Original Article

Evaluation of tooth color distribution in 20 to 30-year-old patients of Shahid Beheshti university related centers in 1389

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Abstract

***Background and Aim*:** Tooth color assessing is very important in esthetic dentistry. The aim of this article was to study tooth color prevalence of 20-30-year-old patients and also presentation of a simple method for color assessment.

***Materials and Methods*:** This cross section descriptive analytic study was performed on One thousand fifty nonsmoker volunteers (501 male, 549 female). In a light, dis tance and angle constant condition the left maxillary incisors were photographed with a digital camera (Canon G9) using a retractor. The pictures were studied with Adobe Photoshop CS5 software. The color of the middle 1/9 of the tooth was measured in L*a*b* system. In the exact above condition vita pan classical shade guide was pho tographed in direction of neutral background. These pictures were studied with Adobe Photoshop CS5 and L*a*b* average was measured for the middle 1/9 of each sample. After measurement of ΔE* for each person and vita pan classical shade guide, mini mum ΔE* was chosen for each tooth as the color of that tooth. Finally, the effect of colored liquid drinks was assessed.

***Results*:** The most popular findings were A3.5 (16.85%) A3 (14.85%) and B1, B2 (9.8%). The results of this study showed that the L* average in nonsmokers who drank colored liquids more than twice a day in comparison to noncolored liquid users was lower. The a* and b* average in this group was higher than noncolored liquid users.

***Conclusion*:** The most common findings were A3.5 (16.85%) A3 (14.85%) B1, B2 (9.8%). Tooth color assessment with a digital camera and computerized study is sim ple and cheap but very sensitive.

***Key Words*:** Spectrophotometry - Colorimetry - Dental photography

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Introduction

The role of color in esthetic dentistry is undoubtedly of the most complicated and unknown matters of the science of restorative dentistry. In this regard, many factors are effective and play a role and all take part in the outcome of the final consequential appearance of the restoration. Therefore, the basic knowledge of color is essential for esthetic restoration [1]. An appropriate understanding of the normal color of the teeth is nec-

essary for a precise and congruent selection of the relevant colors of the restorative material. The tooth consists of the combination of colors with different concentrations. Usually, the color of the tooth fluctuates from the gingival to the incisal area, being significantly darker in the gingival area due to the thinner enamel in this area [2]. A color perception of the teeth leads to a restoration with a normal appearance.

Light reaches the retina after passing the vitreous humor which is a gelatinous substance. The retina consists of two main types of photoreceptor cells; namely, cylindrical and conical. There are approximately 120 million cylindrical cells in each eye, responsible for the black and white vision (achromatic vision), vision in low light (scotopic vision) and interpretation of brightness. In each eye, there are about 6 million conical cells responsible for color vision which are active in only high light. In order to create a clear image, three terms are necessary [3];

1- It should have a definite minimum intensity

2- A particular period of time

3- Contact with a minimum required area of the retina

The white light is composed of three basic spectrums; namely, red (600-700 nm), green (500-600 nm) and blue (400-500 nm). These three colors are nominated as the main colors or the primary colors of the additive system; red (R), green (G) and blue (B).

The wave length of these three main colors are congruent with the sensitiveness limit of the three conical cell types of the retina. Combination of two of these main colors forms the secondary colors of the additive system; yellow (Y), magenta (M) and cyan (C). Combination of a primary color with its opposite secondary color leads to the formation of white (2). Therefore, color is created by the joint impression of the eye and the brain, in a way that stimulating the conical cells of the retina leads to the perception of 7 million colors [3]. We have to bear in mind that the color of the light and the color of the object are not always the same. For instance if red light shines on a white object, that object appears red and if green light shines on a red object, that object seems black. Therefore, in order to determine the color of an object or the teeth precisely, they should be observed in white light [4].

There are color spaces to evaluate the amount of color, but for long periods of time munsell color system and CIE Lab have been used for this purpose. The color of the tooth may be determined by the average of the subjective measurement of the color by the shade guide or the objective measurement by the colorimeter, spectrophotometer and analysis of the digital images.

The color standard used for the teeth's choice of color is called the color shade. There are many color samples for different objectives. The most famous global color guide is the vita classic which regarding hue consists of A (red), B (yellow), C (yellow-grey) and D (orange-grey or brown) colors. In addition, in each color family, with the increase in number from 1 to 4 chroma increases and value decreases. For instance, A2 is lower in value and higher in chroma compared to A1 [2].

Nowadays, the dentists use visual color determination techniques and individual clinical experiences for color determination and based on this judgment they prepare composite restoration materials for private clinics and treatment centers which is an obstacle in reaching desirable results. Besides, this non scientific judgment leads to disproportionate material which is the reason of capital loss.

Healthy and proportionate teeth are the basics of a beautiful face and dental esthetics are one of the objectives of dentistry [5]. When the teeth have to be replaced by restorative material or artificial teeth, special attention should be paid to the color of the teeth. Due to the obscurity of the prevalence of tooth color in the society and based on the Iranian nature and culture and not the book references in other countries; private office, governmental and private treatment center dentists have always faced problems in the

purchase and order of composite material. The objective of this study was to evaluate the teeth color quantitatively in 20 to 30-year-old patients referred to ShahidBeheshti University of Medical Sciences dental clinics as one of the greatest centers for esthetic problems such as tooth color and also presentation of a simple technique for evaluation of tooth color.

Materials and Methods

This was a cross sectional descriptive analytic study. The data were collected by a questionnaire. This study was performed on 1050 patients referred to dental centers of Shahid Beheshti University of Medical Sciences in 2009-2010. Based on the results of case studies and using the option of the proportion of sample volume, Minitab software estimated the minimum sample volume in each center as 350 considering α=0.05 and an accuracy of 0.01. Five hundred one (47.72%) of these patients were male. The age range was 20-30 years. None of the patients were smokers.

The patients' central teeth were caries-free and no composite filling was detected. There was no grinding or history of sensitiveness in the area of the two central teeth. A device was designed to stabilize the distance between the camera and the teeth. This device fixed the distance between the camera location and the patients mouth at 15 cm. The base was perpendicular to the surface the camera was placed on and opposite the oral cavity, forming no angle with it. The two bases were parallel and were attached to a plate so the distance would be permanent. A chin set and head rest were used to fix the patient's head position. A Demetron Shade system (Light Kerr Hawe SA Co. Switzerland) was utilized to reconstruct neutral light with a 6500 Kelvin degree color heat [6].

In accordance with the fact that increase in the camera's resolution capacity (number of pixels) leads to higher confidence and reliability of the determined color [7], Canon G9 with a resolution of 12.0 megapixels was used.

The camera's setting has been demonstrated in Table 1.

Table 1: Camera Setting

Setting Criteria	Applied Setting
ISO	100
Image size	1944×2592
Image quality	Super fine
Digital sensor	CMOS
Function	Manual
F. stop	4.5
Color field	SRGB
Lens type	Macro
Shutter speed	1/125
White light balance	Internal light

Finally, a CA (color assessment) software was designed with the assistance of computer engineers. First L*, a*, b* standards were determined for each of the 16 vita classic colors in the test conditions and were given to this software. For calibration, four different colors shade guides were used and their mean was selected as the study. After choosing the samples among patients from three treatment centers of Behfar, Ghazi Tabatabaee, and the diagnostic department of Shahid Beheshti Dentistry Faculty and explaining the project to them, the prepared forms were filled by the patients. The patients then sat on a chair and placed their forehead and chin on the designed apparatus. The patients' lips were held away from the teeth by a lip retractor. When the patients head was placed in the apparatus, the central teeth were parallel to the camera's lens. When the camera was placed on the same apparatus, the lens was completely perpendicular to the surface. To equalize the color of the teeth, a small round disc punched from grey cardboard with an 18% light reflection was prepared and placed on the right central tooth at the time of photography [8]. The demetron shade light was placed between the camera and the patient's mouth in a way that it was as close to the mouth as possible. After that, the lights were turned off and the only existing light was this source. In this situation, a photo was taken of the central teeth (Figure 1).

Figure 1: One of the photo samples

According to the above mentioned method, a photo was taken of each of the vita classic color samples in the exact light condition and distance and same angle as the patients. All the photos of the patients and the vita color samples were evaluated by CS5 photoshop software based on L*a*b* view point. The number obtained for L*a*b* were entered in the related questionnaire.

After opening the photo in the CS5 photoshop page, the image of the tooth was selected by Slice tool and the 1/9 middle piece with the fixed size of 64×64 pixels was cut by Crop tool. This selected piece was called the useful part of work. For L*a*b* determination, we went to the image menu and in the Mode part we chose the Lab color. For L*a*b* determination, from all the points of this separated image from the Image menu, the Histogram option was selected. In the Channel part, L*, a*, b* were chosen in the exact order mentioned. For each of them the mean was defined and was recorded at the bottom of the page, in each patient's or each color sample's questionnaire. To change the L*, a*, b* figures that were obtained from Adobe Photoshop CS5 to CIE L*a*b* system the following equations were used (2, 9, 10).

$L^*CIE = 0.392 \times L^*photoshop = \frac{100}{255} \times L^*photoshop$

$a^*CIE = a^*photoshop - 128$

$b^*CIE = b^*photoshop - 128$

Using ΔE* which shows the difference of color between two samples, the difference between the color of each patient's left central tooth and all vita color samples was evaluated and recorded in the table prepared. To accomplish this, L*, a* and b* which were determined for vita color samples were entered as standard to the designed software. The role of this software was comparison of the three entered components resulted from the photos of the left central teeth and the ΔE* equation based on the determined standard and determining the least difference as the color of the tooth. The ΔE* equation is as follows (10).

$$E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

$$E^* = L^* \text{mean patient} - L \text{ mean vita}$$

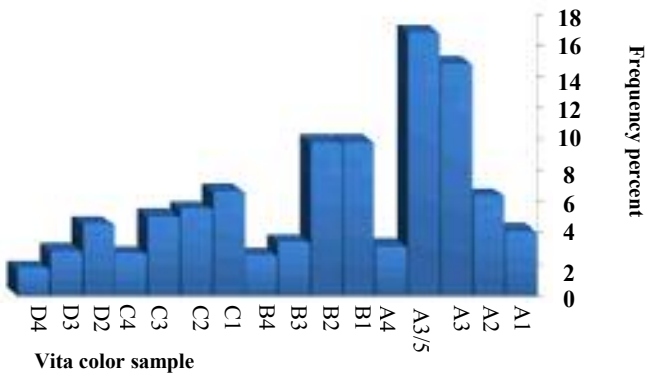
$$a^* = a^* \text{mean patient} - L \text{ mean vita}$$

$$b^* = b^* \text{mean patient} - L \text{ mean vita}$$

The effect of colored drinks was evaluated for each patient in the questionnaire. The data were analyzed statistically using SPSS 16 for Windows (SPSS Inc., Chicago, Il). To determine the effect of gender and drinking on L*, a* and b* two-way ANOVA was used. P value less than 0.05 was considered significant.

Results

The range for L*, a* and b* was measured as 53.94-82.76, -4.01-2.81 and 0.5-23.19, respectively. The mean for L*, a* and b* was 68.82 ± 6.35, -1.06 ± 1.36 and 12.17 ± 5.41, respectively. The most common cases observed were A3.5 (16.85%), A3 (14.85%), B1 (9.8%) and B2 (9.8%). In graph 1, the frequency of the observed colors have been demonstrated in all the patients without considering any variables.



Graph 1: Frequency percent of the observed colors in all the patients without considering any variables

Table 2 shows the mean values of L*, a* and b* separately regarding gender. Gender has no significant effect on L*, but men have a significantly higher mean b* compared to women and women have a significantly higher a* compared to men. P value less than 0.05 was considered significant.

Based on Table 3, in those who drink colored drinks the mean L* is 3.53 lower and the mean b* is 3.51 higher, but the mean a* is approximately similar and the difference is not significant. P value less than 0.05 was considered significant.

Table 2: Mean values of L*, a* and b* separately regarding gender

Gender	Number of specimen		Mean	SD
Woman	549	L*	68.89	6.356
		a*	-0.99	1.392
		b*	11.89	5.312
Man	501	L*	68.73	6.365
		a*	-1.14	1.333
		b*	12.48	5.506

Table 3: Mean values of L*, a* and b* separately regarding usage colored drinks

Usage of colored drinks	Number of specimen		Mean	SD
-	541	L*	70.53	6.36
		a*	-1.12	1.364
		b*	10.47	4.929
+	509	L*	67	5.834
		a*	-1	1.366
		b*	13.98	5.314

Discussion

This study showed that the most prevalent color in this study group was A3.5 (16.85%) and A3 (14.85%). Alber mentioned A2 as the most prevalent color in America [11]. Based on some opinions, tooth color is one of the properties that is related to the individual's genetic, culture and life style and generally, the society's nationality plays a role [5, 12].

In this evaluation, the middle third of the tooth was selected for color determination. The reason this part was chosen was due to the fact that in the incisal third, the capacity of light passage is high; therefore, the selected color depends on the background and in the cervical third, the pink color of the gums effects the selected color [13].

The round grey cardboard was used to regulate the light and the color of the photo in photo shop software. This grey cardboard has an 18% reflectance which is between white and pure black. This spherical grey card acts as a neutral objective. The amount of red, blue and green colors are equal. In other words, a criterion which is grey and has a definite value is considered in the photo. The software also has to take color grey into account [8, 14-16].

In this study a digital camera was used. Of the other tools used for determining tooth color, we may mention colorimeter. This tool cannot be used for the curved surface of the teeth [17]; therefore, its inter instrument validity is less than its intra instrument validity [18]. The color sample obtained by this tool is inconsistent to the color obtained from the color sample [18-20]. Due to its high technical sensitivity [21] and the high sensitivity to light and temperature [22], this tool was not used in this evaluation.

In 2007, in a study conducted by Dozic et al. in Holland, they reached the conclusion that using easy shade instrument (spectrophotometer) and I Kam (digital camera) in the mouth is the most reliable method to determine the color of the teeth [23]. Many researchers have used the spectrophotometer in their studies for color determination [24-27], but based on the fact that spectrophotometers in comparison to other methods are somehow complicated, it is necessary to have a specific expensive instrument with high technical sensitivity and besides they only determine the color of the sample surface [28]. In this study, we did not use this instrument. We used a reliable, low price replacement as the digital camera. In the recent years, use of the digital

camera for color evaluation is a repeatable method both in clinic and laboratory [7].

Based on studies by Elvin in America (2006), Smith in England (2008) and Tung in America (2010), use of the digital camera in color evaluating tests and color determination in dental clinics is reliable [14-16].

In a study conducted by Cal in 2006 and Lath in 2006-2007, using digital images in color tests was similar to the spectrophotometry method regarding validity and reliability [28-30].

Therefore, using the digital camera technique to evaluate tooth color is a reliable and inexpensive method which gives more information about a tooth as a precise clinical example. According to Lath's study, digital photography is a more reliable method in comparison to spectrophotometry [8].

Another method is using the color sample and the visual diagnostic method which is the most common method used in clinics, but because the color samples of different companies are different [13, 31, 32], these samples include a restricted color spectrum [33]. Their quality is different compared to composites and their thickness with restoration is always not similar [34]. Different supervisors have different opinions, in a way that maybe as a result of eye strain, the individual may not confirm the color he himself has selected before [35]. This method was not reliable and valid for precise color determination compared with the other tools [23, 36].

As mentioned before, in this evaluation a digital camera was used, but in order for the digital photography method to be an appropriate replacement for other methods, the distance between the object and the camera, the camera settings and the light circumstances should be appropriate [14-16, 21]. Based on the fact that the higher the camera's resolution capacity, the higher the reliability and validity to the determined color [7]; the number of the camera's pixels shows this capacity. In this study, the highest resolution camera (12 megapixels) at that time was used. The camera settings were performed similar to Bengel's study regarding semi professional digital cameras [8].

In an article review by Bengel, choosing the tooth color in the light of day in the dental office does not have the essential accuracy [8]. The room light effects the color too. Office fluorescent lamps are designed to mimic daylight. They do not have a spectrum and are not ideal neutral. The unit lamp is another light source effective on the tooth color. Halogen lamps have 3000-3400 Kelvin color heat leading to yellow light. In order to reconstruct neutral light creating 6500 Kelvin color heat, we used Demetron shade light which is produced by Kerr manufacturer. Jasinevicus also reached the conclusion that under this light there is a better light accommodation in comparison to the usual light of the laboratories and offices in all vita color samples [37]. Since the fixed distance between the mouth and the camera is important for accuracy of the study [14-16, 21], the optical axis of the camera has to be perpendicular to the frontal plane of the patient and parallel to the occlusal plane [38]. Stability of the patient's head is another important matter which is achieved by the chin rest and the head rest [38]. A tool was designed and produced in which all the above mentioned items were considered and the location of the dimetron tool was placed at the closest distance from the mouth in a 5-7 cm distance [6]. In other studies, the color determination was performed by a digital camera and the distance of the camera was approximately 10-25 cm from the patient [14-21, 30] The focal length of the Canon G9 in the macro state is 1-20 cm; so, the distance between the patient and t camera was 15 cm which was mentioned in the construction of the photo recording tool.

In photography of vita classic color samples, we tried to provide circumstances similar to the oral cavity. By placing the neutral grey cardboard in the background, the interference of the other factors was prevented in the color determination of the samples. In Erbhaeuser's tests in Germany in which photos were taken from one color sample

with different black and white backgrounds, high color difference (ΔE^* = 17) was detected [39]. In this evaluation, the mean of L*, a* and b* in the evaluated society was 68.81±6.35,-1.91±1.36 and 12.17±5.41, respectively. In a similar study on 405 Chinese men and women in the same age range, these figures were 70.67±1.91, 4.29±2.05 and 17.51±4.13 for L*, a* and b*, respectively [40].

In another study in Buffalo city, America; 933 central teeth of 501 cases in the 20 to 30 years age range, the L*, a* and b* figures were 58.71 to 88.7, -3.6 to 7 and 3.7 to 37.3, respectively [43]. In the present study, L*, a* and b* were 53.94 to 82.76, -4.01 to 2.81 and 0.5 to 23.19, respectively.

The questions in the questionnaire were about the effect of colored drinks such as tea, coffee and carbonated beverages and the answers were evaluated. Using colored beverages increased the b*; indicating that in people who drink colored beverages more than twice a day, in the b* part which shows blue or yellow color, there is propensity towards yellow. Moreover, usage of colored beverages decreases the L* component, indicating that in people who drink color beverages more than twice daily have lower teeth brightness compared with other people. These mentioned matters were results of Bagheri and Guler in

Conclusion

The most prevalent colors were A3.5 (16.85%), A3 (14.85%) and B1 and B2 (9.8%).

Using digital photography and evaluation of the photos by computer software to determine tooth color is a relatively simple and inexpensive method.

The mean quantity of L* in men and women who drink colored beverages is significantly lower than the control group; the difference between mean a* quantities in the two groups was not significant. The mean b* quantity in men and women in the group using colored beverages was significantly higher than the other group.

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