

COMPARISON OF HAND-HELD FULL SPECTRUM LIGHT AND TWO DIFFERENT LIGHTING CONDITIONS ON ACCURACY OF VISUAL TOOTH SHADE MATCHING

Mohammad M. Rayyan*

ABSTRACT

Aim: To evaluate the influence of three lighting conditions on the accuracy of tooth shade matching.

Materials and methods: Ten prosthodontists participated in this study after being tested for color deficiency using Ishahara's tests. Ten patients were selected for shade matching procedure. Shade of tooth 11 were taken under three lighting conditions (incandescent light, fluorescent light and hand-held full spectrum light). Using spectrophotometer (Easy Shade ,VITA Zahnfabrik H, Germany), shade of tooth 11 was recorded as control. Delta E was calculated for each reading according to the CIE $L^*a^*b^*$ formula, between visually and digitally recorded shades.

Results: The percent of correct color matching choices with Incandescent light scored the highest number of correct color matching (15), followed by hand-held full spectrum light (7) then fluorescent light (6). Kruskal-Wallis test revealed significant differences in shade matching under the three light sources (P Value = 0.0006). One-way ANOVA revealed significant difference between fluorescent light and incandescent light (P Value= 0.039) while no significant difference was found among other groups.

Conclusion: Different lighting conditions affect color-matching procedure. Hand-held full spectrum light did not improve shade-matching procedure. Incandescent light showed better lighting condition than both fluorescent light and Hand-held full spectrum light.

KEYWORDS: Shade matching, Light source, Shade guide, incandescent light, fluorescent light, hand-held full spectrum light, digital shade analysis, spectrophotometer.

INTRODUCTION

The perception of color is affected by three primary factors: the character of the light, the observer,

and the object being viewed. A change in the condition of any of the three will cause a change in the perception of color. Thus, changes in light or changes in position, can alter perception.⁽¹⁾

* Assistant Professor of Fixed Prosthodontics, Faculty of Dentistry, Beirut Arab University, Beirut, Lebanon, Assistant Professor of Fixed Prosthodontics, Faculty of Dentistry, Misr University for Science and Technology, Cairo, Egypt

The most delicate and sensitive instrument in the whole shade-matching process is the observer's eye.⁽²⁾ It is composed of approximately 120-million light-receiving structures, called rods and cones. The rods see on a gray scale.⁽²⁾ The cones are specialized color receptors. Both of them produce an electrical signal and, act like muscles in the body. This mechanism can fatigue if we gazed at an object for too long. The rule of thumb is not to stare at an object for more than 5 seconds.⁽²⁾

Correctly evaluating tooth shade is as much an art as a science.⁽²⁻⁸⁾ There are many shade guides available for tooth shade recording. The Vita Classical Shade Guide has been the standard shade guide used in dentistry for several decades. It was adequate for that time but analysis of that shade guide shows several problems that led to the many shade mismatches.⁽⁹⁾ More recently, the Vita 3D Master and a recent significant upgrade, the Vita 3D Linear guide, have been introduced for more accurate shade analysis.⁽¹⁰⁾

Recently digital shade analysis devices were available. It was said that they can record base shade better than the average human shade taker, but humans can detect the variances of tooth color better. So, the computers can be used to take base shades, and along with visual perception and high-quality digital photography, used together the three will give accurate shade information to be used by the ceramist.

One of the most overlooked areas in shade matching is the light source. In the past it was said that shade matching was better under day-light. It was found that the best day-time for shade recording is only between 10 am and 12 pm. It is critical that the main light source being used to illuminate the teeth to be a full-spectrum source. Many dental clinics use fluorescent lighting. Fluorescent bulbs are an energy efficient source of light but they are not ideal for rendering color accurately; however, this type of light can be optimized for color matching. There are several light-bulb manufacturers that

produce fluorescent bulbs that can do an adequate job of reproducing color. These bulbs all have a CRI (Color Rendering Index, a range of 1 to 100) above 90. The higher the CRI number, the better it will be for shade matching.

It is very controversial as to what color temperature light to use, eg, 5,000 K, 5,500 K, or 6,500 K.⁽¹¹⁻¹⁴⁾ Most shade guides were fabricated to match a standard in a 5,500 K light source. Shade guides do not have the same optical properties as natural teeth. This means they do not reflect light the same way in all lighting conditions as the tooth would. Thus, visual shade matching should only be done in a lighting environment that is closest to 5,500 K.

Recently, handheld 5,500K LED light are used by practitioners to provide a good source of light for those who cannot adjust their lighting environment. It was introduced to give the practitioner a hand-held full-spectrum light source. The light is held between the observer and the teeth, and has a window that you can look through much like a magnifying glass. Unfortunately there are no previous reports or research data on performance and validity of handheld full spectrum light source.

Recently there are a lot of conflicting reports about how lighting (illumination) affects color perception. But, does different lighting conditions really affect shade selection?

The hypothesis of this research that the handheld full spectrum light will give better results than the other lighting conditions.

MATERIALS AND METHODS

Ten volunteer students were selected based on a predetermined inclusion and exclusion criteria. The right maxillary central incisor (tooth 11) of, the volunteers was chosen for the shade selection procedure. They were informed about the procedure and signed an agreement consent. The inclusion criteria for the selected tooth include sound tooth and presence of complete set of maxillary anterior teeth. Ex-

clusion criteria for the tooth selection were discolored tooth, presence of restoration, non-vital tooth, existing crown or bridge associated with the tooth of interest, moderate to severe malocclusion, smokers, poor oral hygiene and the presence of enamel or dentinal defects such as amelogenesis imperfect or fluorosis. Prior to shade selections procedure, the labial surface of the tooth was cleaned, polished using polishing paste (Prophy paste, Procter & Gamble, USA) on a rotary cup (Upgrade Disposable Prophy Angle's and prophy cup, Sultan healthcare, Hackensack Avenue, USA) then wiped up with gauze prior to measurement. Before beginning of shade recording process, both Easyshade (VITA Zahnfabrik H, Germany) and vita 3D linear shade tabs (VITA Zahnfabrik H, Germany) were tested on each other to ensure that Easyshade was functioning properly and 3D linear shade tabs were not discolored from repeated autoclaving. An intraoral plastic retractor was used to widen the mouth opening, then the shades of the teeth were recorded using Easyshade.

The shade identification using Easyshade was taken as a reference for visual shade selection procedure. The device was set to 'Tooth Single' mode and the probe tip was placed 90° to the tooth surface and flush on the area between the middle third of the crown and the incisal edge. The probe tip was held steadily against the tooth surface and the measurement button on the hand piece was pressed until the machine beeps to indicate completion of the measurement and the result was shown on the device's screen. The reading was repeated several times by one examiner until three constant readings were achieved and this reading was taken as a reference for the tooth. (Fig.1)

Calibration of Easyshade was performed before the readings were taken using a ceramic block installed in the device. A total of 10 Prosthodontic instructors were recruited to perform the shade selection procedure for this study. A color blindness test was carried out for all of them (Ishahar's tests).



Fig. (1) Tooth shade matching using Easyshade.

In order to reduce the environmental factors that may affect the results for the shade selection, the procedure was performed in the same dental lab (BAU simulation lab) throughout the study. This lab was selected as it provides consistent lighting condition, easily accessible and available for the determined time. The procedure was performed between 10.00 am and 12.00 pm on three successive days. In order not to receive faulty readings as a result of over-stressed eyes, every prosthodontist is requested to visually shade select 10 teeth per day. Visual shade selection procedure using Vita 3 D linear was done in four Stages. All the volunteers were seated in upright position with a separate vita 3D linear shade guide for infection control purposes. At all times, all curtains of the lab were closed to block any interfering secondary lights. For



Fig. (2) Tooth shade matching using Shade Light and 3D Linear.

group A; only hand-held full spectrum light (Shade Light, MediPlus Corp., Seoul, Korea) was turned on. (Fig.2,3)

For group B; only ceiling light (florescent light) was turned on. (Fig.4)



Fig. (3) Hand-Held full spectrum light (Shade Light).



Fig. (4) Value recording using 3D linear under fluorescent light.

For group C; unit light was turned on and ceiling light was turned off. (Fig.5)



Fig. (5) Value recording using 3D linear under incandescent light.

All groups are listed in table 1.

TABLE (1) Samples grouping

Group	Lighting condition	No of instructors	No of volunteers
A	Hand-Held full spectrum light	10	10
B	Fluorescent light	10	10
C	Incandescent light	10	10

Each instructor passes through the volunteers and record tooth shade. Each instructor stands in front of a volunteer to record shade, when instructor finishes moves one spot in a rotation manner, to avoid fatigue for both instructors and volunteers. Each shade recording should not exceed 20 Sec. When shade recordings for all volunteers was finished, they were collected and filed.

All records were collected and color coordinates (L, a, b) were then obtained for each shade. Delta E was calculated for each reading according to the CIE L*a*b* formula, given that $L_1a_1b_1$ are for visually recorded shade and $L_2a_2b_2$ are for digitally recorded shade (easy shade, the control).

$$\Delta E_{ab}^* = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$$

The data were collected and statistically analyzed using Kruskal-Wallis test and one-way ANOVA test.

RESULTS

In this study, 10 faculty instructors participated. The mean, median and standard deviation of Delta E in each group are listed in table 2 and chart 1. The percent of correct color matching choices ranging from for delta E compared to spectrophotometer readings for three light sources were calculated (Chart 2). Incandescent light scored the highest number of correct color matching (15), followed by hand-held balanced light (7) then fluorescent light (6). Kruskal-Wallis test revealed significant

differences in shade matching under the three light sources (P Value = 0.0006). One-way ANOVA revealed significant difference between fluorescent light and incandescent light (P Value= 0.039) while no significant difference was found among other groups (Table 3).

TABLE (2) Mean, Median and Standard deviation values of the tested groups

	Mean	Median	Standard Deviation
Group A	6.50444	5.95204	3.04209
Group B	6.91467	6.81666	3.09377
Group C	5.92400	5.36935	3.35403

TABLE (3) One-way ANOVA values among tested groups

	Group A	Group B	Group C
Group A		0.366	0.220
Group B	0.366		0.039
Group C	0.220	0.039	

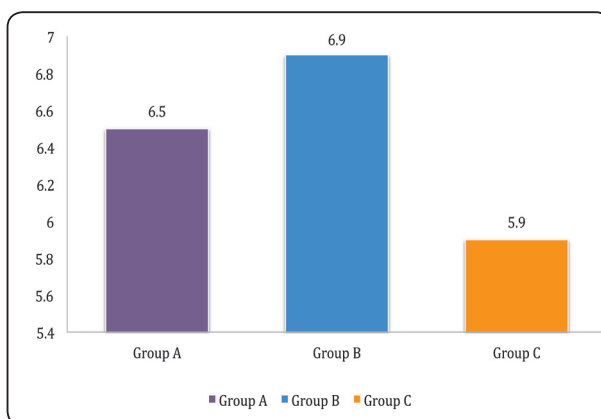


Chart (1) Mean values of Delta E of tested groups.

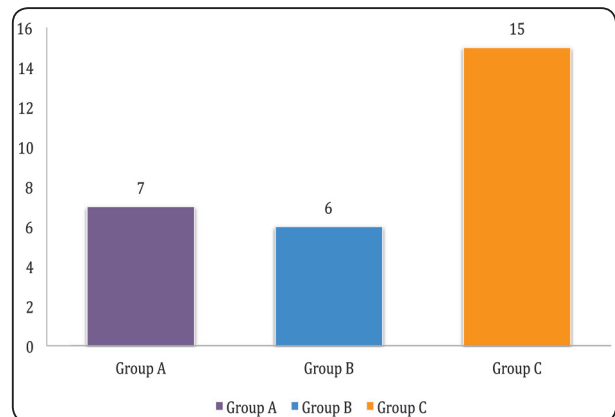


Chart (2) The percent of correct color matching choices among groups.

DISCUSSION

Delta E (ΔE) is defined as the difference between two colors in an $L^*a^*b^*$ color space. As the values determined are based on a mathematical formula, it is important that the type of color formula is taken into account when comparing the values. The CIE $L^*a^*b^*$ formula used to calculate the distance between two points (colors) in a three-dimensional color space. The actual position of the points themselves is irrelevant. Delta E ranging from 0-1 indicates a normally invisible difference and ranging from 1.1-2 indicates very small difference, only obvious to trained eye. On the other hand, Delta E >2 indicates obvious difference.

The light source is an effective factor in shade matching. Although natural light has been suggested to be the ideal light source for shade matching, the quality of day light is not consistent and it is not always possible to choose shades during the day. Therefore, using a consistent light source and an appropriate environmental condition will improve the shade matching performance. In the present study three different lighting conditions were selected. Two of them present the main lighting environment in the dental clinic and under which routine shade matching procedure is done, the unit light (incandescent light) and ceiling light (fluorescent light). The third light was the full

spectrum light (balanced light). It was indicated by many researchers that it improves the quality of shade matching environment. Hand-held balanced light devices may represent a cheap and practical form of balanced light, although not researched before.

3D linear shade guide was used, as it is much simpler and less confusing than 3D master, as tooth shade is only acquired using two steps. Moreover there is no difference in the accuracy of shade selection using both shade tabs.⁽¹⁵⁾ The results of this research came indicating a significant difference between different lighting conditions. The results came in accordance with Nakhei, et al, who's results showed a better performance in shade matching under correcting light source than natural light and clinical light.⁽¹⁶⁾ This finding also is in agreement with both Curd FM, et al,⁽¹⁷⁾ Mete JJ, et al,⁽¹⁸⁾ and Corcodel N, et al,⁽¹⁹⁾

Balanced light did not score the best results opposite to what was concluded with Nakhei, et al,⁽¹⁶⁾ Curd FM, et al,⁽¹⁷⁾ Mete JJ, et al,⁽¹⁸⁾. It may be because have has more concentrated light on the tooth, which may interfered with prper shade matching. Opposite to what they tested in their researches; the ceiling mounted balanced (corrected) light.

The results supported other studies that the external light condition is one of the most effective factors on shade matching performance and the correcting light source improves shade selection.^(17,19-22)

One interesting finding of the research, is that unit light gave better result more than other lighting conditions. That is may be due to the fact that recent dental unit lighting are more optimized for shade matching than the old ones.

One of the limitations in this study was that only hand-held balanced light has been investigated while more studies addressed the ceiling mounted

balanced light. Moreover the effect of interfering secondary lights was not investigated in this study, only one light source was investigated. This condition does not happen clinically where more than one light may be lit during the process of shade selection.

The hypothesis of the research was not proved. Hand-held full spectrum light failed to surpass other tested lighting conditions in accurate shade matching.

CONCLUSIONS

Different lighting conditions affect color-matching procedure. Hand-held full spectrum light did not improve shade-matching procedure. Incandescent light showed better lighting condition than both fluorescent light and Hand-held full spectrum light.

Based on comparison between current research and previous findings; hand-held full spectrum light may not be a successful substitute to ceiling-mounted full spectrum light.

ACKNOWLEDGEMENT

The author would like to thank BAU family and prosthodontic instructors for participating in this research. Special gratitude for Dr. Noura Yassine and Miss. Abeer Hashem for their valuable contributions in the statistic section of this research.

REFERENCES

1. Barna GJ, Taylor JW, King GE, Pelleu GB Jr. The influence of selected light intensities on color perception within the color range of natural teeth. *J Prosthet Dent.* 1981;46:450-453.
2. Chu Sj, Devigus A, Mielsszk. *Fundamentals of Color: Shade Matching and Communication in Esthetic Dentistry.* Chicago, Ill: Quintessence Publishing. 2004.
3. Miller LL. A scientific approach to shade matching. In: Preston JD, ed. *Perspectives in Dental Ceramics.* Chicago, Ill: Quintessence Publishing. 1988;193-208.

4. Sorensen JA, Torres TJ. Improved color matching of metal-ceramic restorations. Part 1: A systematic method for shade determination. *J Prosthet Dent*. 1987;58:133-139.
5. Miller LL. Shade selection. *J Esthet Dent*. 1994;6:47-60.
6. Miller LL. Shade matching. *J Esthet Dent*. 1993;5:143-153.
7. Sproull RC. Color matching in dentistry. Part II: Practical applications of the organization of color. *J Prosthet Dent*. 1973;29:556-566.
8. Clark EB. An analysis of tooth color. *J Am Dent Assoc*. 1931;18:2093-2013.
9. Miller L. Organizing color in dentistry. *J Am Dent Assoc*. 1987; (Special Issue):26E-40E.
10. McLaren EA. The 3D-master shade-matching system and the skeleton buildup technique: science meets art and intuition. *Quintessence Dent Technol*. 1999;22:55-68.
11. Saleski CG. Color, light, and shade matching. *J Prosthet Dent*. 1972;27:263-268.
12. Bergen SF, McCasland J. Dental operator lighting and tooth color discrimination. *J Am Dent Assoc*. 1977;94:130-134.
13. Preston JD. Color and esthetics. In: Yamada HN, ed. *Dental Porcelain: The State of the Art—1977*. Los Angeles, University of Southern California. 1977;307-315.
14. Preston JD, Ward LC, Bobrick M. Light and lighting in the dental office. *D Clin N Am*. 1978;22:431-451.
15. Corcodel N, Rammelsberg P, Jakstat H, Moldovan O, Schwarz S, Hassel AJ. The linear shade guide design of Vita 3D-master performs as well as the original design of the Vita 3D-master. *J Oral Rehabil*. 2010 Nov;37(11):860-5.
16. Nakhaei M, Ghanbarzadeh J, Keyvanloo S, Alavi S, Jafarzadeh H. Shade matching performance of dental students with three various lighting conditions. *J Contemp Dent Pract*. 2013 Jan 1;14(1):100-3.
17. Curd FM, Jasinevicius TR, Graves A, Cox V, Sadan A. Comparison of the shade matching ability of dental students using two light sources. *J Prosthet Dent*. 2006 Dec;96(6):391-6.
18. Mete JJ, Dange SP, Khalikar AN, Vaidya SP. Comparative study of shade matching performance of dental students under natural daylight and daylight lamp conditions. *Eur J Esthet Dent*. 2013 Summer;8(2):192-9.
19. Corcodel N, Rammelsberg P, Moldovan O, Dreyhaupt J, Hassel AJ. Effect of external light conditions during matching of tooth color: an intraindividual comparison. *Int J Prosthodont*. 2009 Jan-Feb;22(1):75-7.
20. Jasinevicius TR, Curd FM, Schilling L, Sadan A. Shadematching abilities of dental laboratory technicians using a commercial light source. *J Prosthodont* 2009; 18(1):60-63.
21. 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(9):900-04.
22. Hassel AJ, Koke U, Schmitter M, Beck J, Rammelsberg P. Clinical effect of different shade guide systems on the tooth shades of ceramic-veneered restorations. *Int J Prosthodont* 2005; 18(5):422-26.