

The relationship between tooth color, skin and eye color

Purpose

Tooth color is one of the most important factors in dental and facial esthetics. The aim of this study was to determine the tooth color of the upper frontal teeth in subjects and to provide comparisons with different skin and eye colors.

Material and methods

Tooth color was determined in 255 patients in the intercanine sector of the maxilla using an intraoral spectrophotometer Vita Easyshade® (Vita Zahnfabrik. H Rauter GmbH & Co. KG. Bad Sackingen. Germany). Skin and eye color was determined by visual perception. The shades of the Vita Tooth Guide 3D Master (Vita Zahnfabrik, H Rauter GmbH & Co, KG, Bad Sackingen, Germany) were registered by the spectrophotometer. Pearson's chi-squared test was used to examine the differences between tooth color and skin and eye color.

Results

The most frequent shade registered in the central incisors was 2M1 (62 subjects, 8.10%); in the lateral incisors, 1.5M1.5 (65 subjects, 8.50%); and in the canines, 2M3 (142 subjects, 18.56%). Pearson's chi-squared test results showed a statistically significant difference in the relations between skin and eye color and central incisor color ($p < 0.01$; $p < 0.001$), lateral incisor color ($p < 0.001$), and canine color ($p < 0.001$; $p = 0.001$). On the other hand, no significant difference was observed in the relation of the lateral incisors and canines with eye color.

Conclusion

Skin and eye color significantly correlate with tooth color; however, the color of lateral incisors and canines does not correlate significantly with eye color.

Keywords: Color determination, intraoral spectrophotometer, eye color, tooth color, skin color

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Introduction

The color of teeth is strongly determined by dentin with more translucent enamel playing a lesser role through scattering at wavelengths in the blue range (1). The tubules are the predominant cause of light scattering in dentin and in enamel the hydroxyapatite crystals contribute significantly to scattering (2). At the outermost incisal and proximal edges of teeth, the layer of enamel is backed only by its own curved surface; because of the interfacial reflection caused by the change in index of refraction, this surface acts as a condensing mirror focused on the dentin (3).

Many authors reported that color matching is difficult and the results are inadequate (4-8). The use of unsuitable shade guides for color selection adds to the problems making consistent color matching impossible (6, 9). Existing shade guides are unsuitable (10) as the shades do not conform to tooth color (8, 11) and there is a lack of any organized distribution of the samples (5, 6, 8). Also, they are constructed in different materials and the colors do not match the restorative material (6).

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Prosthodontists, in their daily routine have to harmonize tooth shade with facial appearance in fully edentulous patients or complete fixed appliances. Authors (12) suggest that the color of the teeth must harmonize with the surrounding environment such as skin, hair, eye color and age all with the aim of enhancing facial appearance. The color of the restorations is a significant factor affecting dental appearance of maxillary anterior teeth in patients and, therefore, the clinician has to be very careful in choosing the right one using reliable tools (13). The knowledge of human tooth color and its distribution are very important in aesthetic dentistry (14). Tooth color has an influence on aesthetics and it is important for social rehabilitation of denture wearers (15, 16). Sykora (17), concluded that the determination of the color of posterior teeth should be based on premolars and for anterior teeth on upper central incisors.

The denture aesthesis has been defined as "the cosmetic effect produced by a dental prosthesis which affects the desirable beauty, attractiveness, character and dignity of the individual (18). Based on Veeraganta (19), it can be concluded that tooth shade value is significantly influenced by age. Chi-square statistical test demonstrated that younger subjects have lighter tooth shade values. According to Richardson,

the illusion of greater contrast between skin color and tooth shade explains the visual perception that individuals with darker skin color have lighter shades of teeth (20). Lagouvardos *et al.* (21), concluded that teeth color was not related to eye color. The purpose of this study was therefore the determination of tooth shades of the upper frontal teeth in subjects and their comparison with different skin and eye color.

Materials and Methods

Study population

This study analyzed the tooth color, measured by a spectrophotometer in different skin and eye color and was realized in the University Dental Clinical Center of Kosovo (UDCCK). Before we started with this research, on 09th of November 2009, the Ethical Approval was issued from UDCCK. The statement for appropriation of the investigation was issued with no. 138/2009 and signed from members of Ethical Board in UDCCK. The measurements, which were conducted at the University Dental Clinical Center of Kosovo, were made in the intercanine sector of maxilla in 255 subjects of Kosovo Albanian population (130 females and 125 males). Based on visual perception, the skin tones were divided into 3 categories: light, medium and dark skin. The eye color was categorized into four groups: brown, green, blue, very dark brown eye color. The total of 765 left teeth from the midline of maxilla (central incisors, lateral incisors and canines) were analyzed. The subjects' teeth color measurements, were determined using an intraoral spectrophotometer Vita Easyshade® (Vita Zahnfabrik. H Rauter GmbH & Co, KG, Bad Sackingen, Germany), Figure 1.

Color assessment

The shades of Vita Tooth Guide 3D Master (Vita Zahnfabrik. H Rauter GmbH & Co, KG, Bad Sackingen, Germany) were registered from the spectrophotometer. The color of skin and eyes were determined by visual perception. In this study, only patients with natural teeth, without any fillings, stains and non-smokers were included. Before the color measurement, teeth were polished with tooth paste and brush. After that, Vita Easyshade was turned on and the lamp was warmed up. The Infection Control Shield was inserted to the probe tip, Figure 2. After the calibration, the normal measurement mode was used, which provides a possibility to measure the base shade of a tooth, with the selection of "Tooth Single" on the measurement style menu, Figure 3. The probe tip was holed at 90°, to the third middle segment of vestibular surface of the tooth. The 3D Master data shades were collected.

Statistical analysis

All statistical analysis were performed using the Statistical Program STATISTICA 7.1 (Stat. Soft, Inc.; Tulsa, OK, USA). To evaluate the relationship between tooth color, skin and eye color, Pearson's test was used. Chi square test of independence were selected to evaluate bivariate relationships among variables. Confidence level was set to 95% and p values less than 0.05 were considered as significant.



Figure 1. Intraoral spectrophotometer Vita Easyshade®.

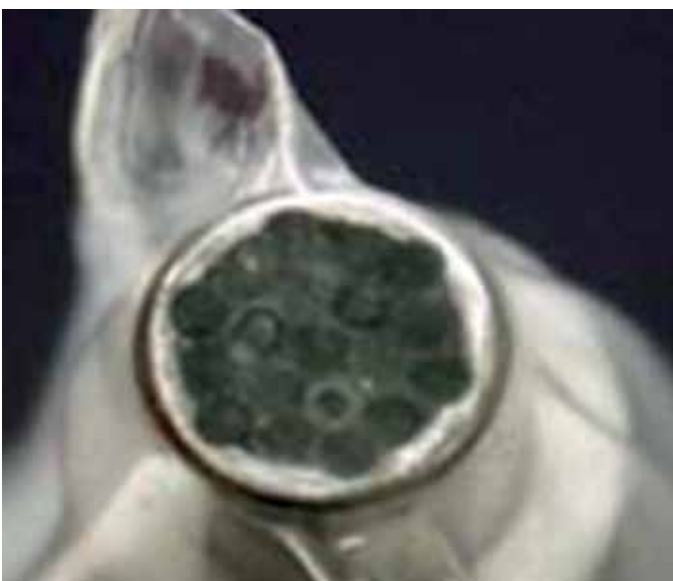


Figure 2. The Infection Control Shield was inserted to the probe tip of the spectrophotometer.

Results

In the central incisors the most frequently registered shade was 2M1 in 62 subjects (8.10%). The shades that were registered rarely were: 3.5M2.5 (0.13%), 4M1 (0.13%), 4M2.5 (0.13%), 1M1.5 (0.13%), 2.5M2 (0.13%), 3L2.5 (0.13%), and 2R2 (0.13%).

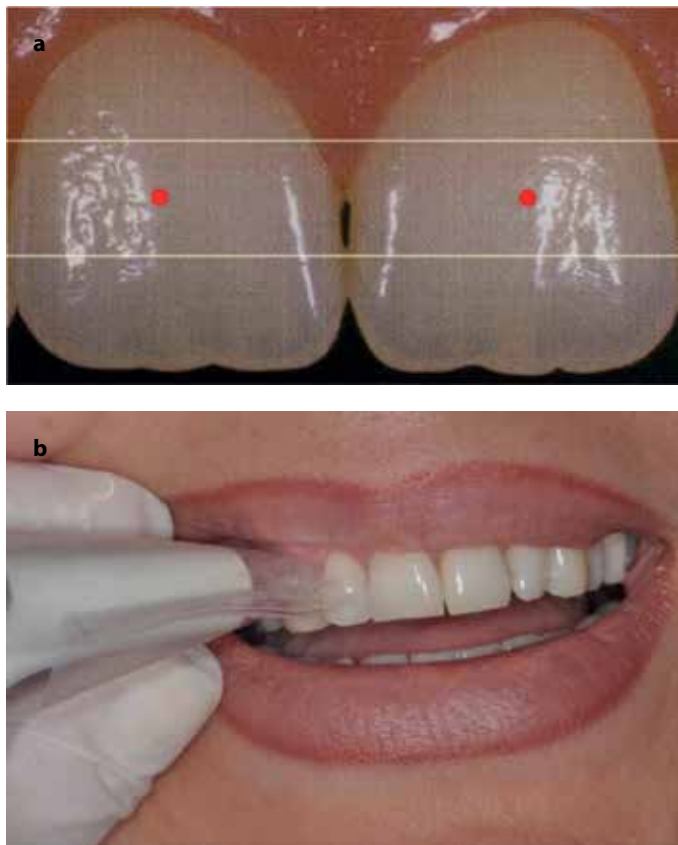


Figure 3. a, b. The tooth color measurement was made with program "Tooth Single" in the middle vestibular third.

In the lateral incisors the most frequent shade registered was 1.5M1.5 in 65 subjects (8.50%). The shades that were registered rarely were: 4M1 (0.13%), 3R2.5 (0.13%), 2.5M1.5 (0.13%), 2L1.5 (0.13%), and 2.5M2 (0.13%). In the canines the most frequent shade registered was 2M3, in 142 subjects (18.56%). The shades that were registered rarely were: 4M1 (0.13%), 2.5R2 (0.134%), 4M3 (0.13%), 4R1.5 (0.13%), and 3M2.5 (0.04%).

The relation between skin color and tooth shades in central incisors, lateral incisors and canines are presented in Table 1. From 765 analyzed teeth, in 189 teeth a light skin color was determined, in 501 teeth there was a relation with medium skin color, whereas 75 teeth were related to dark skin color.

There was a statistical significant difference observed in the distribution between skin color and tooth shades. The results for central incisors were $\chi^2=179.72$ and $p<0.001$ ($p=0.000$); for lateral incisors 179.43 , $df=82$, $p=.001$, and for canines 127.42 , $df=90$, $p=.006$. There was a statistical significant difference observed in the distribution between skin color and tooth shades. The relation between eye color and tooth shades is presented in Table 2. The results for relation between central incisors and eye color was $\chi^2=210.71$ and $p<0.001$ ($p=0.000$) which indicates a significant statistical difference in distribution.

The results for relation between lateral incisors and eye color were $\chi^2=137.53$ and $p>0.05$ ($p=0.18$) and this shows that in the distribution the difference was statistically insignificant. The relation between canines and eye color was $\chi^2=142.16$ and $p>0.05$ ($p=0.18$). In the shown distribution there was no statistically significant difference observed.

Discussion

The study was designed to explore the relationship between natural tooth shades, skin and eye color. The measurement of tooth color remains a challenge. Therefore, a thorough under-

Table 1. The tooth shades and distribution/Skin color

	Spectrophotometer	Skin color light	Skin color medium	Skin color dark	Total
Total	0.5M2-4M3 2L1.5-4L2 2R2-4R2.5	189	501	75	765
%	/	24.71%	65.49%	9.80%	

Pearson Chi-square: 179.72.d $f=82$. $p=.000$ / Central incisors

Pearson Chi-square: 179.43. $df=82$. $p=.001$ /Lateral incisors

Pearson Chi-square: 127.42. $df=90$. $p=.006$ / Canines

Table 2. The tooth shades and distribution/Eye color

	Spectrophotometer	Brown eyes	Blue eyes	Green eyes	Very dark brown	Total
Total	0.5M2-4M3 2L1.5-4L2 2R2-4R2.5	426	96	210	33	765
%	/	55.69%	12.55%	27.45%	4.31%	100%

Pearson Chi-square: 210.71. $df=123$. $p=.000$ / Central incisors

Pearson Chi-square: 137.53. $df=123$. $p=.18$ /Lateral incisors

Pearson Chi-square: 142.16. $df=135$. $p=.32$ / Canines

standing of appearance attributes of natural teeth is required along with new shade guides and shade taking instruments to maximize shade-matching results (22).

Spectrophotometers are amongst the most accurate, useful and flexible instruments for color matching in dentistry (23, 24). Compared with visual perceptions by the human eye, or conventional techniques, it was found that spectrophotometers offered a 33% increase in accuracy and a more objective match in 93.3% of cases (25). Vita Easyshade is a handheld spectrophotometer for tooth shade matching. The instrument consists of a handpiece and a base unit, which are connected by a mono coil fiber optic cable assembly. This device provides accurate shade determination for natural and bleached teeth and a variety of restorations. Easyshade displays its output on a touch-screen that is also used to make menu selections and enter data. It has the capability to measure the color in the vestibular thirds including cervical, middle and incisal area (26). From the 3D Master shade guide, results of Easyshade measurements for the central incisors showed that the most frequent shade was 2M1, in lateral incisors 1.5M1.5 and in canines 2M3.

Based on the literature it can be observed that a relation between ethnic background and tooth shade exists (27). Gómez-Polo *et al.* (28), concluded that the most frequent color among the Spanish population is 3M1. They also represented the most common color parameters according to the 3D Master System in the Spanish population and concluded as follows: lightness group was 2; the most frequent hue group was M and the most frequent chroma group was 1.5. Compared with the results of this study, it can be said that the Spanish and the Albanian population of Kosovo are part of the M group and this fact can be explained by the fact that the two population samples belong to the same neutral color, with different group of lightness and the same chrome intensity.

Veeraganta *et al.* (19) did not find any statistically significant differences according to tooth shade value, gender or skin color. Based on Goodkind and Schwabacher (29), women's teeth in general were lighter, less chromatic and less reddish-colored than men's; aging produced darker and more reddish teeth, whereas Dosumu and Dosumu (12), did not find any significant association between tooth shade and skin color nor between tooth shade and gender ($p < 0.05$). These findings do not correspond with the results of the present study. In the relation between central incisors and eyes color $p < 0.001$ ($p = 0.000$) there was a statistically significant difference. Also, between lateral incisors and skin color there was a significant statistical difference $p < 0.01$ observed. However, no significant association was found between tooth shade in lateral incisors and canines to eye color $p > 0.05$. Lagouvardos *et al.* (21), concluded that teeth color was not related to eye color, but persons with lighter teeth were found to be associated with lighter skins and redder lateral incisors to lighter hair. Darker facial skins or yellower forehead areas were also associated with darker hair and vice versa. Based on conclusions of Hassel *et al.* (30), teeth and eye color coordinates were not correlated. The other study (22), which investigated facial characteristics concluded that these characteristics are inter-correlated weakly to moderately, and for this reason predicting the color parameters of one facial characteristic by another would not be accurate, but helpful for a rough color selection as associations show.

The Saudi Arabian, East Asian, and Indian groups had positive linear correlation with the lightness value between tooth and skin color (31). A significant correlation was found between tooth and skin color. This study found an association between skin color and tooth shade. Based on statistical analysis and results of this study, it was found that there was significant correlation between light skin color and tooth shades with low lightness; between dark skin color and tooth shades with highest lightness and between medium skin color and tooth shades with medium lightness. These results are similar to the findings of Jahangiri *et al.* (15) who found inverse relationship between tooth shade and skin color in their study on multiracial population. From all analyzed subjects, as more representative skin color was medium, whereas eye color was brown. The tooth shades in the central incisors correlated with medium skin color and brown eye color showed that there is a significant statistical difference. The most frequent shade in the central incisors was 2M1. The tooth shades in the lateral incisor related with skin color with a significant statistical difference. The most frequent shade in the lateral incisors was 1.5M1.5. On the other hand, the correlation between eye color and lateral incisors did not show a significant statistical difference the tooth shades in the canines, in relation with skin color showed that there is a significant statistical difference. The most frequent shade in the lateral incisors was 2M3, whereas, the correlation between eye color and canine showed no statistically significant difference.

Conclusion

Teeth color of prosthodontic appliances, must harmonize with the factors such as skin and eye color. The shades obtained from the intercanine sector (2M1, 1.5M1.5 and 2M3), might be used as a guide for shade selection for prosthodontic appliances. The most frequent group from Hue was M, which indicates that during the teeth color determination we should be focused more on neutral shades from the Vitapan 3D-Master shade guide. The skin and eye color significantly correlate with the tooth color, except in the relation with lateral incisors and canines to eye color. Therefore, this fact will serve as a guidance to the appropriate selection of tooth color for prosthodontic appliances.

Ethics Committee Approval: Ethical Approval was issued from University Dental Clinical Center of Kosovo. The statement for appropriation of the investigation was issued with no. 138/2009.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: TPK, EX, NA, TB, LD and ZL designed the study. TPK, TB, LD and ZL generated the data. TPK, NA, TB, LD and ZL gathered the data. TPK analyzed the data and wrote the majority of the original draft. All authors approved the final version of paper.

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Türkçe öz: Diş rengi, cilt ve göz rengi arasındaki ilişki. Amaç: Diş tonları, diş estetiği ve yüz estetiğinde en önemli faktörlerden biridir. Bu çalışmanın amacı, deneklerdeki üst ön dişlerin diş tonlarını belirlemek ve farklı cilt tipi ve göz rengi ile karşılaştırmalar yapmaktır. Gereç ve yöntem: Deneklerin diş renk ölçümleri, intraoral spektrofotometre Vita Easyshade® (Vita Zahnfabrik, H Rauter GmbH & Co. KG, Bad Sackingen, Almanya) kullanılarak yapıldı. Ölçümler maksillerin kaninler arasında ve 255 hastada yapıldı. Cilt ve göz rengi görsel algı ile belirlendi. Vita Diş Rehberi 3D Master'ın (Vita Zahnfabrik, H Rauter GmbH & Co, KG, Bad Sackingen, Almanya) tonları spektrofotometre ile kaydedildi. Diş rengi ile cilt ve göz rengi arasındaki farkları incelemek için Pearson Chi-square testi kullanıldı. Bulgular: Orta kesici dişlerde en sık görülen ton 2M1 (%8,10) 2M1, yan kesicilerde 65 olguda (%8,50) 1.5M1.5 ve 142 olguda kanin dişinde (%18,56) 2M3 idi. Pearson Chi-square testi sonuçları, santral dişlerin cilt ve göz rengi ile ilişkisinde istatistiksel olarak anlamlı bir farklılık olduğunu göstermiştir ($p<0,01$; $p<0,001$); lateral kesici dişlerde $p<0,001$, kaninlerde $p<0,001$ ($p=0,001$) olarak bulundu. Öte yandan, lateral kesici dişlerin uçlar ile kanin dişlerinin göz rengiyle ilişkisinde anlamlı bir fark gözlenmemiştir. Sonuç: Deri ve göz rengi, lateral ve kanin dişlerinin göz rengiyle ilişkisi dışında, diş rengiyle anlamlı şekilde korelasyon göstermektedir. Anahtar kelimeler: Renk tayini, İntraoral spektrofotometre, göz rengi, diş rengi, ten rengi

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