Relationship between the color of the maxillary central incisors and age, sex, and skin color: value analysis using a spectrophotometer

H Susanty¹, Farisza Gita¹*, L S Kusdhany¹ and Pinta Marito¹

¹Department of Prosthodontics, Faculty of Dentistry, Universitas Indonesia, Jakarta, 10430, Indonesia

Email: farisza.gita@yahoo.com

Abstract. The increasing esthetic-related concerns of edentulous patients, especially concerning denture color, are a challenge for dentists and prosthodontists. Yet, there are no studies assessing anterior teeth in order to determine more esthetically appealing tooth colors. The limited information that is used to determine tooth color, namely, age, sex, and skin color, makes it difficult to choose the appropriate denture shade. This study aimed to analyze color differences in three maxillary anterior teeth and the correlation of maxillary central incisors with age, sex, and skin color. This was a cross-sectional study of teeth color determination using a spectrophotometer on the maxillary central incisors, lateral incisors, and canines in 84 subjects. Skin color was matched using the Wardah compact shade guide powder based on the Fitzpatrick skin color classification. Kruskal–Wallis testing revealed significant differences in the color of the central incisors, lateral incisors, and canines (p < 0.05), and chi-square testing revealed significant differences in teeth color based on age (p < 0.05), although no significant differences by sex or skin color were found (p > 0.05). Color differences in the three types of maxillary anterior teeth are commonly seen. Age affects teeth color, but sex and skin color do not effect.

1. Introduction

Selecting the right color is very important for achieving a natural look in dental restorations [1]. There are two methods that are most often used for color adjustment: visual (conventional) and digital [2, 3]. According to Chu et al. the use of a shade guide in visual color assessment is subjective to weaknesses in human vision (i.e., each eye perceives a slightly different color) [4]. Age, sex, the experience and eye fatigue level of the operator, the light source, the position of the patient and the background color can all affect the process [1]. A color determination tool has recently been developed, which seemingly solved the problem of subjectivity in visual color adjustment. The spectrophotometer is a tool that is used to determine colors by measuring the amount of light that is reflected by the object at a distance of 1–25 mm [5].

Sharma et al., Herekar et al., and Jahangiri et al. have found that age, sex, and skin color are factors that should be considered while determining denture color, especially in the anterior region, where esthetic consideration are the greatest [6, 7]. However, information on the correlation between teeth
color and age, sex, and skin color is still limited. There is a common perception among dentists that individuals with dark skin have brighter-colored teeth [6–9]. Some studies have found that the aging process causes the teeth to darken in color and that women have brighter-colored teeth than men [6–8, 10, 11]. These studies mostly determined teeth color using a conventional shade guide, and there have been no studies using a spectrophotometer.

In 1905, Munsell introduced a visual color order system to describe teeth color, which is still used today and is based on three dimensions of color (i.e., hue, chroma, and value) [8, 12]. For the purposes of efficiency, simplification, and consistency, the Munsell color order system is used as the basis of color determination in dentistry. However, there are some important optical characteristics, such as translucency, fluorescence, and opalescence, that this system does not consider [13].

Anterior teeth often have a slightly different color from one another depending on their position on the dental arch. The central incisors are brighter than the canines, which look more reddish/yellowish, with a higher chroma color [14]. There is also a gradient in teeth color from the cervical to the incisal area. The color on the cervical area is affected by the reflection of the gingival light, whereas the color on the incisal area, which is more translucent, may be affected by the light from the background of the oral cavity. Therefore, for research purposes, it has been recommended that the middle third of the tooth be used to represent the tooth color [8, 9, 14].

Age can affect teeth color. As we get older, the pulp chamber becomes narrower because of the deposition of secondary dentine, which makes the tooth color more opaque [15]. Dental characteristics based on age were grouped by Hegenbarth (1990) and divided into three age ranges: young adults (15–30 years old), adults (30–50 years old), and elderly (over 50 years old) [15].

Skin color is another factor that is associated with tooth color determination. According to Jahangiri et al., there is a correlation between teeth color and skin color, in which medium and dark skin tones are associated with brighter teeth compared to subjects with lighter skin tones [8]. The study used L’Oréal compact makeup, which divided skin color into four groups: fair, light, medium, and dark. Jahangiri et al. Herekar et al., and Sharma et al. found that women have brighter-colored teeth than men [6–8, 11].

In this study, we sought to determine the colors of three maxillary anterior teeth—central incisors, lateral incisors, and canines—and to assess any correlation between teeth color and age, sex, and skin color using a spectrophotometer. Another aim of the study was to establish guidelines for the color selection of dentures based on age, sex, and skin color.

2. Methods
This was a cross-sectional study that was conducted in 2014 at a social service event at the Ignatius Church of Jakarta, Center of Aging Universitas Indonesia, and Faculty of Dentistry, Universitas Indonesia. The subjects were 62 individuals meeting the inclusion criteria of a minimum age of 18 years, with a complete set of maxillary anterior teeth, no restorations causing discoloration in these teeth, no crowns, no anomalies in development, no fluorosis, no tetracycline staining, no history of bleaching, no former or current smoking, no excessive exposure to sunlight, and not under orthodontic treatment, good Simplified Oral Hygiene Index (OHIS). Subjects that meet this inclusion criteria then filled the informed consent. Tools and materials used include a Vita Easyshade Compact spectrophotometer, sterile dental mirror No. 4, 70% alcohol, prophylaxis paste and brush with low speed, low-speed micromotor, and a Wardah compact shade guide.

Before the teeth color assessment, the teeth of the subjects were cleaned with a prophylaxis paste and brush. Subjects were asked to sit in an upright position, their upper lip was retracted with a dental mirror, and the operator then performed an observation. The assessment was performed using a Vita Easyshade Compact spectrophotometer, in which the tip of the spectrophotometer was placed on the tooth to be measured with a 90° position to the tooth surface. The device beeps and then displays the results on an LCD screen.
Skin color determination was performed using the back of the patient’s hand since this area would have no makeup or residue. The hand skin color was matched using a Wardah compact shade guide. Researchers were assisted by two operators that had been trained in skin color determination using the Wardah compact shade guide. This shade guide was used because it had six colors according to Fitzpatrick’s skin classification.

Data were analyzed using SPSS software, version 17, and univariate and bivariate analyses were conducted.

3. Results
In this study, 84 out of 92 subjects examined met the inclusion criteria. Subjects were divided into three age groups and were then divided by sex and two types of skin color (Table 1).

Table 1. Distribution of data.

| Variable               | Frequency (n = 84) | Percentage (%) |
|------------------------|--------------------|----------------|
| **Age group**          |                    |                |
| Teenagers              | 15                 | 17.9           |
| Adults                 | 29                 | 34.5           |
| Pre-elderly and elderly| 40                 | 47.6           |
| **Sex**                |                    |                |
| Female                 | 42                 | 50             |
| Male                   | 42                 | 50             |
| **Skin color**         |                    |                |
| Type 3                 | 34                 | 40.5           |
| Type 4                 | 50                 | 59.5           |

![Figure 1. Distribution of teeth color by age group.](image)

The highest color distribution for teenagers was seen in the bright range (A1 and B2), with as much as 35.7% of the teeth in this group being categorized as such (Fig. 1). In the adult group, 34.5% were classified as A1 and 20.7% were classified as B2. In the pre-elderly and older adults, 24.4% were classified as A3 and 17.1% were classified as C3.
Figure 2. Distribution of teeth color based on sex.

In female subjects, the greatest distributions were seen in A1 (33.3%) and B2 (19%). In male subjects, the greatest distributions were seen in B2 (28.6%) and A3 (19% (Figure 2)).

Distribution of teeth color based on skin color shows that in subjects with skin color type 3, the greatest distributions were found in B2 (28.1%) and A3 (21.9%). In subjects with skin color type 4, the greatest color distributions were found in A1 (32.7%) and B2 (20.4%).

In this study, a spectrophotometer device was used on the central incisors, lateral incisors, and canines in order to determine whether there were differences between the three types of anterior teeth. The results, in accordance with the Master Vita 3D scale, appeared on screen and the 24 shades were subdivided into five groups.

Figure 3. The distribution of central incisors, lateral incisors, and canines by color value.

The color distributions of the central incisors, lateral incisors, and canines measured using a spectrophotometer are shown in Figure 3. In the central incisors, 6% were categorized as the brightest, and most (66.7%) were categorized as bright. In the lateral incisors, none were classified as the brightest, 58.3% were categorized as bright, and 26.2% were categorized as a bit bright. In the canines, bright color had the highest percentage (34.5%), and dark color was high as well (32.1%).

The results of the color assessments of the central incisors, lateral incisors, and canines were then reviewed and compared for each subject. Kruskal–Wallis testing revealed that there were significant color differences between the groups ($p = 0.00$).
For the bivariate analysis, the five classifications were compressed into two teeth color groups (bright and dark); those with values of 1 and 2 were classified as bright, and those with values 3 to 5 were classified as dark.

**Table 2. Differences in anterior teeth color based on age, sex, and skin color.**

| Tooth Color Determination Results | Bright | Dark | No. | P      |
|----------------------------------|--------|------|-----|--------|
| **Age Groups**                   |        |      |     |        |
| Teenagers                        | 11     | 4    | 5   | 0.024* |
| Adults                           | 26     | 3    | 9   |        |
| Pre-elderly and elderly          | 24     | 16   | 0   |        |
| **Gender**                       |        |      |     |        |
| Female                           | 31     | 1    | 2   | 0.807  |
| Male                             | 30     | 2    | 2   |        |
| **Skin color**                   |        |      |     |        |
| Type 3                           | 21     | 3    | 4   | 0.066  |
| Type 4                           | 40     | 0    | 0   |        |

*Significantly different (p < 0.05).

A significant correlation between age and teeth color was found (p = 0.024) (Table 2). In the teenage age group, most teeth were categorized as bright (values 1 and 2), whereas in the elderly age group, the dark category (values 3, 4, and 5) was frequently seen.

In females, 31 out of 42 were classified as bright (~73.8%), similar to in males, at 30 out of 42 (~71.4%). Chi-square testing revealed no correlation between sex and teeth color (p = 0.807).

Subjects with skin color type 4 were found to have bright teeth at a rate of 80% (40 subjects), whereas in those with skin color type 3, the rate was 61.7% (21 subjects) (Table 2). Chi-square testing indicated that there was no correlation between skin color and teeth color (p = 0.066).

**Table 3. Conversion table for denture color selection.**

| Bright (values 1,2) | Dark (values 3,4,5) |
|--------------------|--------------------|
| A1                 | A3                 |
| A2                 | A3.5               |
| B1                 | A4                 |
| B2                 | B3                 |
|                    | B4                 |
|                    | C1                 |
|                    | C2                 |
|                    | C3                 |
|                    | C4                 |
|                    | D3                 |
|                    | D4                 |

The conversion of spectrophotometer measurement values to denture color using A–D shades is shown in Table 3. For teenagers and adults, the denture color selection was bright, whereas in the pre-elderly and elderly group, the denture color was dark.
For both teenagers and adults, teeth color distribution was the highest in the bright values of A1 and B2. Teeth color determination for the pre-elderly and elderly groups was the highest in the dark values of A3 and C3 (Fig. 1).

4. Discussion

Teeth color determination in edentulous patients is a challenge for dentists and prosthodontists. There are two types of shade guide tools: the visual or conventional method and digital tools such as the spectrophotometer. Some studies have found the use of a spectrophotometer to be better, as it reduces the subjectivity of the conventional shade guide.

In this study, the color distribution on the central incisors, lateral incisors, and canines in 84 subjects were assessed. The brightest color of the central incisors had a value of 1, and the highest color distribution of central incisors was in the bright color range, with a value of 2. In the lateral incisors, the highest color distribution also had a value of 2, as well as a value of 3 (a bit bright). In canines, the highest color distribution had a value of 3 (a bit bright), followed by a value of 4 (dark). No lateral incisors or canines were assigned the value 1 (brightest).

In this study, significant color differences were found between the central incisors, lateral incisors, and canines. As of now, a set of acrylic dentures does not differ in color from one tooth to another. Color adjustments, particularly in the anterior region, would help to make dentures appear more natural.

The teeth that were linked to color determination by age, sex, and skin color were the central incisors. The central incisors are located at the front of the jaw arch, and the color is the brightest there and covers a wider area when compared with the lateral incisors, making color assessment easier. For canines, its location at the corner of the mouth causes difficulty in color selection, but in general the color of canines is darker [8, 9, 14]. In this study, the color was assessed in the middle third part of the tooth, which other researchers had recommended because of the gradation of teeth color from the cervical to the incisal areas [14].

In this study, we found a significant correlation between age and teeth color. We found that as age increases, the teeth color darkens. In a study conducted by Herekar et al. (2010), color determination was performed with two types of shade guides, which were the Vita Lumin and Chroma Scop, on the maxillary and mandibular central incisors [11]. Other studies have also found that the aging process affects the teeth color, causing them to darken [7, 8, 10, 11].

Teeth color was obtained using a spectrophotometer, with 31 out of 42 female subjects (~73.8%) and 30 out of 42 male subjects (~71.4%) found to have a bright tooth color. No correlation between sex and tooth color was found (p = 0.807). Jahangiri et al., Herekar et al., and Sharma et al. found that females have brighter-colored teeth than males, but Jahangiri et al. used a shade guide on the lateral incisors, making it difficult to find a color value, and Herekar et al. used a shade guide and Chroma Scop on the maxillary and mandibular central incisors and found a significant correlation between sex and teeth color [6–8, 11].

For skin color, we followed the general classification of Fitzpatrick, and in this study the reason behind choosing the Wardah compact shade guide was to match the skin color to fit the skin color of Indonesians. However, from the skin color classification, this study used only skin color types 3 and 4, whereas in other studies, types 3 and 4 were included as one group in the medium category. Skin color type 4 was found to be associated with teeth with a bright value in 80% of cases, which was higher compared with skin color type 3, which was associated with teeth with a bright value in 61.7% of cases, but analysis revealed a p value of 0.066, which indicated that the correlation of skin color with teeth color was weak.

Jahangiri et al. (2002) discussed the perception among dentists that individuals with dark skin color had bright-colored teeth [6, 8, 9]. Jahangiri et al. used L’Oréal True Illusion compact makeup, divided into four skin types, but in this study, we did not have a shade guide for dark colors and for teeth color examination used Vita classical. Sharma (2010) used Revlon makeup for a shade guide and divided
skin types into three groups [6]. All of the studies above were still performed using a conventional shade guide. The use of conventional shade guides to determine the color spectrum of teeth could lead to inconsistent color determination [2, 5].

The results of this study could be used in dentistry, especially by prosthodontists, as data for selecting dentures to achieve more esthetically pleasing results, with central incisors, lateral incisors, and canines having different colors. Central incisors usually have a brighter color, lateral incisors can be of the same color or darker than the central incisors, and canines have a darker color. Age was found to affect teeth color; for teenagers and adults, brighter values of 1 and 2 were found, whereas for pre-elderly and elderly persons (an age group that more commonly receives full dentures), the teeth color was in the dark range of values (3, 4, and 5).

From the conversion table results of Vita to denture color, we got bright values on denture colors of A1, A2, B1, and B2 and dark values on A3, A3.5, A4, B3, B4, C1, C2, C3, C4, D3, and D4. The most frequently selected teeth colors for teenagers and adults were A1 and B2, whereas for pre-elderly and elderly persons, they were A3 and C3.

For the purposes of clinical application of the results of this study, we created a guideline card for full denture color determination based on age, by setting two choices of teeth color based on age. The patient would be shown two color choices with a shade guide or could also with arranging the anterior teeth elements which are divided into two different color choices according to age. After the patient tries the denture wax, he/she can choose the color of the dentures according to his/her wishes from the two colors.

A weakness of this study was the relatively small number of subjects, which prevented researchers from dividing teeth color into five groups and instead limited them to two groups (bright and dark). Another weakness was that skin color was mostly of types 3 and 4, and no special skin color shade-guide was not used for this study.

5. Conclusion
In this study, it was found that there is a difference in color between the three types of maxillary anterior teeth. Age affects teeth color, but sex and skin color do not. It is suggested that the denture color for adolescents and adults to be A1 or B2 and that for the pre-elderly and elderly to be A3 and C3.

References
[1] Tunçdemir A R, Gungor A Y and Kahraman B 2012 the relationship of some patients factors with shade of their teeth measured by spectrophotometry in Turkish people Pak. J. Med. Sci. 28 67–70.
[2] Al-Dosari A A F 2010 Reability of tooth shade perception by dental professional and patients Pak. Oral. Dental J. 30 244–9.
[3] Todorovic A, Todorovic A, Špadijer-Gostović A, Lazic V, Milicic B and Djurisic S. 2013 Reability of conventional shade guides in teeth color determinatiant Vojnosanit. Pregl. 70 929–34.
[4] Chu S J, Devigus A and Mieleszko A J 2010 Fundamentals of Color: Shade Matching and Communication in Esthetic Dentistry. 2 ed. (Chicago: Quintessence Publising Co., Inc.)
[5] Chen H, Dong X, Qian J, He J, Qu X and Lu E 2012 A systemic review of visual and instrumental measurements for tooth shade matching Quintessence Asia pacific Edition 1 46–56.
[6] Sharma V, Punia V, Khandelwal M, Punia S and B RL 2010 A study of relationship between skin color and tooth shade value in population of Udaipur, Rajasthan Int. J. Dent. Clin. 2 26–9.
[7] Zarb G A, Borlender C L, Hickey J C and Carlson G E 1990 Boucher's Prosthodontic Treatment
foe Edentulous Patients. (St. Louis: The CV Mosby Co.)

[8] Jahangiri L, Reinhardt S B, Mehra R V and Matheson P B 2002 Relationship between tooth shade and skin color: an observational study J. Prosthet. Dent. 87 149–52.

[9] Ahmad S, Habib SR and Azad AA 2011 Scientific and artistic principles of tooth shade selection: a review Pak. Oral Dent. J. 31 222–6.

[10] Azad A A, Ahmad S, Zia M and Sharif M 2007 Relationship of age, gender and skin tone to shades of permanent maxillary central incisors Pak. Oral Dent. J. 27 119–26.

[11] Herekar M, Fernandes A and Mangalvedhekar M 2010 The most prevalent tooth shade in a particular population: a survey JIDA 4 499–502.

[12] Krasniqi T P and Pustina B 2012 The correlation of the color in maxillary central incisors Digital Dental News 6 6–11.

[13] Fondriest J 2006 Shade Matching in Restorative Dentistry: The Science & Strategies Esthetics 3 1–56.

[14] Joiner A 2003 Tooth colour: a review of the literature J. Dent. 32 312.

[15] Hegenbarth EA 1990 Creative Ceramic Color: A Practical System. (Chicago: Quintessence Publishing Co. Ltd.)