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Original Article

The effects of age on tooth color and of viewing distance on visual tooth color matching in aesthetic dentistry

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Abstract

Aim: This study aims to question the effect of visual distance on color selection by scoring the maxillary central tooth color with the visual color selection method and to investigate the relationship between tooth color and patient age.

Methodology: Maxillary central tooth color was determined by a single operator using visual methods from two different distances, 35 cm and 70 cm, in a total of 100 people between the ages of 20-80 and of different genders. The value, hue and ages of the teeth were recorded using the VITA Toothguide 3D-MASTER color scale at 2 different viewing distances. Visual color selection was made in natural daylight, preferably between 10:00 and 12:00 in the morning. Subjects were observed at eye level, and all color assessments were performed rapidly (5-7 s). Independent T-test was used for independent groups and Chi-square test was used for dependent groups.

Results: Considering the relationship of lightness with distance, there is a significant difference between the values at 35 cm and 70 cm distances. It was observed that the lightness increased when the measurements made from 70 cm were compared with the measurements made from 35 cm. As the age increases, the ratio of the brightness value of 1, which is the highest lightness, decreases, and the ratio of the darker 3 and 4 lightness increases. R (reddish) hue was found to be higher in the 40-59 and over 60 age groups compared to the 20-39 age group.

Conclusion: It was observed that the tooth color was determined lighter in the measurements made from 70 cm compared to the measurements made from 35 cm. It is important to determine the color at 35 cm so that the incorrect lightness (value) is not selected. It can be said that as the age increases, the tooth gets darker and the reddish and yellowish hue increases.

Keywords: Age, color, tooth, viewing distance

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Introduction

With the increase in aesthetic concerns, the importance of aesthetic dentistry is also increasing. The color of the teeth is one of the most important features affecting the aesthetic appearance of the teeth and also significantly affects the success of tooth restoration. Accurate color evaluation and selection for

prosthetic restorations greatly contribute to patient satisfaction with prosthetic treatment (1).

Visual shade matching using color shades is one of the most frequently used techniques for tooth color selection. However, color selection is limited by clinical experience, time constraints, patient collaboration, and color knowledge. In addition, visual shade matching is subjective, and multiple factors affect color perception (e.g., lighting conditions, gingiva color, and background colors); any changes in any of these factors can result in altered color perception (2). Full-spectrum lighting is required to bring out the full range of colors a tooth can reflect. The blue light emitted by fluorescence neutralizes some of the yellow light and makes the tooth appear whiter. Therefore, the light source must have a component close to ultraviolet light (3).

The color of human teeth varies according to the dentition; permanent teeth are darker and less chromatic than primary teeth. Color perception is affected by various parameters such as shadow, saturation, brightness, translucency, opacity, reflection, and fluorescence. The color of natural teeth depends on the optical properties of enamel and dentin. Teeth are translucent at the highest incisors and least at the cervical region. Natural tooth enamel is responsible for opacity (3, 4).

Color is formed by the physical impact of light energy on an object and the observer's psychophysical perception of this event. Wavelengths reaching the eye are perceived by the rod and cone cells and transmitted to the visual cortex by the optic nerves. Thus, it can be concluded that color perception is affected by the distance between the observer's eye and the object (5). When dentists match colors with teeth, their eyes should be at the level of the patients' teeth. Shade tabs should be located in the same plane as the teeth and in the same relative edge position. The first impression of tooth color is usually the most accurate. The color matching attempt should take only 5–7 s as the visual pigment is quickly depleted, and to avoid eye strain. The color dimensions of objects also vary greatly according to the objects' physical dimensions (e.g., height, width, and length); thus, it is very difficult to distinguish individual color dimensions when only a single object is observed (3).

The distance between the eyes and the object is directly related to the formation of perception. In visual color matching, viewing distance and viewing angle stimulate the color-related region of the retina of the eye. Therefore, viewing distance is important for the visual tooth color selection procedure (5). The tooth color–matching distance should be 25–35 cm (3).

When dentists match colors with teeth, their eyes should be at the level of the patients' teeth. Shade tabs should be located in the same plane as the teeth and in the same relative edge position. The first impression of tooth color is usually the most accurate. The color matching attempt should take only 5–7 s as the visual pigment is quickly depleted, and to avoid eye strain. The color dimensions of objects also vary greatly according to the objects' physical dimensions (e.g., height, width, and length); thus, it is very difficult to distinguish individual color dimensions when only a single object is observed (3).

The color of human teeth varies according to the dentition; permanent teeth are darker and less chromatic than primary teeth. The teeth are also most translucent at the highest incisors and least translucent at the cervical region. Color perception is also affected by various parameters, such as shadow, saturation, brightness, translucency, opacity, reflection, and fluorescence. The color of natural teeth depends on the optical properties of the enamel and dentin. Natural tooth enamel and dentin are responsible for tooth opacity/translucency (3, 4). Tooth color is also a result of the thickness and chemical makeup of enamel and dentin. As enamel abrasion and secondary dentin deposition increase with aging, tooth color changes over time (6). The increase with age in the thickness of the dentin layer, which plays an important role in the formation of tooth color, reveals that tooth color and age are interrelated factors.

The present study was conducted to determine the effect of visual distance on tooth color matching by scoring the maxillary central tooth color using the visual color selection method, and to investigate the relationship between tooth color and patient age. The null hypothesis was that visual distance has no effect on determining tooth color and that there is no relationship between tooth color and age.

Materials and Methods

The ethics committee of the Necmettin Erbakan University granted permission to conduct the study (number 10923). In total, one hundred volunteers of both genders, aged 20–80 years, who applied to the Necmettin Erbakan University Faculty of Dentistry for prosthetic treatment, were included in the study. A consent form was completed by all patients. The maxillary central teeth were used for color matching. The following exclusion criteria were employed in the selection of patients: gingival problems, a history of traumatic injury, the presence of excessive abrasions, malocclusion, a history of orthodontic or bleaching treatment, observable tooth staining, caries, and teeth with composite fillings. The natural maxillary central teeth of a sample of 100 individuals were measured. For the purposes of the study, the patients were divided into three subgroups based on age [20–39 years (n=44); 40–59 years (n=36); and 60–80 years (n=20)].

The color of the labial surface of the permanent maxillary central tooth was determined using the VITA Toothguide 3D-MASTER (VITA; Zahnfabrik) color scale by a single operator with more than three years of clinical experience. The clinician was subjected to the Ishihara test. No color mismatches were found. All measurements were made in the same dental clinic. Visual color selection was recorded in daylight, between 10:00 am and 12:00 am. Anyone wearing make-up was asked to remove it, and the patients' faces were covered with a blue cloth. Subjects were observed at eye level, and all color assessments were performed rapidly (in 5–7 seconds). After choosing a

color from 35 cm in one go, the operator's eyes were rested by focusing on a gray cover for 5 seconds, then the color was determined from 70 cm. The lightness level (value) was also selected. Starting from the darkest to lightest group, a number from 1-5 was noted. Then, the hue was determined, and the ages of the patients were recorded.

Statistical analysis

The independent t-test was used for independent groups, and the chi-square test was employed for dependent groups. The data obtained in our study were analyzed with SPSS V21 (IBM SPSS Inc., Armonk, NY, USA). The Kruskal-Wallis test was used for non-normally distributed data, and one-way (ANOVA) was employed for normally distributed data.

Results

When the relationship between lightness and distance was examined, a statistically significant difference was found between 35 cm and 70 cm (Table 1). When the measurements made from 70 cm were compared with the measurements made from 35 cm, the lightness value increased acceptably (Table 2). No statistically significant difference was found in the parameters for color tones and distance (Table 3). Reddish and yellowish hues were found to be higher in the 40-59 and over 60 age groups compared to the 20-39 age group. So, as the age increased, the ratio of 1, which was the lightest value, decreased, and the ratio of the darker 3 and 4 values increased (Table 4). There was no significant difference between viewing distance and hue when measurements were made from 35 cm.

Table 1. Lightness comparison of two different distances

Group	N	Mean	Std.Deviation	Std.Error
35 cm	100	2.1400	0.81	0.08
70 cm	100	1.8300	0.71	0.07

*The difference between median values was significant (p <.005).

Table 2. The proportions of value measurements at different distances

Value	Group of 35 cm	Group of 70 cm
1	9.0%	16.5%
2	29.5%	26.5%
3	7%	6%
4	4.5%	1%

*p <.05, (n=100), significant difference.

Table 3. The proportions of hue measurements at different distances

Hue	Group of 35 cm	Group of 70 cm
L	12.5%	10.5%
M	28.0%	32.5%
R	9.5%	7.0%

*L (yellow), R (red), and M (middle) hues indicate tooth shade, p >.05, significant difference not found.

Table 4. The proportions of hue and value according to age groups

		AGE		
		20-39	40-59	60-80
HUE	L	6%	7%	12%
	M	33%	16%	7%
	R	4%	7%	8%
VALUE	1	15%	2%	1%
	2	26%	24%	9%
	3	3%	5%	6%
	4	0%	4%	5%

*p <.05, (n=100), significant difference.

Discussion

This study compared two different viewing distances using a visual color selection method and found that the 35 cm distance provided significantly better discrimination than the 70 cm distance (p < 0.05). In the measurements made from 70 cm, the color of the teeth was determined to be lighter than in the measurements made from 35 cm. Accordingly, if the viewing distance increases, the perception changes and the teeth are determined to be lighter. There was no significant relationship between the hue measured from different viewing distances; therefore, the viewing distance seems to have no effect on determining the hue. These results indicate that the null hypothesis should be rejected and that viewing distance significantly affects the results of visual color matching.

Based on physiological conditions, Paravina et al. suggested an observation distance of 25-35 cm for visual shade matching (3). Similarly, Klinke et al. found that viewing distance has a significant effect on visual color identification quality. In their study, the shorter viewing distance of 35 cm yielded measurably better results than the longer distance of 70 cm, and therefore, 35 cm was recommended for a visual color selection procedure (5).

Value and hue were compared with patient age. Hasegawa et al. showed that tooth color, including yellowness, tends to increase with advancing age (7). Similarly, the red hue was less common in young people, confirming the observation red and yellow hues increase with age.

In line with the results of previous studies, Kim et al. found that the maxillary central teeth were darker, more yellowish, and more reddish with age (8). In particular, secondary dentin formation and increased pigmentation contribute to dentin chroma saturation, and prolonged enamel abrasion also causes tooth discoloration.

Veeraganta et al. discovered a definite relationship between the patient's age and the tooth shade value, showing darker tooth color values with age (9). Gozala et al. stated that the natural color of the maxillary teeth is related to age. As age increases, the maxillary teeth become darker, reddish, and yellower (10). In accordance with these studies, the teeth were found to be darker, yellower, and redder with increasing age in this study.

Conclusions

Visual distance affects color matching by the visual method, and several studies have revealed the ideal color selection distance is 35 cm. In this study, in the measurements made from 70 cm, the tooth color was determined to be lighter than in the measurements made from 35 cm, but the distance had no effect in determining the hue. Therefore, color selection should be made from 35 cm so that the wrong value is not selected. As age increases, teeth become darker, redder, and yellower.

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