Use of a new skin colour measurement method for the investigation of relationship between skin and tooth colour

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Introduction

In prosthetic dentistry, esthetics of final restoration is one of the most important factors influencing the success of therapy. Dental treatment should be in harmony with the rest of the face, and a life-like appearance which is acceptable by the patient should be aimed.¹,² Selection of the correct tooth shade is one of the leading factors for an acceptable esthetics. Presence of teeth mostly provides convenience in selecting tooth shade. However, internal and external factors may influence the tooth shade; teeth may not have a natural appearance, and therefore, it may be hard to identify color using present teeth.³,⁴ Selection of tooth shade may become even more difficult for the clinicians when there is no tooth to be used as reference. In these situations, selection of tooth shade may more subjective, and accordingly, some methods to overcome this issue were studied in the past and published.⁵,⁶ Other characteristics of the patients

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can be utilized for tooth shade selection in these situations. Some previous studies have reported that individual’s eye, skin, hair color, and factors like sex and age can be used when selecting the tooth shade.5-7

Some studies have indicated that tooth shade of women is lighter than men [8-10]. Some others reported that teeth with darker shade should be preferred for elderly individuals.11,12 A correlation was determined between hair color and tooth shade even if it was poor. While a significant correlation was observed in some studies investigating the correlation between the skin color and tooth shade, some studies reported no correlation.5,2,10

Different methods are used to determine the skin or tooth shade. While some researchers preferred using shade guides and various classifications providing more subjective data, and some others used computer programs and digital instruments to determine the color.11,13-16 The methods used in studies on a delicate issue like colorimetry are critical in terms of obtaining true and precise results. Digital methods were used to obtain the values that belong to both skin and teeth, however, a well-accepted method for skin color measurement has not been reported in the literature previously.

The aim of this study was to investigate any correlation between L*, a*, b* values of skin and tooth shade considering the gender using a novel color measurement technique. The null hypothesis was that the tooth and skin color would not be in a correlation.

Materials and Methods

This study was conducted on 149 dental students (67 male, 82 female, age range 18-23 and mean age of 20.8 ± 2). Ethics committee approval and informed consent of all volunteers were received for the study (Decision Number: 70904504/335).

Individuals who had completely erupted maxillary right central incisors without decay and restoration, no skin disorder, and no postoperative facial cicatrix and individuals who did not undergo any color changing procedure on the face or skin were included in the study. Individuals who had restored teeth, teeth undergoing root canal therapy, teeth with internal or external discoloration, and who were smokers were excluded from the study.

Recommendations from previous studies were followed to design the image capturing technique for teeth and face in this study.14,17,18 Two weeks before the shade measurements of teeth, the test teeth were cleaned with polishing brush and polishing paste attached to a low-speed hand piece. Measurements were made from the middle third of labial surfaces of right maxillary central incisors of individuals using a clinical spectrophotometer (VITA Easyslide Advance, VITA Zahnfabrik) and according to the instructions of the manufacturer. CIE L*a*b* values were recorded.

Facial images were taken4,18 A digital camera (Nikon D5200) with 24.2 megapixel resolution was used in the present study. The participants were asked to wash their faces gently and remove their make up before their photographs were taken. They were kept in an environment with normal room temperature for 20 minutes before the photographs were taken. Camera adjustments included a macro lens with focal length ranging from 90 to 120 mm, shutter speed of 1/50, and lens aperture of f/5. Soft box light sources were used for illumination and an opaque white background was used. External light sources and ambient conditions were kept constant for all individuals. Before photographs were taken, eyeglasses, jewellery, and hat were removed. Images of frontal appearances were taken by ensuring individuals to pose when Frankfurt horizontal plane was parallel to the ground and midsagittal plane was perpendicular to the ground.

CIELab values of the skin were measured through facial images by using a software which was specially manufactured for present study. The software automatically selects three zones on the face including frontal, right, and left malar areas, and the measurement of excessive changes of color (rashes, moles, etc.) on the skin is also automatically excluded through a button in the interface of the software (Figure 1). Average of CIE L*, a*, and b* values were taken automatically from approximately 100.000 separate points in total in selected zones, excluding blotchy areas. Using this method, it was aimed to prevent zonal skin color changes to deviate the results of the measurements. SkinL*, SkinA, SkinB and ToothL*, ToothA and ToothB were the codes to represent the L*, a* and b* values of skin and teeth.

![Figure 1. Use of the computer software to obtain CIELab values of skin color.](image)

Statistical analysis

Descriptive statistics and t-tests were used for L*, a*, and, b* parameters of the skin and tooth color, and regression and correlation analysis were performed to reveal any correlation between them. Regression analysis was performed between the components (coordinates) which define the same properties of the color of the skin and the teeth. Regression analysis was also performed when values which define different chromatic properties were highly correlated A statistical software was used for all analyzes (SAS 9.4).

Results

Table 1 displays overall data of dependent and independent variables of individuals, descriptive statistics for male and females, and the results of t-test. According to these results, significant differences were observed with respect to gender between mean values of skinL, skinA, skinB, and toothA (p<0,01).
Table 2 displays the correlation between dependent (toothL, toothA, and toothB) and independent (skinL, skinA, and skinB) variables for males and females together, males, and females. There was high, moderate, no correlation between values of varying components. While the toothL component does not correlate with any other component, the toothA component was moderately correlated with the skinB component in for only males and for both genders together situation (p<.05). In addition, the toothA component had a correlation with the skinB component for males (p<.05).

A high correlation was observed between the toothB component and the skinL component in all three cases of gender (p<.01). While the tooth component for females correlated moderately with the skinb component (p<.05), a high correlation was observed between these components for males and for both genders situation (p<0.01).

Table 3 displays the regression analysis results between each of the dependent variables of tooth (toothL, toothA, and toothB) and corresponding independent variables of skin. Considering these results, skinB had a statistically significant effect in describing toothB (p<0.01), while skinL and skinA were observed to be insufficient in describing toothL and toothA (p>.05). This was associated with the fact that there was scarcely any correlation between skinL and toothL and skinA and toothA. The highest regression value was observed between the toothB and skinL parameters.

Discussion

Tooth shade is a complex phenomenon directly associated with the esthetics of the individual and involving subjective and objective factors. There is no sufficient scientific information about the correlation between tooth and skin color, information or reports in agreement. Some researchers stated that there was a reverse correlation between tooth and skin color; whereas, some others indicated a linear correlation. In the present study, it was observed that while a linear correlation was observed between some parameters of color, reverse correlation was observed in other parameters. There was a linear and significant correlation between b* values of the skin and the tooth. This result is similar to the result by Haralur et al. In contrast with this result, a powerful reverse correlation was observed between L* values of skin and b* values of tooth. This is in line with the results by Jahangiri et al. and N’Guessan et al., who found a reverse correlation between the tooth and skin color. Some researchers reported that there was no correlation between skin color and tooth color. The difference in

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### Table 1. Descriptive statistics and t-test results of variables of skin and tooth (*p<0.05, **p<0.01)

|       | Male | Female | Male and Female |
|-------|------|--------|-----------------|
| skinL | 67   | 56.103 | 46.293 73.867 57.943 46.293 73.867 0.000** |
| skinA | 67   | 22.250 | 21.291 25.287 21.722 26.963 21.817 26.963 0.006** |
| skinB | 67   | 15.327 | 14.220 20.511 14.718 21.817 16.213 26.963 0.012* |
| toothL| 67   | 84.369 | 80.100 91.133 84.785 26.833 71.667 91.133 0.019 |
| toothA| 67   | -0.562 | -0.869 0.767 0.708 -2.300 1.500 0.008** |
| toothB| 67   | 19.503 | 18.344 21.817 18.866 26.833 91.133 1.500 0.074 |

### Table 2. Correlations between dependent (toothL, toothA, and toothB) and independent (skinL, skinA, and skinB) variables (*p<0.05, **p<0.01)

|       | skinL | skinA | skinB |
|-------|-------|-------|-------|
| Male   | 0.00515 | -0.06765 | -0.04012 |
| toothL| -0.17089** | 0.04513 | 0.08258 |
| toothB| -0.28683** | -0.06146 | 0.25561** |

|       | skinL | skinB |
|-------|-------|-------|
| Male   | -0.10784 | -0.05953 | 0.05026 |
| toothL| -0.26698* | -0.07481 | 0.16683* |
| toothB| -0.31778** | -0.09817 | 0.29397** |

|       | skinL | skinA |
|-------|-------|-------|
| Female| 0.00829 | -0.01698 | -0.08488 |
| toothL| 0.00594 | 0.06360 | -0.0620 |
| toothB| -0.21927** | -0.09944 | 0.19292* |

| Parameter | Estimation | Standard error | t value | p |
|-----------|------------|----------------|---------|---|
| Dependent toothL | Intercept 84.5963 3.03048 27.92 0.0001 |
| skinL    | 0.0032 0.05213 0.06 0.9503 |
| Dependent toothA | Intercept -1.05606 0.59664 -1.7700 0.0788 |
| skinA    | 0.01497 0.02734 0.5500 0.58470 |
| Dependent toothB | Intercept 13.3588 1.74611 7.65000 0.000 |
| skinB    | 0.3742 0.11672 3.21000 0.00170 |
| SkinL    | -0.2427 0.0668 -3.6301 0.000 |
those results might be associated with varying methods used in different studies. In several previous studies, color records were visually made using shade guides or various classifications for skin and tooth color selection. In a visual method, skin color or tooth shade is generally categorized. Color selection depends on subjective assessment of researcher and ambient light may directly influence the type of color selection. These limitations in visual color selection might have affected the these study results. In the present study, digital methods were preferred when measuring both tooth and skin color, and the effect of light was minimized by eliminating the subjective factors. Haralur et al. used a spectrophotometer, which is not affected from external lights when measuring tooth color and facial images when measuring the color skin. Seck et al., on the other hand, used facial images in both processes. Researchers compared the results by taking color value from a few points determined on the face in photographs. When human skin was examined closely, excessive color changes were observed on small areas. Therefore, it is possible to obtain different CIE Lab values on every pixel where color sample is taken. In order to avoid this problem, a new software was used when obtaining facial color on the images in the present study. The software gives the average of L*, a* and b* values taken from approximately 100,000 points by excluding severe color changes detected on the face from the measurement.

While the t-test results obtained in our study revealed a significant difference for gender in terms of mean values, no highly significant differences were found in the correlation analysis between teeth and skin color. When the results of tooth-skin correlation of male, female, male and female were examined separately, it was observed that the significances were similar (Table 2). There was no effect of gender found in describing tooth color and skin color correlation.

When the results from the regression analysis were examined, b* values of skin had a statistically significant effect in explaining the b* values of tooth. The highest correlation was observed between the b* values of the tooth and the L* and b* values of the skin. When the color components of the skin and teeth are evaluated separately, significant correlations were observed between the skin and tooth color for different CIELab parameters. When the color components of the skin and teeth are evaluated separately, the b* values of the teeth and the L* and b* values of the skin are highly correlated. The results indicated that some CIELab parameters of the skin color may be used for tooth color selection in case of loss of natural teeth or when existing teeth are discolored.

Conclusion

Within the limitations of the present study, different significant correlations were observed between the skin and tooth color for different CIELab parameters. When the color components of the skin and teeth are evaluated separately, the b* values of the teeth and the L* and b* values of the skin are highly correlated. The results indicated that some CIELab parameters of the skin color may be used for tooth color selection in case of loss of natural teeth or when existing teeth are discolored.

Türkçe Özeti: Cilt ve diş rengi arasındaki ilişkisinin araştırılması ve CIELab parametreleri kullanılması. Araç: Literatürde kalıcı diş rengi ile cilt rengi arasındaki ilişki hakkında çok popüler bir döküman vardır. Bu çalışmanın amacı, cilt ve dişler arasindaki ilişkinin yeni bir cilt rengi ölçüm yöntemi kullanılarak değerlendirilmesidir. Ge- reç ve Yöntem: Dişlerin cilt renginleri, klinik spektrofotometre kullanılarak ölçülüyordu. Verilerin analizi için bir istatistiksel analiz programı (SAS 9.4) kullanıldı. Verilerin değerlendirilmesinde Kolmogorov-Smirnov testi, t-testi ve çok değişkenli regresyon analizi kullanıldı (p < 0.05). Bulgular: Değişkenlerarası korelasyonlar deri rengini için a* değerleri için düşük ve istatistiksel olarak anlamalı değerler, diğer değişkenlerarası değerler anlamalı korelasyonların ise orta düzeyi geçmediği gözlendi (p < 0.05). Regresyon analizi sonuçları dikkate alındığında, cilde a* değerleri ile dişlere a* değerleri istatistiksel olarak anlamalı düzeyde tanımlandı, cilde a* ve a* değerlerinin dişlere a* ve a* değerlerinin tanımlamasında yeteriş olduğu gözlandi. Sonuç: Bu çalışmanın sonuçları, L*, a* ve b* parametreleri için cilt ve diş rengi arasındaki farklı korelasyonların bulunmadığı göstermedi (p < 0.05 ve p > 0.01). Sonuçlar, doğal dişlerin tamamen kaybedildiği veya mevcut dişlere renk değişikliği olması durumunda, cilt renginin diş rengi seçimi için kullanılabilirceği göstermektedir. Anıhtar Kelimeler: renk seçilmesi, diş rengi, ten rengi, CIELab, estetik

Ethics Committee Approval: Ethics committee approval and informed consent of all volunteers were received for the study (Decision Number: 70904504/335).

Informed Consent: The informed consents were provided by the participants.

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Author contributions: NT, USB, IK, and BY designed the study. NT and USB participated in generating the data for the study. NT participated in gathering the data for the study. NT, USB, IK, and BY participated in the analysis of the data. NT and USB wrote the majority of the original draft of the paper. NT, USB, IK, and BY participated in writing the paper. All authors approved the final version of this paper.

Conflict of Interest: The authors have no conflict of interest to declare.

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