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Effect of Tooth Bleaching on The Color Change of Laminate Veneer Restorations: A Pilot Study

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ABSTRACT

Objective: This pilot study aimed to evaluate the effect of tooth bleaching on the long-term color change of laminate veneers restored with different translucency CAD/CAM materials.

Methods: In this study, 20 upper central teeth extracted due to periodontal, orthodontic problems and trauma were used. The teeth were embedded in acrylic blocks and divided into 4 groups of 5 teeth each. Groups A and B were bleached with a vital bleaching agent for two 20-minute sessions before preparation and teeth were prepared for laminate veneer restoration following bleaching. Groups C and D were prepared without bleaching treatment. Groups A and C were restored with high translucent A1 IPS Emax CAD material and Groups B and D were restored with low translucent A1 IPS Emax CAD material. For all restorations adhesive cementation was applied and aged for 2 years by thermal cycling. The color of the restorations was measured using a spectrophotometer after cementation and the measurement was done again after 2 years aging. The Kruskal Wallis test was used to compare data and multiple comparisons were tested with Dunn's test.

Results: The translucency of the blocks and tooth bleaching caused a significant difference between the groups according to the Kruskal Wallis test. Color changes (ΔE00) of Group A, B, C and D was 0.89±0.01, 0.87±0.01, 0.81±0.01, 0.8±0.01 respectively.

Conclusion: Tooth bleaching causes a greater color change in laminate veneer restorations and the translucency of the material affects the color change of the laminate veneer restorations after aging.

Keywords: Laminate veneer, bleaching, translucency, IPS Emax CAD

1. INTRODUCTION

One of the most important goals of modern dentistry is to restore the tissue integrity, function and phonation of patients and natural dental aesthetics. Currently, it is possible to produce restorations with optical properties similar to those of natural teeth (1).

Owing to the complex optical properties of natural teeth, it is very difficult for dentists to achieve color harmony in aesthetic restorations. To ensure color harmony for aesthetic restorations, it is necessary to know the optical properties of the tooth and materials (2). Translucency is one of the main factors that affect material selection and aesthetics. All dental ceramics contain crystals such as lithium disilicate, leucite, and fluorapatite. An increase in the crystal content increases the opacity of the material and may negatively affect its aesthetics (3). In terms of the lens effect, the high translucency of the material improves the natural appearance of the restoration owing to the reflectance of the natural teeth. However, translucency decreases the covering capacity so that discolorations may be visible through restoration (4).

Porcelain laminate veneers are minimum thickness restorations. The low thickness and high translucency of the material increases the optical property, which is an important criterion for aesthetics and provides a natural tooth appearance (5). Tooth discoloration is an important esthetic problem and can be treated by bleaching and laminate veneer restorations. Following bleaching procedures, it is possible to choose more translucent materials and contribute to aesthetics (6).

Color is a complex concept that includes both subjective and objective phenomena. Since Sigried Forsius first descripe color in 1611, many systems and approaches have been developed to explain it (7). Although there are many different color determination systems, Munsell and CIE color systems are the most preferred in terms of international acceptability, reliability and ease of application (8,9).

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Although there are many studies on the color changes of laminate veneer restorations in the literature, there are not enough studies on laminate veneer restorations applied to bleached teeth. This pilot study aimed to evaluate the effect of tooth bleaching on the long-term color change of laminate veneer restorations produced with different translucency CAD/CAM materials. The first null hypothesis was that bleaching does not affect the long-term color stability of lamina veneer restorations after aging. The second null hypothesis was that translucency would not affect the long-term color stability of laminate veneer restorations after aging.

2. METHODS

Ethical approval was obtained from the Ethics Committee of Marmara University Faculty of Medicine 09.2021.418 protocol number was obtained for this pilot study.

In this study, 20 maxillary central teeth (A4 shade) which kept in 10% thymol solution, without caries extracted due to periodontal, orthodontic problems or trauma were used. Teeth were kept in 10% thymol solution at the time of extraction. The specimens were embedded in acrylic blocks and divided into 2 main groups (n = 10) according to the bleaching procedure applied. Each of these groups were divided again into subgroups (n=5) according to the translucency of the lithium disilicate glass ceramic material as high and low translucency. The study groups are shown in Figure 1.

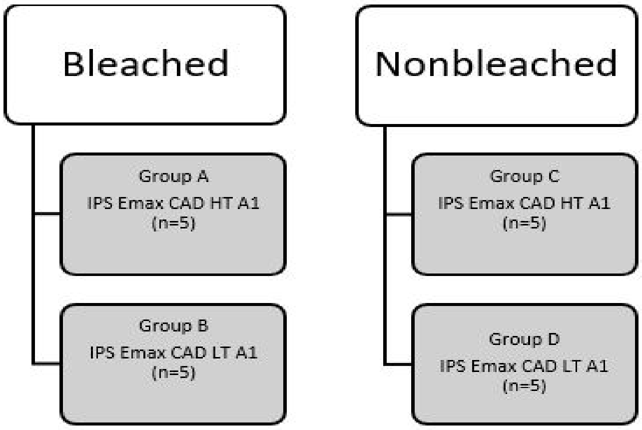

Figure 1. *Study groups*

2.1. Tooth Bleaching Procedures

Groups A and B were bleached before preparation of laminate veneer restorations. Groups C and D were prepared without any bleaching procedure. Office type whitening agent containing 40% hydrogen peroxide (Opalescence Boost, Ultradent Products, USA) was applied to the labial surfaces of the specimens with the help of a brush in accordance with the manufacturer's recommendations and activated by 460 nm wavelength LED light device (Flash Whitening Lamp; WHITEsmile GmbH, Birkenau, Germany) for 20 minutes. The bleaching agent was then removed with the help of cotton pellets and the same application was repeated once more after one week. As a result, two bleaching sessions were performed on the specimens.

2.2. Tooth Preparation

All specimens were prepared for all-ceramic laminate veneer restorations one week after the bleaching procedure. Self-limiting depth-cutting burs (Laminate Veneer Kit, Meisinger USA, LLC) of 0.3 and 0.5 mm were used initially to standardize the depth-cut and the facial surface was reduced 0.3 mm at the cervical third and 0.5 mm at the middle and incisal thirds. A chamfer diamond bur was used for final refinement of the preparation. A total of 1 mm reduction was performed at the incisal edge with a fissure diamond bur under a water coolant. Proximal finish lines were located at the proximal contact areas of the specimens. The cervical finishing lines were prepared 1 mm above the cemento-enamel junction without sharp line angles. The labial surface of each specimen was smoothened with a fine diamond-finishing bur.

2.3. Impression of Specimens

A Cerec laboratory scanner inEos X5 (Sirona, Dentsply, Bensheim, Germany) was used to obtain digital impressions of all the prepared specimens.

2.4. Fabrication of CAD/CAM Laminate Veneers

High and low translucent A1 CAD blocks (Emax, Ivoclar Vivadent, Schaan, Liechtenstein) were used for the laboratory production of 20 laminate veneer restorations using the Cerec inLab CAD/CAM (Dentsply Sirona, Germany, Bensheim) system. The restoration designs were made using inLab Software 18.1 (Dentsply Sirona, Germany, Bensheim). All restorations were designed 0.6 mm at the gingival region and 1 mm at the incisal region. Crystallization and glazing of lithium disilicate laminate veneer restorations were achieved using the IPS Ivocolor Glaze Powder (Ivoclar Vivadent) with Programat P310 (Ivoclar Vivadent) in Programme number 81 (crystallization/glaze mode).

2.5. Cementation

All laminate veneer restorations were etched with hydrofluoric acid (Ultradent porcelain etch, USA) for 20 seconds followed by washing with water and an air jet. The G-Multi Primer agent was then applied to the restorations and dried in oil-free air for 5 seconds. The prepared tooth surfaces were etched with 37% phosphoric acid (d'line phosphoric acid gel, Lithuania) for 30 seconds followed by washing with water and air jet. The filler-free bonding agent (G-Premio bond, Japan) was applied homogeneously with a brush for 10 seconds and diluted by 5 seconds of air. Laminate veneer restorations were cemented with GC Veneer (Japan) transparent cement which was applied to the inner surface of the lamina veneer restorations and placed on the extracted teeth with finger pressure. Excess cement was removed using a probe. Led Rainbow Curing Light (Liang Ya, Guangdong, China) with a 430 nm wave length was used for the polymerization process. The curing light was first applied to the palatal surfaces of the specimens for 90 seconds and then to the buccal surfaces of the specimens for 90 seconds to ensure light polymerization.

2.6. Thermocycle

After 24 hours after cementation, all specimens were subjected to thermocycling procedures (Thermocycling TC-3; SD Mechatronik GMBH), 20.000 thermal cycles per specimen with temperature changes from 5° to 55° every 30 seconds. There are literature reviews concluded that 10.000 cycles corresponds to approximately 1 year of in vivo functioning (10,11,12), therefore, the specimens were aged for 2 years with 20.000 thermal cycles.

2.7. Evaluation of the color stability

Color measurements of the specimens were performed after cementation and again after 2 years of aging using a spectrophotometer (Vita Easyshade, Vident, Brea, California, USA) and measurements were taken at the middle third of the restorations. Each measurement was performed three times and the average of all three scores was calculated. The CIEDE2000 formula (ΔE_{00}) was used to calculate color change.

Currently, the CIEDE2000 formula, which belongs to the CIE color system, is used in the literature. ΔL′, ΔC′ and ΔH′ in the CIEDE2000 formula (ΔE_{00}) represent the lightness, brightness and hue, respectively that match the samples. The RT rotation function calculates the differences between the color and hue in the blue region. The weighting function (SL, SC, SH) regulates the variations between the total color differences of the pairs in the L′, a′, and b′ coordinates and the parametric factors (KL, KC, KH) (8). In the literature, the perceptibility limit in the CIEDE2000 color difference formula is specified as $\Delta E_{00} \leq 0.8$, and the acceptability limit is $\Delta E_{00} > 1.8$ (9).

$$\Delta E_{00} = [(\Delta L/kLSL)^2 + (\Delta C/kCSC)^2 + (\Delta H/kHSH)^2 + RT\,(\Delta C/kCSC)(\Delta H/kHSH)\,]^{1/2}$$

2.8. Statistical Analysis

IBM SPSS V23 was used to evaluate and compare data. Conformity to normal distribution was evaluated using the Shapiro-Wilk test. An independent samples t-test was used to compare normally distributed data according to the paired groups. The Mann Whitney U test was used to compare the data that were nonnormally distributed according to the paired groups. One-way analysis of variance was used to compare normally distributed data according to groups of three or more and multiple comparisons of the results were analyzed using Tukey HSD and Tamhane's T2 tests. The Kruskal Wallis test was used to compare nonnormally distributed data by groups of three or more and multiple comparisons were tested with Dunn's test. Analysis results are presented as the mean ± standard deviation and median (minimum – maximum). The significance level was set at $\alpha < .05$.

3. RESULTS

The shade of all groups was changed and became darker, more red and more yellow but all the ΔE_{00} values were within the acceptability limit as the ΔE_{00} value was below the 1.8 threshold (Figure 2).

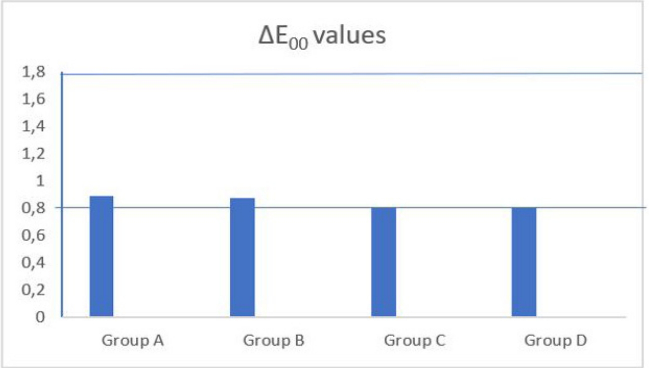

Figure 2. *ΔE_{00} values of all groups*

Table 1 shows the means of ΔL, ΔC, ΔH, and ΔE_{00}, test statistics and the p values.

Table 1. *Mean, standard deviation and median (minimum – maximum) values of color coordinates and color change of the samples as a result of thermal aging*

	Group A	Group B	Group C	Group D	Test statistic	p value
ΔL	0.8 ± 0.1	0.8 ± 0.07	0.7 ± 0	0.66 ± 0.05	10.664	**.014**
	0.8 (0.7 – 0.9)	0.8 (0.7 – 0.9)	0.7 (0.7 – 0.7)	0.7 (0.6 – 0.7)		
ΔC	0.68 ± 0.15	0.68 ± 0.11	0.7 ± 0	0.7 ± 0.1	0.259	0.968
	0.7 (0.5 – 0.9)	0.7 (0.5 – 0.8)	0.7 (0.7 – 0.7)	0.7 (0.6 – 0.8)		
ΔH	0.86 ± 0.18	0.82 ± 0.25	0.82 ± 0.08	0.9 ± 0.19	0.214	0.885
	0.9 (0.6 – 1.1)	0.8 (0.6 – 1.2)	0.8 (0.7 – 0.9)	0.9 (0.6 – 1.1)		
ΔE_{00}	0.89 ± 0.01	0.87 ± 0.01	0.81 ± 0.01	0.8 ± 0.01	16.368	**.001**
	0.89 (1 – 1)	0.87 (1 – 1)	0.81 (1 – 1)	0.80 (1 – 1)		

ΔL, ΔC and ΔH= Color coordinates, ΔE00= color change

Table 2. *Mean, standard deviation and median (minimum – maximum) values of color change of bleached and nonbleached groups*

	Bleached Group	Nonbleached Group	Test statistic	p value
ΔE_{00}	0.88 ± 0.01	0.81 ± 0.01	0.000	**< .001**
	0.88 (1 – 1)	0.81 (1 – 1)		

ΔE00=Color change

Statistically significant differences were found between the medians of the ΔL values of the groups according to the Kruskal Wallis test (p= .014). This difference was due to the difference between the low translucent lithium disilicate glass ceramic (bleached) group and the low translucent lithium disilicate glass ceramic (nonbleached) group. The median ΔL value for the high translucent lithium disilicate glass ceramic (bleached) group and low translucent lithium disilicate glass ceramic (bleached) group was 0.8, and the median ΔL value for the high translucent lithium disilicate glass ceramic (nonbleached) group and low translucent lithium disilicate glass ceramic (nonbleached) group was 0.7.

There was no statistically significant difference between the medians of ΔC values between the groups according to the Kruskal Wallis test (p= .968) and there was no statistically significant difference between the means ΔH values of the groups according to one-way analysis of variance (p= .885).

Statistically significant differences were found between the medians of the ΔE_{00} values of the groups according to the Kruskal Wallis test (p= .001). The highest median value was 0.89 in high translucent lithium disilicate glass ceramic (bleached) group followed by low translucent lithium disilicate glass ceramic (bleached) group with 0.87, while the lowest median value was 0.80 in low translucent lithium disilicate glass ceramic (nonbleached) group and followed by high translucent lithium disilicate glass ceramic (nonbleached) group with 0.80.

Statistically significant differences were found between the medians of ΔE_{00} values according to their bleaching status according to the Mann Whitney U test (p< .001) (Table 2). The median ΔE_{00} value of the bleached groups (Group A and Group B) was 0.88 while the median of those nonbleached groups (Group C and Group D) was 0.81. The color change was higher in the bleached group.

4.DISCUSSION

The first null hypothesis that there would be no difference in the long-term color stability of laminate veneer restorations after aging depending on bleaching was rejected. A significant color change was observed in the bleached groups. The second null hypothesis that there would be no difference in the long-term color stability of laminate veneer restorations after aging depending on translucency was also rejected. High translucent materials changed color significantly more in both bleached and nonbleached groups. According to this pilot study, it can be concluded that more color change was obtained at laminate veneer restorations that were constructed on bleached teeth and the translucency of the material affected the color change after aging.

Meireless et al (13) in their in vitro study, investigated the effect of the concentration of bleaching agents containing 10% and 16% carbamide peroxide on the reversal of whiteness and reported that the original concentration of the bleaching agent was not effective in restoring whiteness. Therefore, in this pilot study, office bleaching agent which containing 40% hydrogen peroxide was preferred.

The preparation depth and thickness of ceramic restorations may affect the overall shade (2). Self-limiting depth-cutting burs were used for the standardization of the tooth preparation and the thickness of 0.6 mm at the gingival region and 1 mm at the incisal region were selected for the manufacturing of all laminate veneer restorations to standardize color measurements (10).

Currently, CAD/CAM systems are frequently used for the production of laminate veneer restorations because of their advantages of digital workflow and time saving (14). More translucent ceramic systems, such as lithium disilicate, increase natural appearance by allowing greater light transmission (1). Therefore, IPS Emax CAD blocks containing lithium disilicate crystals were used in this pilot study.

It is possible to use light-cure or dual-cure resin cements for the cementation of laminate veneer restorations. Dual-cure resin cement may change color over time owing to presence of amine groups. Light-cure resin cements are frequently preferred for the cementation of laminate veneer restorations because they do not change color, offer different translucency and color alternatives and have advantages such as a long working time (15). In this pilot study, a light-cure resin cement (G-Cem Veneer) was used for cementation.

Subjective and objective methods have been used to evaluate color changes after bleaching procedures and aging (16). Spectrophotometers, colorimeters and computer software programs are the objective methods. Colorimeters measure only three wavelengths of reflected light whereas spectrophotometers measure reflections in the entire visible spectrum of the light. Colorimeters provide inconsistent results, especially on curved surfaces. A spectrophotometer was used to obtain error-free and consistent results (17). In this pilot study a spectrophotometer (VITA Easyshade) was used to evaluate color change values.

Gómez-Polo et al (18) compared the CIELab and CIEDE2000 formulas to determine differences in color perception. Within the limits of this study, it was concluded that the CIEDE2000 formula reflects the color difference perceptible by the human eye better than the CIELab formula. The amount of color change is interpreted according to two different threshold values: the color change value that can be noticed by 50% of the observers is defined as the 'perceptibility threshold' and the acceptable color change by 50% of the observers is defined as the 'acceptability threshold' value. Paravina et al (9) reported a perceptibility threshold of 0.8 and the acceptability threshold of 1.8 for ΔE_{00}. In this pilot study the color change due to aging was calculated using the new CIEDE2000 formula. The detectability threshold value was used as ΔE_{00}=0.8 and the acceptability threshold value was ΔE_{00}=1.8.

In the literature, reversal of whitening efficacy has been reported at a rate of 41% at 1 year for in-office bleaching (19) and a return rate of 26% was reported at 18 months for at-home bleaching (20). In this pilot study, the color change of the bleached groups was significantly higher than the nonbleached groups after 2 years of bleaching procedures. Therefore, the amount of color change may be higher in the bleached groups, because the whiteness is reversed.

Several studies have been conducted on the color stability of ceramics after aging (5,21 – 23). Different results have been reported in these studies, such as increasing or decreasing L, C and H values. In their study in 2012, Bagis and Turgut investigated the color change of laminate veneer restorations produced from ceramic materials using different production techniques and reported that ceramics become darker and more red and yellow after aging (2). In 2017, Alghazzawi compared the optical properties of 7 different translucent zirconia and lithium disilicate materials after aging. All materials got darker and more red, more yellow after aging in this study too (21). Parallel to the results of these two studies, after 2 years of aging L, C and H values were also affected in this pilot study. All groups became darker, red and yellow, the L values decreased and the C and H values increased.

Azer et al (22) investigated the effect of translucency of leucite glass and composite resin laminate veneer restorations on color and concluded that the translucency of the tested materials affected the color of the restorations and that the translucent ones changed color more than the opaque ones. Lee et al (23) investigated the color stability of laminate veneer restorations using different ceramic and resin systems after aging and used high and low translucent forms of nanofluorapatite and lithium disilicate materials. They reported that the color change values were higher for materials with high translucency. The results of this study were consistent with those of Azer and Lee's studies. High translucent forms of lithium disilicate glass ceramic exhibited more color change than low translucent forms.

Dalloo et al (24) examined the impact of bleaching before and after veneer preparation on the color masking ability of laminate veneer restorations manufactured using high translucent lithium disilicate glass ceramic in 3 groups as nonbleached, bleaching before and bleaching after preparation. They concluded that the bleached group exhibited a significant ΔE value compared with the nonbleached group. These results were consistent with those of this pilot study. The bleached after preparation group exhibited the highest ΔE_{00} value.

Yuan et al (25) compared the color stability of lithium disilicate and zirconium materials after brushing and thermal aging. 5, 10 and 15 years of brushing and thermal aging were applied to the specimens and the color changes were calculated using the CIELab formula. They concluded that the color change of both materials was within the clinically acceptable values. The results of this study are consistent with those of Yuan et al and the color changes of the lithium disilicate material groups were within clinically acceptable values.

In 2019, Kim and Kim investigated the color stability and translucency parameters of lithium disilicate and monolithic zirconia. The materials were aged by autoclave for 1, 3, 5 and 10 hours. While the color change of the monolithic zirconia material was above the acceptable threshold value, that of the lithium disilicate material was below the detectability threshold value (26). In this pilot study, the color change of lithium disilicate materials was below the acceptability threshold and above the perceptibility threshold. This difference may be due to the fact that thermal aging was used as the aging method in this pilot study, whereas Kim and Kim used autoclave aging.

One of the limitations of this pilot study was that only lithium disilicate glass ceramic materials were tested. Different CAD-CAM materials used for laminate veneer restorations may differ in their color masking ability. In this study, office bleaching agent containing 40% hydrogen peroxide was used. Different results can be obtained with bleaching agents with a different contents and percentages. Although the purpose of in vitro studies is to simulate the clinical situation, clinical trials are needed to investigate the extent and detection of color changes under clinical conditions.

5. CONCLUSION

The application of bleaching process before preparation for laminate veneer restorations affects the long-term color stability of laminate veneer restorations but within the acceptability limit.

The translucency of the material used in the production of laminate veneer restorations effects the long-term color stability of the laminate veneer restorations. More translucent material changes color more.

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Author Contributions:
Research idea: BAA, ŞBT
Design of the study: BAA, ŞBT
Acquisition of data for the study: BAA
Analysis of data for the study: BAA
Interpretation of data for the study: BAA
Drafting the manuscript: BAA
Revising it critically for important intellectual content: ŞBT
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REFERENCES

[1] Turgut S, Bagis B. Effect of resin cement and ceramic thickness on final color of laminate veneers:An in vitro study. J Prosthet Dent. 2013;109(3):179-186. DOI: 10.1016/S0022-3913(13)60039-6.

[2] Vafaei F, Izadi A, Abbasi S, Farhadian M, Bagheri Z. Comparison of properties of laminate veneers made of zolid fx katana utml zirconia and lithium disilicate ceramics. Front Dent. 2019;16(5):357-368. DOI: 10.18502/fid.v16i5.2284.

[3] Materdomini D, Friedman MJ. The contact lens effect: Enhancing porcelain veneer esthetics. J Esthet Dent 1995;7:99-103. DOI: 10.1111/j.1708-8240.1995.tb00725.x.

[4] Ledic K, Majnaric I, Milardovic S, Ortolan SM, Spalj S, Stefancic S, Mehulic K. Analysis of translucency parameter of glass-ceramics fabricated by different techniques. Acta Stomatol Croat. 2015;49:27-35. DOI: 10.15644/asc49/1/4.

[5] Bagis B, Turgut S. Optical properties of current ceramics systems for laminate veneers. J Dent. 2013;415:24-30. DOI: 10.1016/j.jdent.2012.11.013.

[6] Majeed A, Farooq I, Grobler SR, Rossouw RJ. Tooth-Bleaching: A review of the efficacy and adverse effects of various tooth whitening products. J Coll Physicians Surg Pak. 2015;25(12):891-896. DOI: 1029271/jcpsp.2015.12.891.

[7] Brewer JD, Wee A, Seghi R. Advances in color matching. Dent Clin N Am. 2004;48(2):341-358. DOI: 10.1016/j.cden.2004.01.004.

[8] Pecho OE, Ghinea R, Alessandretti R, Pérez MM, Della Bona A. Visual and instrumental shade matching using CIELAB and CIEDE2000 color difference formulas. Dent mater. 2016;32(1):82-92. DOI: 10.1016/j.dental.2015.10.015.

[9] Paravina RD, Ghinea R, Herrera LJ Bona AD, Igiel C, Linninger M, Sakai M, Takahashi H, Tashkandi E, Perez Mdel M. Color difference thresholds in dentistry. J Esthet Restor Dent. 2015;27:1-9. DOI: 10.1111/jerd.12149.

[10] De Munck J, Van Landuyt K, Coutinho E, Poitevin A, Peumans M, Lambrechts P, Van Meerbeek B. Micro-tensile bond strength of adhesives bonded to class-I cavity-bottom dentin after thermo-cycling. Dent Mater. 2005;21(11):999-1007. DOI: 10.1016/j.dental.2004.11.005.

[11] Gale MS, Darvell BW. Thermal cycling procedures for laboratory testing of dental restorations. J Dent. 1999;27:89–99. DOI: 10.1016/s0300-5712(98)00037-2.

[12] Spierings T, Bosman F, Peters MCRB, Plasschaert AJM. Determination of the convective heat transfer coefficient. Dent Mater. 1987;3:161–164. DOI: 10.1016/S0109-5641(87)80027-1.

[13] Meireles SS, dos Santos IS, Della Bona A, Demarco FF. A double-blind randomized controlled clinical trial of 10 percent versus 16 percent carbamide peroxide tooth-bleaching agents: One-year follow-up. J Am Dent Assoc. 2000;140(9):1109-1117. DOI: 10.14219/jada.archive.2009.0337.

[14] Omar H, Atta O, El-Mowafy O, Khan SA. Effect of CAD-CAM porcelain veneers thickness on their cemented color. J Dent. 2010;38. DOI: 10.1016/j.jdent.2010.05.006.

[15] Tsitrou E, Helvatjoglou-Antoniades M, Pahinis K, van Noort R. Fracture strength of minimally prepared resin bonded Cerec inlays. Oper Dent. 2009;34(5):537–543. DOI: 10.2341/08-030-L.

[16] Paravina RD, Powers JM, Fay RM. Dental color standards: Shade tab arrangement. J Esthet Restor Dent. 2001;13(4):254-263. DOI: 10.1111/j.1708-8240.2001.tb00271.x.

[17] Park JH, Lee YK, Lim BS. Influence of illuminants on the color distribution of shade guides. J Prosthet Dent. 2006;96(6):402-411. DOI: 10.1016/j.prosdent.2006.10.007.

[18] Gómez-Polo C, Muñoz MP, Luengo MCL, Vicente P, Galindo P, Casado AMM. Comparison of the CIELab and CIEDE2000 color difference formulas. J Prosthet Dent. 2016;115(1):65-70. DOI: 10.1016/j.prosdent.2015.07.001.

[19] Sulieman M. An overview of bleaching techniques: I. History, chemistry, safety and legal aspects. Dent Update. 2004;31(10):608-616. DOI: 10.12968/denu.2004.31.10.608.

[20] Haywood, VB. Achieving, maintaining and recovering successful tooth bleaching. J Esthet Dent 2005;8:31-38. DOI: 10.1111/j.1708-8240.1996.tb00906.x.

[21] Alghazzawi TF. The effect of extended aging on the optical properties of different zirconia materials. J Prosthodont Res. 2017;61(3):305-314. DOI: 10.1016/j.jpor.2016.11.002.

[22] Azer SS, Rosenstiel SF, Seghi RR, Johnston WM. Effect of substrate shades on the color of ceramic laminate veneers. J Prosthet Dent. 2011;106(3):179-183. DOI: 10.1016/S0022-3913(11)60117-0.

[23] Lee SM, Choi YS. Effect of ceramic material and resin cement systems on the color stability of laminate veneers after accelerated aging. J Prosthet Dent. 2018;120(1):99-106. DOI: 10.1016/j.prosdent.2017.09.014.

[24] Dalloo GAM, Faraj BM, Al-Zahawi AR. Impact of bleaching before or after veneer preparation on color masking ability of laminate veneers: An In Vitro Study. BioMed Research Int. 2021;2021:6611173. DOI: 10.1155/2021/6611173.

[25] Yuan JC, Barão VAR, Wee AG, Alfaro MF, Afshari FS, Sukotjo C. Effect of brushing and thermocycling on the shade and surface roughness of CAD-CAM ceramic restorations. J Prosthet Dent. 2018(6):1000-1006. DOI: 10.1016/j.prosdent.2017.06.001.

[26] Kim HT, Kim SH. Effect of hydrotermal aging on the optical properties of precolored dental monolithic zirconia ceramics. J Prosthet Dent. 2019;121(4):676-82. DOI: 10.1016/j.prosdent.2018.06.021.

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