International Journal of Biomedicine 13(1) (2023) 146-150
http://dx.doi.org/10.21103/Article13(1)_OA21

ORIGINAL ARTICLE

Dentistry

INTERNATIONAL JOURNAL OF BIOMEDICINE

The Color Differences in Cervical, Middle and Incisal Segments of Maxillary Frontal Teeth

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Abstract

The purposes of our study were to apply criteria of color differences among parameters L*, a*, and b* in three vestibular segments (cervical, middle, and incisal) of the maxillary frontal teeth.

Methods and Results: This study included 255 dentistry students who volunteered to participate in this study. The color of the central incisors, lateral incisors, and canines of the maxilla was measured by the probe tip of the spectrophotometer Vita Easyshade® (Germany).

The color parameters L*, a*, and b* in the maxillary anterior teeth differed not only from one another but also from one segment to another segment of the same tooth. The differences in color between the maxillary anterior teeth are evident; especially, these differences in color were noticed between the maxillary incisors and canines. It was concluded that the differences were of high significance between maxillary incisors and canines. The significant differences in frontal teeth were stronger between the cervical and middle segments than between these segments and incisal segments.(**International Journal of Biomedicine. 2023;13(1):146-150.**)

Keywords: maxillary frontal teeth • color • tooth segments

For citation: Krasniqi TP, Xhajanka EX, Krasniqi ZL, Dula L, Olloni T. The Color Differences in Cervical, Middle and Incisal Segments of Maxillary Frontal Teeth. International Journal of Biomedicine. 2023;13(1):146-150. doi:10.21103/Article13(1)_OA21

Introduction

To avoid the artificial look and reproduce the color of porcelain appliances as close to the original color as possible, matching natural maxillary anterior teeth is of high esthetic importance in the dental work routine. Because visual perceptions might be inaccurate and flawed, digital systems for matching color are preferred.

Spectrophotometers, colorimeters, and imaging systems are useful and relevant tools for tooth color measurement and analysis, and for quality control of color reproduction.[(1)]

The future of digital dentistry is in the design of integrated approaches providing personalized treatments to patients. In addition, esthetic dentistry can benefit from those advances by developing models allowing a complete characterization of tooth color and enhancing the accuracy of dental restorations.[(2)]

Dental spectrophotometers provide the highest overall accuracy and precision among different shade selection methods, while needing clinical settings to control related effective factors, conditions and technological improvement to perform optimally.[(3)] The impact of color science can be seen on various restorative materials, ranging from ceramics to maxillofacial prosthetic materials.[(4)]

The teaching of esthetic dentistry in North American dental schools is highly variable and, in many schools, is shared among different disciplines. Dental schools should work together to establish the parameters for teaching this subject and should formulate the necessary standards for education and research in this new field. The majority of the studies of tooth color determinations with digital devices were based on color parameters established in 1976 by the Commission Internationale de l'Eclairage (CIE).[(5)]

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In the literature, color is described based on the Munsell color space in terms of lightness, chroma, and hue. The CIE L*a*b* color space has a vertical axis that indicates relative lightness or darkness. The two horizontal axes represent the amounts of a*~ red/green and b*~ yellow/blue. In the L*a*b* color space, L* is a measure of the lightness of an object, which represents the quantity of light reflected by an object; a* is a measure of redness/a >0/or greenness/ a<0/; and b* is a measure of yellowness/b>0/or blueness/ b<0. Chroma is the strength or dominance of the hue; it can also be described as a saturation of color. Hue describes a dimension of color.[6]

Differences in lightness, chroma, and hue of pairs of natural anterior teeth, are important for providing more accurate information on color for the production of dentures with a natural appearance.[7]

Goodkind and Schwabacher,[8] in a colorimetric study of maxillary anterior teeth, concluded that the best representation of tooth color was in the vestibular middle third of the tooth; women's teeth were lighter, less chromatic, and less reddish-colored than men's; aging produced darker and more reddish teeth; cuspid teeth were darker than incisors; central incisors had the highest lightness.

Seghi et al.[9] found that the photo-electric tristimulus colorimeter showed the best overall performance on porcelain surfaces, supporting its use as a valuable tool for evaluating color in dentistry.

Tooth color determination has attracted attention in the field of dentistry. It can be measured by visual perception and via digital instruments. The Munsell system created by A. Munsell is presently one of the most popular spaces for measuring object color and is widely used in virtually all fields.[10] It is one of the uniform color spaces defined by CIE in 1976 in order to reduce one of the major problems of the original Yxy space: equal distances on the x, y chromaticity diagram. In this space, L* indicates lightness, and a* and b* are the chromaticity coordinates. The a* and b* indicate color directions: +a* is the red direction, -a* is the green direction, +b* is the yellow direction, and -b* is the blue direction. The center is achromatic; as the a* and b* values increase and the point moves out from the center, the saturation of the color increases.[11] Improved shade guides, availability of shade-taking devices, and research in the area of human color vision have improved the potential of clinicians to achieve excellent color-matched restorations. An understanding of the appearance attributes of natural teeth is required, along with new shade guides and shade-taking instruments, to maximize shade-matching results.[12] Many investigators from a range of different countries have reported L*, a*, and b* values for teeth measured in vivo using instrumental techniques such as spectrophotometers, colorimeters, and image analysis of digital images. In general, these studies show a large range in L*, a*, and b* values, but consistently show that there is a significant contribution of b* value or yellowness in natural tooth color.[13]

The purposes of our study were to apply criteria of color differences among parameters L*, a*, and b* in three vestibular segments of the maxillary frontal teeth.

Materials and Methods

This study included 255 subjects. The study was performed in the Dental Branch, Faculty of Medicine, University of Pristina. The dentistry students volunteered to participate in this study. The criteria for involvement in the study were to have intact teeth without any pigments, decay, or other elements that could affect the tooth color.

The color of the central incisors, lateral incisors, and canines of the maxilla was measured by the probe tip of the spectrophotometer Vita Easyshade® (VITA Zahnfabrik H. Rauter GmbH and Co. KG, Bad Sackingen, Germany) (Figure 1).

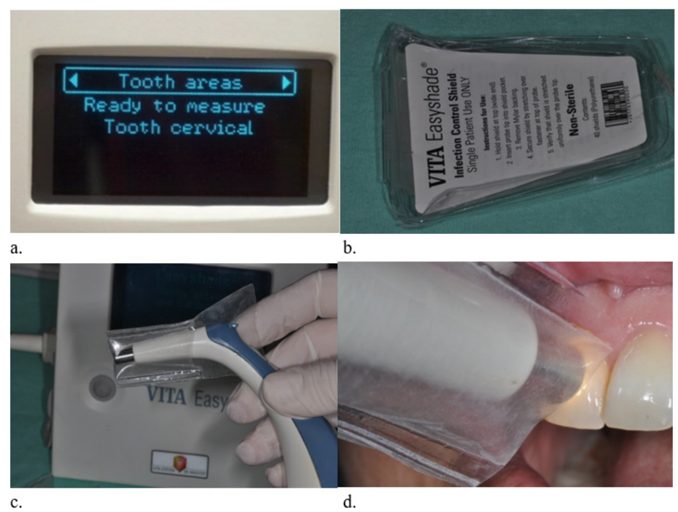

Fig. 1. *a. Program Tooth Areas of the spectrophotometer Vita Easyshade®; b. Infection control shield; c. The infection control shield placed on the probe tip; d. Digital measuring of the tooth color.*

Before measurements in every volunteer, an infection control shield was placed on the probe tip. The program Tooth Areas in the spectrophotometer Vita Easyshade® enables measuring tooth color in three segments of the vestibular surface of the tooth: cervical, middle, and incisal. The L* a* b* parameters of the tooth color were collected.

In previous studies,[13,14] variations of color coordinates have been reported for human teeth in the range of L*=60−95 (where 0=black and 100=white), b*=8−25 (positive values designate colors towards yellow, negative values designate colors towards blue), and a*= -2 to +10 (negative values designate colors towards green, positive values designate colors towards red).

Statistical analysis was performed using the Statistica 7.1 software package (Stat-Soft Inc., USA). A Bonferroni test, a series of t-tests performed on each pair of groups, was applied. A probability value of $P<0.05$ was considered statistically significant.

Ethical approval for this study was obtained from the Ethical Committee of the University of Pristina. All participants provided written informed consent.

Results

Table 1. shows the results of differences between mean values of L* for the target tooth, in the distribution of Central Incisor/Lateral Incisor/Canine (CI/LI/C) and their segments, Cervical/Middle/Incisal (Cs/Ms/Is), analyzed with Bonferroni Post Hoc Test.

The mean L* for CI/Cs (85.39) was significantly higher than for CI/Ms (83.15) and CI/Is (79.56) of the same tooth (*P*<0.001 in both cases). The mean L* for CI/Cs (85.39) was significantly greater than for LI/Ms (82.85) and LI/Is (80.34) and for C/Cs (82.23), C/Ms (80.21) and C/Is (77.54) (*P*<0.001 in all cases). The mean L* for CI/Ms (83.15) was significantly greater than for CI/Is (79.56), LI/Is (80.34), C/Ms (80.21), and C/Is (77.54) (*P*<0.001 in all cases). The mean L* for CI/Is (79.56) was significantly less than for LI/Cs (83.57), LI/Ms (82.85), and C/Cs (82.23) (*P*<0.001 in all cases); at the same time, it was significantly greater than for C/Is (77.54) (*P*<0.01). The mean L* for LI/Cs (83.75) was significantly greater than for LI/Is (80.34), C/Ms (80.21), and C/Is (77.54) (*P*<0.001 in all cases). The mean L* for LI/Ms (82.85) was significantly greater than for LI/Is (80.34) and C/Ms (80.21) (*P*<0.001 in both cases). The mean L* for LI/Is (80.34) was significantly less than for C/Cs (82.23) (*P*<0.01) and significantly greater than for C/Is (77.54) (*P*<0.001). The mean L* for C/Cs (82.23) was significantly greater than for C/Ms (80.21) and C/Is (77.54) (*P*<0.01 in both cases). The mean L* for C/Ms (80.21) was significantly greater than for C/Is (77.54) (*P*<0.001).

Table 1.

Bonferroni Post Hoc Test / L*

Bonferroni test; variable L *											
	Tooth	Seg-ment	(1) 85.39	(2) 83.15	(3) 79.56	(4) 83.75	(5) 82.85	(6) 80.34	(7) 82.23	(8) 80.21	(9) 77.54
1	CI	C		***	***	*	***	***	***	***	***
2	CI	M	***		***			***		***	***
3	CI	I	***	***		***	***		***		**
4	LI	C	*		***			***		***	***
5	LI	M	***		***			***		***	
6	LI	I	***	***		***	***		**		***
7	C	C	***		***			**		**	***
8	C	M	***	***		***	***		**		***
9	C	I	***	***	**	***	***	***	***	***	

-P<0.05; **-P<0.01; *-P<0.001*

Table 2 shows the differences in mean values of parameter a* (red/green) for the target tooth, in the distribution of CI/LI/C and their segments (Cs/Ms/Is).

The mean a* for CI/Cs (-1.14) was significantly higher than for CI/Ms (-1.59) and CI/Is (-1.80) of the same tooth (*P*<0.001 in both cases). The mean a* for CI/Cs (-1.14) was significantly less than for LI/Cs (-0.44) (*P*<0.001) and was significantly higher than for LI/Is (-1.47) (*P*<0.05). The mean a* for CI/Cs (-1.14) was significantly less than for C/Cs (0.79), C/Ms (0.58), and C/Is (0.11) (*P*<0.001 in all cases). The mean a* for CI/Ms (-1.59) was significantly less than for LI/Cs (-0.44) and LI/Ms (-1.09) and for C/Cs (0.79), C/Ms (0.58) and C/Is (0.11) (*P*<0.001 in all cases). The mean a* for CI/Is (-1.80) was significantly less than for LI/Cs (-0.44) (*P*<0.001), LI/Ms (-1.09) (*P*<0.001) and LI/Is (-1.47) (*P*<0.05), and for C/Cs (0.79), C/Ms (0.58), and C/Is (0.11) (*P*<0/001 in all cases. The mean a* for LI/Cs (-0.44) was significantly higher than for LI/Ms (-1.09) and LI/Is (-1.47) (*P*<0.001 in both cases); at the same time, it was significantly less than for and for C/Cs (0.79), C/Ms (0,58) and C/Is (0.11) (*P*<0.001 in all cases). The mean a* for LI/Ms (-1.09) was significantly higher than for LI/Is (-1.47) (*P*<0.001); at the same time, it was significantly less than for C/Cs (0.79), C/Ms (0.58) and C/Is (0.11) (*P*<0.001 in all cases). The mean a* for LI/Is (-1.47) was significantly less than for C/Cs (0.79), C/Ms (0.58) and C/Is (0.11) (*P*<0.001 in all cases). The mean a* for C/Cs (0.79) was significantly higher than for C/Is (0.11) (*P*<0.001) and the mean a* value for C/Ms (0.58) was significantly higher than for C/Is (0.11) (*P*<0.001).

Table 2.

Bonferroni Post Hoc Test/Parametar a*

Bonferroni test; variable a*											
	Tooth	Seg-ment	(1) -1.14	(2) -1.59	(3) -1.80	(4) -0.44	(5) -1.09	(6) -1.47	(7) 0.79	(8) 0.58	(9) 0.11
1	CI	C		***	***	***		*	***	***	***
2	CI	M	***			***	***		***	***	***
3	CI	I	***			***	***	*	***	***	***
4	LI	C	***	***	***		***	***	***	***	***
5	LI	M		***	***	***		**	***	***	***
6	LI	I	*		*	***	**		***	***	***
7	C	C	***	***	***	***	***	***			***
8	C	M	***	***	***	***	***	***			***
9	C	I	***	***	***	***	***	***	***	***	

-P<0.05; **-P<0.01; *-P<0.001*

Table 3 shows the differences in mean values of parameter b* (yellow/blue) for the target tooth, in the distribution of CI/LI/C and their segments (Cs/Ms/Is). The mean b* for CI/Cs (21.62) was significantly higher than for CI/Ms (18.22) and CI/Is (16.42) of the same tooth (P<0.001 in both cases). The mean b* for CI/Cs (21.62) was significantly higher than for LI/Ms (19.47) and LI/Is (17.08) (P<0.001 in both cases). The mean b* for CI/Cs (21.62) was significantly less than for C/Cs (29.39), C/Ms (26.59) and C/Is (24.02) (P<0.001 in all cases). The mean b* for CI/Ms (18.22) was significantly higher than for CI/Is (16.42) (P<0.001) and LI/Is (17.08) (P<0.05); at the same time, it was significantly less than for LI/Cs (21.98), C/Cs (29.30), C/Ms (26.59) and C/Is (24.02) (P<0.001 in all cases). The mean b* for CI/Is (16.42) was significantly less than for LI/Cs (21.98), LI/Ms (19.47), C/Cs (29.39), C/Ms (26.59), and C/Is (24.02) (P<0.001 in all cases). The mean b* for LI/Cs (21.98) was significantly higher than for LI/Ms (19.47) and LI/Is (17.08) of the same tooth (P<0.001 in both cases); at the same time, it was significantly less than for C/Cs (29.39), C/Ms (26.59) and C/Is (24.02) (P<0.001 in all cases). The mean b* for LI/Ms (19.47) was significantly higher than for LI/Is (17.08) (P<0.001); at the same time, it was significantly less than for C/Cs (29.39), C/Ms (26.59) and C/Is (24.02) (P<0.001 in all cases). The mean b* for LI/Is (17.08) was significantly less than for C/Cs (29.39), C/Ms (26.59) and C/Is (24.02) (P<0.001). The mean b* for C/Cs (29.39) was significantly higher than for C/Ms (26.59), C/Is (24.02) (P<0.001 in both cases), and the mean b* for C/Ms (26.59) was significantly higher than for C/Is (24.02) (P<0.001).

Table 3.
Bonferroni Post Hoc Test - Parameter b*

Bonferroni test; variable b*											
	Tooth	Segment	(1) 21.62	(2) 18.22	(3) 16.42	(4) 21.98	(5) 19.47	(6) 17.08	(7) 29.39	(8) 26.59	(9) 24.02
1	CI	C		***	***		***	***	***	***	***
2	CI	M	***		***	***	**	*	***	***	***
3	CI	I	***	***		***	***		***	***	***
4	LI	C		***	***		***	***	***	***	***
5	LI	M	***	**	***	***		***	***	***	***
6	LI	I	***	*		***	***		***	***	***
7	C	C	***	***	***	***	***	***		***	***
8	C	M	***	***	***	***	***	***	***		***
9	C	I	***	***	***	***	***	***	***	***	

-P<0.05; **-P<0.01; *-P<0.001*

Discussion

Our results show that values of L* were higher for CI/Cs than for LI/Cs, LI/Ms, LI/Is, C/Cs, C/Ms, and C/Is. Thus, the obtained data showed that the cervical segment of the frontal teeth of the maxilla has higher lightness than the middle and incisal segments.

Schwabacher et al.[15] found that correlations between hue, lightness, and chroma were not significant for incisal and cervical sites. For the middle site, these Munsell color coordinates were highly correlated and closely confined to a planar region of the color space, described by a single equation.

In a study by Çetin et al.,[16] based on the right-left localization variable, L* (Right L*: 79.7, Left L*: 80.2, P<0.001), and a* parameters showed statistical higher (Right a*: -0,1 / Left a*: -0.2, P=0.020) values in general.

Zhao and Zhu,[17] using a fiber-optic spectrophotometer (FMC-9204, Kunming, China) for in vivo color measurements of 410 healthy maxillary anterior teeth of 70 Kunming residents aged 18 to 70, showed that the color of the maxillary anterior teeth was related to tooth position: the central incisor had the highest value of L*, and the canine had the lowest. The canine was also redder, yellower, and more saturated.

Savas et al.[18] performed a spectrophotometric color analysis of maxillary permanent central incisors based on apical developmental stage, age, and gender groups. Digital images were quantified by non-contact spectrophotometry to determine the tooth color. Each tooth's color shade and L*, a*, and b* values were recorded. A statistically significant difference was found between the 7- to 12-year-old and 13- to 18-year-old age groups in the general tooth shade and its L* value in the overall, cervical, middle, and incisal sites (P<0.05). The authors concluded that there is a strong relationship between the apical developmental stages of the teeth and the L* values.

Dozic et al.[19] found a relation in color between the maxillary incisors and canines, which was stronger between the cervical than between the middle and incisal segments. In a study by Tabatabaian et al.,[20] central and lateral teeth showed color matches in middle and incisal regions, while lateral and canine teeth disclosed color matches in cervical regions.

In a study by Dozic et al.,[21] the color relation between three tooth segments (cervical, middle, and incisal) in vital upper central incisors, using digital photography was determined. The authors found statistically significant linear correlations for L* and b* between the three tooth segments (cervical, middle, and incisal) (all r's≥0.06, P<0.001). The correlation coefficient for a* was lower compared to L* and b* values.

Conclusion

The color parameters L*, a*, and b* in the maxillary anterior teeth differ not only from one another but also from one segment to another segment of the same tooth. The differences in color between the maxillary anterior teeth are evident; especially, these differences in color were noticed between the maxillary incisors and canines. It was concluded that the differences were of high significance between maxillary incisors and canines. The significant differences in frontal teeth were stronger between the cervical and middle segments than between these segments and incisal segments. The clinical implication of this study is a way to provide proper shade selection, especially when the color of the teeth is measured visually; dentists and assisting staff should concentrate on the cervical and middle segments of the tooth. It is an essential basic step to achieve perfect esthetic results. The color of the teeth is influenced by many factors, causing subjective differences. Color differences should also be considered when producing denture teeth, to come as close as possible to the natural color.

Competing Interests

The authors declare that they have no competing interests.

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