Journal of Dental Applications

Open Access

Austin Publishing Group

Research Article

Clinical Evaluation of the Influence of Illumination During Visual Shade Matching

Martinez CIE[1], Vasconcellos DK[1], Özcan M[2] and Volpato CAM[3]*

[1]Department of Dentistry, Federal University of Santa Catarina, Florianópolis, Brazil

[2]Dental Materials Unit, Center for Dental and Oral Medicine, Clinic for Fixed and Removable Prosthodontics and Dental Materials Science, University of Zurich, Zurich, Switzerland

[3]Volpato CAM, Department of Dentistry, Federal University of Santa Catarina, Florianópolis, Brazil

***Corresponding author:** Volpato CAM, Department of Dentistry, Federal University of Santa Catarina, Florianópolis, 145, Prefeito Antenor Mesquita St, 1004/B, Florianópolis, Santa Catarina, Brazil, 88015150, Tel: +55 48 3721 5086; Fax: (55) 48 3721 9520; E-mail: claudia.m.volpato@outlook.com / claudiamvolpato@hotmail.com

Received: September 15, 2014; **Accepted:** September 17, 2014; **Published:** September 20, 2014

Abstract

Purpose: This study evaluated the influence of ambient light and a D65 standard light source during visual shade matching for natural teeth.

Materials and Methods: Sixty undergraduate students (33 female; 27 male), studying at the Dental School participated in this study. The shade of a maxillary incisor was initially determined using an intraoral spectrophotometer (Vita Easyshade Compact, VITA Zahnfabrik, Bad Säckingen, Germany) and acted as the reference values (A1 and 1M2) for the subjects. After calibration of the students, the shade of a maxillary central incisor was determined visually for three times using two shade guides, the Vita Classic (VC) and Vita 3D Master Linearguide (VL3D), with and without the aid of a standard light source (D65). The obtained results were compared to the reference value. The data were analyzed using the Mann-Whitney U-test.

Results: Both the light source and the shade guide showed significant effects on the outcome (P<0.0001). The use of a D65 light source increased the probability of correct visual shade matching with both VC (50%) and VL3D (63.3%) shade guides when compared to ambient light (3.3% and 6.7% for VC and VL3D, respectively).

Conclusion: Standardized lighting with a D65 light source may improve the correct choice of tooth shade by students, although errors in correct shade matching were not completely eliminated.

Keywords: Color; Matching visual; Lighting; Shade; Shade guide

Abreviations

VC: Vita Classic; VL3D: Vita 3D Master Linearguide; CIE: International Comission on Illumination

Introduction

Accurate visual shade matching is a crucial step in clinical procedures for successful dental restorations. In general, the information on color is transferred to the dental laboratory using conventional shade guides, because it is a quick, feasible and inexpensive method, and it does not require sophisticated equipment [1]. Although shade guides have long been used in dentistry, inherent subjectivity remains an obstacle in obtaining acceptable clinical results, resulting in varied and unpredictable differences in color evaluation and matching among clinicians [2].

The disadvantages of visual shade matching have been associated with the following factors: shade guides are not systematically distributed according to the standard color space (CIELab color space); the material used for fabricating the shade guides is not the same as that used in clinics and laboratories, and the thickness of the teeth in the shade guides do not simulate clinical conditions[1,3,4]; variables such as weather, time and location where the shade selection is taking place, influence of external light, type and intensity of light source, angle of incidence, previous eye exposure, human eye fatigue and physiological variables such as color blindness, may lead to inconsistent color readings [3,5,6].

During visual shade matching, the teeth and shade guides are observed simultaneously under the same light source, the patient should be seated, the teeth should be clean and dry, and the color selection must be done quickly to avoid eyestrain [5,7]. Since the light source directly influences the visual matching, natural daylight between the hours of 1100 and 1400 has been considered essential, because the light during this time of the day presents a uniform distribution of spectral energy [6,8]. However, natural daylight is not always available when selecting shades, because the spectral energy distribution and color temperature of daylight changes depending the time of year, cloud cover, weather conditions, humidity and level of pollutants [9]. Consequently, standard natural daylight is rarely available [8,10]. Due to the inherent variability of daylight, many professionals use ambient light to color match. However, different light sources are present in dental clinics and laboratories (incandescent and fluorescent light sources), and may change the perceived color of teeth and shade guides [7,11,12]. Many authors suggest the use of measuring instruments such as colorimeters and spectrophotometers, because they make the process objective, quantifiable and fast color matching. However, despite being a promising method, its clinical use is yet to be associated with the method of visual selection, not replacing it completely [6,8,11].

Light quality is considered the most critical influencing factor in the selection of correct shades; changes in lighting conditions can cause changes in the perceived color [6,7]. Therefore, accurate and reproducible color matching requires a standard light source and

Citation: Martinez CIE, Vasconcellos DK, Özcan M and Volpato CAM. Clinical Evaluation of the Influence of Illumination During Visual Shade Matching. J Dent App. 2014;1(5): 95-99.

spectral distribution [8]. Researchers have shown encouraging results regarding the use of standardized lighting conditions [8,9,10,13,14]. Many of these studies have been conducted among dental students, because they are generally young adults in the same age range and have little or no experience in shade matching [9,10,13,15-8]. In addition, important studies have shown that the level of experience is not a factor in shade matching [14,16,19]. The aim of this paper is to compare the influence of ambient light and the standard D65 light source during visual shade matching for natural tooth. The null hypothesis tested was that neither light source would affect the selected shade.

Materials and Methods

The study was performed at the Federal University of Santa Catarina School of Dentistry. It was approved by the Research Ethics Committee of the University (Certification #1849). Sixty volunteer undergraduate students (33 female; 27 male), with a mean age of 23 years and undergoing dental education, participated in the study. The visual shade matching was performed on one patient having a sound maxillary central incisor, free of restorations, and without a history of beaching or pigmentation. The objective of the study was explained to both the patient and the participants and they signed an informed consent (with information on voluntary participation, maintaining the confidentiality of the identity of participants, description of the procedure performed and time of participation in the survey). Before performing visual shade matching, the students were subjected to a test for Color-Blindness (Ishihara's Tokyo, Kanehara) to detect any deficiency in the visual perception of colors [10]. None of the participants presented any evidence of color blindness.

Prophylaxis was performed on the tooth and a silicone guide (Zetalabor, Zhermack, Rovigo, Italy) was constructed with an open window, where only the maxillary right central incisor was exposed in the oral cavity. The shade of this tooth (for both the VITA Classical and VITA Linearguide 3D-Master shade guides) was initially determined using an intraoral spectrophotometer (Vita Easyshade Compact, VITA Zahnfabrik, Bad Säckingen, Germany). According to the manufacturer's instructions, the color was selected in the initial mode, with the tip of the spectrophotometer in touch with the middle third of the tooth surface. The reference values were derived from the three consecutive measurements (reference values: A1 for VITA Classical and 1M2 for VITA Linearguide 3D-Master). For the visual shade matching, two shade guides, namely VC (VITA Classical, VITA Zahnfabrik, Bad Säckingen, Germany) and VL3D (VITA Linearguide 3D-Master, VITA Zahnfabrik, Bad Säckingen, Germany), were used to compare the data with the reference values (Figure 1).

All participants individually received theoretical and practical instruction and a demonstration of the techniques of visual shade matching for both shade tabs (VC: number lote # 1009 and VL3D: number lote # 1010). The participants also practiced the whole procedure 3 times on different patients prior to the actual experiment. After calibration of the students, the shade of a maxillary central incisor was determined visually for three times using two shade guides (VC and VL3D) and under two lighting conditions (with and without the aid of a standard light source D65).

The silicon guide was positioned in the subject's mouth prior to measurements and it was removed between each observation to avoid tooth dehydration. All experiments were performed between 0800 and 1100, independent of the light source used. The patient was always seated in the same dental chair, positioned at a 90 degree angle and the operator remained standing next to the patient, with the sight line as parallel as possible to the occlusal plane of the patient, at an average distance of an arm's length from the observer. Each observer had two minutes to select the shade with each of the shade guides.

Figure 1: Silicone guide with an open window in the maxillary right central incisor and visual shade matching.

The participants were randomly assigned to two groups. While half of the participants (n=30) selected the shade of the central incisor tooth using VC and VL3D shade guides under ambient light, the other half (n=30) selected the shade under the standard D65 light source. The ambient light included the light present in the dental clinic, without the aid of a dental reflector. All visual shade matches with ambient light were made in a single day. For the standard D65 light source, an auxiliary standard LED (Light Emitting Diode) D65 light source was fixed to a binocular and an external energy source was used to turn on the light at the time of shade matching. The external power source for the D65 light source was switched on for 2 minutes during shade matching and switched off immediately after the selection (Figures 2 and 3). All visual shade matching with the standard D65 light source were made in a single day. To prevent any influence from other students, only one student was allowed in the testing room at a time. Furthermore, no information was given to the students regarding the shade of the tooth. The students were asked to rest their eyes by looking at a blue card. The results were recorded in an individual table and compared to the reference values.

A scoring system was created according to the nomenclature of

Figure 2: Binocular with auxiliary standard LED D65 light source.

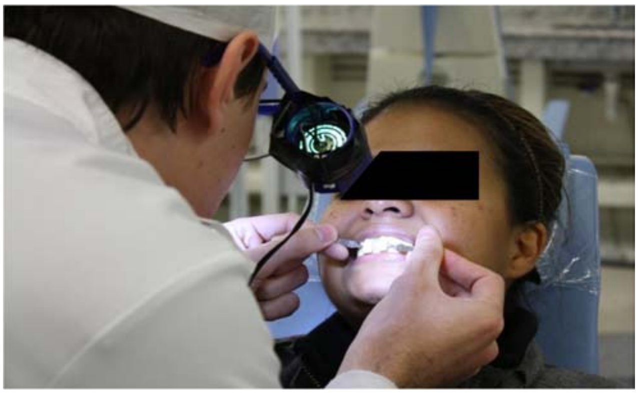

Figure 3: Visual shade matching with the aid of a standard light source (D65).

VC and VL3D shade guides. The VC shade guide presented different saturations for each hue and 5 chromas (A1, A2, A3, A3, A4 and A5). Score 0 indicated the right choice of color (A1), Score 1: Presence of an error of one level in the choice of color, Score 2: Any other variation in saturation; Score 3: Different shades of "A" were chosen. The assumption adopted was that an error with a score of 1 received a score closer to the correct result than the other errors balancing the importance of error in the original color (i.e. A1: Score 0, A2: Score 1; any other variation of saturation: Score 2; other hues: Score 3).

The color matching with the VL3D shade guide was initiated by the choice of value. A value guide was developed with 6 sets of different values (0, 1, 2, 3, 4, 5), in which different shades and chromas were present. With the same reasoning applied for the VC shade guide, considering the value scale for the VL3D shade guide, scores were established as follows: Group 0= Score 1; Group 1= Score 0; Group 2: Score 1; Group 3: Score 2; and other changes in value: Score 3.

Statistical analysis was performed using SPSS 11.0 software for Windows (SPSS Inc., Chicago, IL, USA). The data were statistically analyzed using Mann-Whitney U-Test and compared with the reference values. P values less than 0.05 were considered to be statistically significant for all tests.

Results

Results obtained with VC and VL3D shade guides for both ambient light and the standard D65 light source and their comparison with the reference shade values obtained by the spectrophotometer are presented in Tables 1a and 1b. Both the light source and the shade guide type significantly affected the results ($P<0.0001$). VC did not present a statistical significant difference at ambient light ($P=0.5536$) and standard D65 light source ($P=0.2974$) when compared to the reference values. VC ($P=0.0409$) and VL3D ($P<0.0001$) showed significant differences with and without the standard D65 light source (Table 2).

The use of the standard D65 light source increased the probability of correct visual shade matching for students with both VC (50%) and VL3D (63.3%) shade guides when compared to the ambient light (3.3% and 6.7% for VC and VL3D, respectively). These results emphasize that the use of standardized lighting conditions makes color matching a more accurate process, resulting in prostheses and restorations that mimic natural teeth better.

Table 1a: Results of visual shade matching using VITA Classical (VC) and VITA 3D Master Linearguide (VL3D) shade guides under ambient light.

Participant	VC	VL3D	Participant	VC	VL3D
1	B2	2M2	16	A2	2M1
2	B2	2M2	17	D2	3M1
3	A2	1M2	18	B2	2R1.5
4	A2	2R1.5	19	D2	3M1
5	D2	3L1.5	20	D3	2M2
6	D2	2R1.5	21	A2	1M2
7	D2	2R1.5	22	A2	2L1.5
8	A2	2M2	23	A2	2R1.5
9	A1	2R1.5	24	A2	2M2
10	A2	2R1.5	25	B1	1M1
11	C1	1M1	26	C2	2R2.5
12	A2	2M2	27	A2	2M2
13	A2	2M1	28	C1	2R2.5
14	C1	2R1.5	29	A2	2R1.5
15	D2	2M2	30	D3	2M2

Table 1b: Results of visual shade matching using VITA Classical (VC) and VITA 3D Master Linearguide (VL3D) shade guides under standard D65 light source.

Participant	VC	VL3D	Participant	VC	VL3D
1	A1	2M1	16	C1	1M1
2	A1	1M2	17	B2	1M2
3	A1	1M2	18	A1	1M2
4	B1	1M2	19	A2	2R1.5
5	B1	1M2	20	A1	1M1
6	C1	1M2	21	C1	1M1
7	B1	1M2	22	A1	1M2
8	C1	1M2	23	A1	1M2
9	A1	1M2	24	A1	1M1
10	B2	2R1.5	25	A1	2L1.5
11	B2	1M2	26	A1	1M2
12	B1	1M1	27	A1	1M1
13	A1	1M2	28	B1	1M2
14	B1	1M2	29	A1	1M2
15	A1	1M2	30	C1	2L1.5

Discussion

Visual shade matching for a dental restoration by using a neighboring tooth as a reference is a common procedure in restorative dentistry, despite its limitations due to the subjectivity of the method, type and intensity of light source, physiological variables and metamerism [4,5]. Lighting is an important factor in dental shade matching, with the best light source being natural daylight [6]. However, it is not always possible to match shades during the day, while the daylight changes over time [8,9]. Therefore, other authors have suggested that the consistency of artificial lighting may contribute to better shade matching [8,10,11]. This present study compared the influence of ambient light and the standard D65 light source during visual shade matching for natural teeth. Based on the

Table 2: Results of the Mann-Whitney U-Test for comparison of scores with VC and VL3D shades guides, without and with standard D65 light source.

Shade guide	Scores summarize	Significance
VC	Without = 577 With = 323	*P* = 0.0409
VL3D	Without = 772.5 With = 127.5	*P* < 0.0001

results, the light source significantly affected the results. Thus, the null hypothesis, that neither light source would affect the selected shade, was rejected.

Shade matching in ambient light was compared with shade matching using the standard D65 light source, which has a spectrum corresponding to conditions equivalent to daylight and a color temperature of 6.500K (the daylight that occurs between 1100 and 1400 hours [7,10,12]). Studies have made comparisons with other light sources using acrylic resin or porcelain specimens and concluded that these specimens were not representative of visual shade matching in a patient in a dental clinic [6,16]. For this reason, this current experiment was performed on a real patient, as in other studies [15,17,18].

The participants in this study were dental students in the final year of their undergraduate program. Studies have shown that the lack of experience did not affect the shade-matching scores of dental students [16]. A multicenter study evaluated the influence of gender and level of experience on shade matching quality and concluded that gender plays an important role in shade matching (females achieved better shade matching than males), however, the level of experience was not found to be significant factor in shade matching, because students with no or little experience in shade matching achieved the same results as experienced dental professionals [19]. According to Curd et al., dental students represent a suitable population for testing shade-matching abilities, because they are usually young adults in the same age range and are likely to have fewer systemic conditions that might affect shade perception.

Even though the participants in the current study had prior experience and knowledge on issues related to color and visual shade matching (due to their education) and were calibrated prior to performing the study, differences were observed between individuals with both shade guides due to the high number of variables that are linked to subjective analysis of color [10,14]. Moreover, fundamental differences exist in the shade guide systems, which influences the performance of individuals during visual shade matching [3,6]. From the two shade guides studied, the VC shade guide is based on an empirical analysis that includes fewer colors and does not offer a uniform color distribution, making it more prone to errors [11]. It is organized according to the colorimetric parameters of hue and chroma, presented in 16 shade tabs. With this shade guide type, actual value could not be assessed but only theoretical equivalences with other shade guides could be made.[11] On the other hand, the VL3D shade guide system is based on the distribution of Munsell´s color space. It incorporates the determinants of color in a logical sequence; consisting value, chroma and hue. During visual shade matching using this system, value is the first colorimetric parameter to be evaluated. This is because the observer has more than 120 million receptors capable of judging the brightness of an object; whereas approximately 7 million receptors exist that distinguish hues. Thus, value is perceived easier than the hue [3,4].

The VL3D shade guide showed slightly better performance (6.6%) than that of the VC shade guide (3.3%) under ambient light, which was not statistically significant. However, these results with both shade guides could be considered extremely poor. Under the standard D65 light source; however, both VL3D shade guide (63.3%) and VC shade guide (50%) showed superior performance. Dagg et al. [6] used a special lamp to achieve ideal light conditions and reported that light quality was the most critical factor in shade matching. Studies by Curd et al. [10] and Hakhaei et al. [13] concluded that a student's shade matching abilities were better with a corrected light source than when under natural light and/or clinical light. In the present study, similar results were found under the standardized D65 light source. The choice of the standard D65 light source for this study is because it is economical and easy to use. Moreover, it presents a high degree of functionality / portability, allowing the operator to place it in front of the patient, with a parallel view to the tooth to be observed.

When agreement between the participants is compared, the most commonly selected shade using the VC shade guide in ambient light was A2 (with 13 matches) followed by D2 (6 matches). This result differs from that obtained by the reference shade measured only once by the spectrophotometer (A1). With the use of the VL3D shade guide under ambient light, the most commonly selected shade was 2R1.5 (10 times) followed by 2M2 (9 times), differing also from the ones measured by the spectrophotometer (1M2) twice. When the standard D65 light source was used, the agreement among the participants greatly increased (15 hits for A1 and 19 hits for 1M2), reinforcing the contribution of standard lighting during visual shade matching.

According to the current methodology, when the electronically selected shade is compared with the shade obtained by the visual method, one can make an objective comparison considering only two options: hit or miss. The visual matches that did not have the exact result obtained by the electronic analysis, but approached the correct shade, were given scores by approximation based on the different saturations for VC and values for VL3D [6]. With this approach and using the standard D65 light source, the degree of error range with the two shade guides decreased.

In this present study, only one tooth in a single patient was used to standardize the object of evaluation. If more teeth or patients were included, standardization would not be possible and the presence of confounding variables such as stains, surface texture, different saturations, and whitening, would affect the results. In that respect, this study could be considered a pilot study, where the initial statistical results proved its viability. Additionally, a pilot study has shown the necessity of using only one tooth, preferably isolating it from neighboring teeth by using a neutral color silicone matrix. The current results may vary when teeth with more character are incorporated in shade matching. Furthermore, the two procedures were not applied to both groups because, when the observer visually shade matched with or without lighting, they could become biased with the outcome of the first observation, which could eventually affect the second decision under the other light source. This would then act as a previous selection bias.

Conclusions

From this present study, the following could be concluded:

1. Shade matching under the standard D65 light source improved the ability to select the correct dental shade when compared to ambient light when using VC and VL3D shade guides, allowing that errors in correct color matching were not completely eliminated.

2. VC and VL3D shade guides showed significant differences with and without the standard D65 light source.

References

1. Fondriest J. Shade matching in restorative dentistry: the science and strategies. Int J Periodontics Restorative Dent. 2003; 23: 467-479.
2. Geary JL, Kinirons MJ. Colour perception of laboratory-fired samples of body-coloured ceramic. J Dent. 1999; 27: 145-148.
3. Knispel G. Factors affecting the process of the color matching restorative materials to natural teeth. Quintessence Int. 1991; 22: 525-531.
4. Douglas RD, Brewer JD. Variability of porcelain color reproduction by commercial laboratories. J Prosthet Dent. 2003; 90: 339-346.
5. Amano K, Foster DH. Colour constancy under simultaneous changes in surface position and illuminant. Proc Biol Sci. 2004; 271: 2319-2326.
6. Dagg H, O'Connell B, Claffey N, Byrne D, Gorman C. The influence of some different factors on the accuracy of shade selection. J Oral Rehabil. 2004; 31: 900-904.
7. Corcodel N, Rammelsberg P, Moldovan O, Dreyhaupt J, Hasel AJ. Effect of external light conditions during matching of tooth color: an intraindividual comparison. Int J Prosthodont. 2009; 22: 75-77.
8. Paravina RD. Evaluation of a newly developed visual shade-matching apparatus. Int J Prosthodont. 2002; 15: 528-34.
9. Mete J, Dange S, Khalikar A, Vaidya S. Comparative study of shade matching performance of dental students under daylight and daylight lamp conditions. Eur J Esthetic Dent. 2013; 8: 192-99.
10. Curd FM, Jasinevicius R, Graves A, Cox V, Sadan A. Comparison of the shade matching ability of dental students using two light sources. J Prosthet Dent. 2006; 96: 391-396.
11. Paravina RD. Performance assessment of dental shade guides. J Dent. 2009; 37: 15-20.
12. Gokce HS, Piskin B, Ceyhan D, Gokce SM, Arisan V. Shade matching performance of normal and color vision-deficient dental professionals with standard daylight and tungsten illuminants. J Prosthet Dent. 2010; 103: 139-147.
13. Hakhaei M, Ghanbarzadeh J, Keyvanloo S, Alavi S, Jafarzadeh H. Shade matching performance of students with three various lighting conditions. J Contemp Dent Pract. 2013; 14: 100-3.
14. Jasinevicius TR, Curd FM, Schilling L, Sadan A. Shade-matching abilities of dental laboratory technicians using a commercial light source. J Prosthodont. 2009; 18: 60-63.
15. AlSaleh S, Labban M. AlHariri M, Tashkandi E. Evaluation of self shade matching ability of dental students using visual and instrumental means. J Dent. 2012; 40: 82-87.
16. Bahannan SA. Shade quality among students using visual and instrumental methods. J Dent. 2014; 42: 48-52.
17. Jaju RA, Nagai S, Karimbux N, Da Silva JD. Evaluating tooth color matching ability of dental students. J Dent Education. 2010; 74: 1002-10.
18. Della Bona A, Barret AA, Rosa V, Pinzetta C. Visual and instrumental agreement in dental selection: three distinct observer populations and shade matching protocols. Dent Mater. 2009; 25: 276–81.
19. Haddad HJ, Jakstat HA, Arnetzl G, Borbely J, Vichi A, et al. Does gender and experience influence shade matching? J Dent. 2009; 37: 40-44.

J Dent App - Volume 1 Issue 5 - 2014
ISSN : 2381-9049 | www.austinpublishinggroup.com

Citation: Martinez CIE, Vasconcellos DK, Özcan M and Volpato CAM. Clinical Evaluation of the Influence of Illumination During Visual Shade Matching. J Dent App. 2014;1(5): 95-99.