Vita Easyshade determination was greater than the reported average one color difference (ΔE 3.7) [5]. The spectrophotometer used in the present study showed a very good match with visual shade determination of body color of natural teeth as shown in previous articles [6].

The obvious conclusion is that, probably, the visual assessment of color is not a perfect way to determine color of teeth or restorations.

The human eye and the visual perception can be easily influenced in the process of color detection by a vast number of environment factors: the color of the patient's complexion, the wave length of the illuminating source, the surface characteristics of the teeth.

It's obvious that the USPHS criteria are subjective, so they can easily result in a mismatch.

Under controlled environment conditions, one unit color difference in CIE Lab system is equal to the delineation point of human detection for 50 percent of the subjects studied [5].

The difference between A and B ratings make us suppose that there are many other factors which can play a role in the perception of tooth color and also of the restoration color.

The colorimetric evaluation offers a good method to assess tooth color, and the fact that Vita Easyshade is easy to handle, makes it a useful tool for better esthetic restorations.

Concerning the lower rating obtained using visual observation, a factor that may play a role is the sample key used. The Vita Classical shade key is less accurate than the more complex Vita 3 D Master shade guide [10].

The weak correlation coefficient we obtained between the visual and colorimetric analysis and the wide range of differences in color we obtained, compared with the colorimetric one, make us assess that visual determination of color is not sufficient for a good restoration.

Conclusions

Within the limitation of this study, we can say that the visual color matching using USPHS and EVRSAM are not accurate enough to obtain a perfect color match for a resin veneer.

Accurate, clinically acceptable shade match cannot be achieved using only the visual shade guide system. Color evaluation by only visual examination may not be a reliable method due to inconsistences resulting from individual variations of the examiner and also environmental factors.

We can also conclude that the simple shade determination is not enough to characterize the complex aspect of tooth color.

Shade matching using spectrophotometer Vita Easyshade meets all the requirements for successful choice of shade, in accordance to the physiology of vision and science of color.

This easy to handle method for shade determination can be recommended in everyday practice and should characterize the present and future of restorative dentistry.

Conflict of Interest

The author declares that they have no conflict of interest.

List of abbreviations

EVRSAM = Extended Visual Rating Scale for Appearance Match
USPHS = United States Public Health Screening Criteria

References

1. Cvar J, Ryge G. Reprint of criteria for the clinical evaluation of dental restoration materials. US Public Health Service Publication, 790, San Francisco US: Government Printing Office, 1971, Clinical Oral Investigation 2005;9:215-32.
2. Cvar J, Ryge G. Criteria for the clinical evaluation of dental restoration materials. US Public Health Service Publication, 790, San Francisco US: Government Printing Office, 1971.
3. Hunter RS. The Measurement of Appearance, New York, John Wiley and Sons, 1975.
4. Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for posterior teeth. Int J Periodontics Restorative Dent 2002;22:241-9.
5. Kuehni RG, Marcus RT. An experiment in visual scaling of small color differences. Color Res Appl 1979;4:83-91.
6. Lee YK, Powers JM. Color changes of resin composites in the reflectance and transmittance modes. Dent Mater 2007;23:259-64.
7. Ferreira JL, A Espina de Ferreira, Ortega AJ. Methods for the analysis of hard dental tissue exposed to high temperatures. For Sci Int 2008;178:119-24.
8. Fondriest J. Shade matching in restorative dentistry: the science and strategies. J of Periodontal and Restoration Dentistry 2003;23:259-64.
9. Kim-Pusateri S, Brewer JD, Davis EL, Wee AG. Reliability and accuracy of four dental shade matching devices. J Prosthetic Dentistry 2009;101:193-9.
10. Corciolani G, Vichi A, Ferrari M. Color corespondence of a ceramic system in two different shade guides. J of Prosthetic Dentistry 2009;37:98-101.
11. Joiner A. Tooth color: a review of the literature. J Dent 2004;32(suppl 1):3-12.
12. Seghi RR, Johnston WM, O' Brien WJ. Spectrophotometric Analysis of Color Differences Between Porcelain Systems. J Prosthet Dent 1986;56:35-40.