Official Dental Journal of Suez Canal University
DENTAL SCIENCE Updates
Print ISSN 2636-3836
Online ISSN 2636-3844
www.dsujournals.ekb.eg
DSU — Vol. 3, No. 2, September (2022) — PP. 237:245

IN VIVO EVALUATION OF SHADE MATCHING ABILITY OF THREE RESIN COMPOSITES WITH THREE DIFFERENT TEETH SHADES

Mohamed Sanad[1], Ola Ibrahim Fahmy[2], Ahmed Fawzy Abo El-Ezz[3]

DOI: 10.21608/dsu.2022.121171.1108
Manuscript ID: DSU-2202-1108

KEYWORDS

Color, Composite, Shade.

- E-mail address: sanado85@hotmail.com

1. Assistant Lecturer of Operative Dentistry, Faculty of Dentistry, Suez Canal University, Egypt.
2. Professor of Operative Dentistry, Faculty of Oral and Dental Medicine, Misr International University, Egypt.
3. Assistant Professor of Operative Dentistry, Faculty of Dentistry, Suez Canal University, Egypt.

ABSTRACT

Aim: To digitally evaluate the color matching ability of a "single-shaded" resin composite versus a "single translucency" resin composite system placed in patients' teeth with different shades, and to compare both of them to a gold standard multi-shaded resin composite system, immediately after placement, after 6 months and after 12 months. **Methods:** 90 anterior teeth and premolars were selected in patients with class V lesions and categorized into three groups according to teeth shades (S_1, S_2 and S_3). These groups were further subdivided into three subgroups according to restorative material placed in the cavities (M_1, M_2 and M_3). Restoration shades were recorded directly after placement (T_1), after 6 months (T_2) and after 12 months (T_3) and ΔE was calculated. **Results:** Single-shaded resin composite (M_1) recorded significant lower ΔE values wih S_1 followed by S_2 and S_3 respectively ($P \leq 0.05$). The color matching ability of the single translucency group-shaded resin composite was inferior to that of the single-shaded resin composite at shade S_1 while it was superior to that of the single shade resin composite at shades S_2 and S_3. Multi-shaded resin composite (M_3), generally showed the best results with the three teeth shades compared to the other two materials. Time had no significant effect on color matching of the three types of restorative materials ($P \leq 0.05$). **Conclusions:** The single-shaded resin composite showed more acceptable color matching with lighter teeth shades than darker teeth shades. Multi-shaded resin composite showed superior color matching ability at the three different teeth shades.

INTRODUCTION

Successful esthetic treatments largely depend on precise matching of the shade of the restoration to that of the neighboring tooth structure and accurate adaptation of the restoration to the surrounding structures [(1)]. However, shade selection usually increases chair time and is subjective to the individual performing the shade-taking procedure, which is burdensome for both dentists and patients [(2)]. To address this issue, resin composites with five "cloud shades" that cover the full VITA color range of natural teeth have been introduced. Cloud shades cover more than one VITA shade, because the shade of these universal restorations is influenced by the color of the surrounding tooth structure; a phenomenon called *chameleon effect*. Recently, a new resin-based composite (Omnichroma®) has been developed, formulated on a "Wide Color Matching" concept, creating shades that can cover a wide range of natural teeth colors to reduce the time of shade taking and reduce the

amount of composite shades needed. Omnichroma® resin composite is a structurally colored single shade composite based on "Smart Chromatic Technology" that exhibits the ultimate wide-range color-matching ability, covering all VITA classical shades with just one shade of composite. Thus, it was found interesting to evaluate clinically the color matching ability of these recent esthetic materials at different time intervals compared to traditional multiple shaded composite resin materials.

MATERIALS AND METHODS

This study was conducted in the clinic of Department of Operative Dentistry, Faculty of Dentistry, Suez Canal University after the approval of Research Ethical Committee (REC) of Faculty of Dentistry, Suez Canal University with approval no. 200/2019. Healthy adult patients, from among patients attending at the clinic of Operative Dentistry Department diagnosed with class V carious lesions in their anterior teeth and premolars required to be restored with direct composite resin were selected for this study (Figure 1a).

In this study, 90 selected teeth were divided according to their shade (S) into three groups with 30 teeth in each group; group (S_1) for teeth with shade A2, group (S_2) for teeth with shade A3 and group (S_3) for teeth with shade A3.5. Each group was then divided into three subgroups with 10 teeth in each subgroup according to the restorative material (M) that would be placed in the prepared cavity; subgroup (M_1) for teeth that would be restored with Omnichroma® (Tokuyama Dental America Inc.), subgroup (M_2) for teeth that would be restored with Ceram.X® SphereTEC™ one (Dentsply), and subgroup (M_3) for teeth that would be restored with Filtek Z250™ XT (3M ESPE). The shade of each restoration was recorded at three time intervals (T); immediately after placement (T_1), after 6 months (T_2) and after 12 months (T_3). (n = 10)

Sample size calculation

To assess differences in the in-vivo study; a two way repeated measures analysis of variance (ANOVA) was proposed. A total calculated sample size of 90 samples was sufficient to detect the effect size of 0.25 according to Cohen [18], a power (1-β=0.95) of 95% at a significance probability level of $p<0.05$ partial eta squared of 0.06. According to sample size calculations each tooth shade (S_1,S_2, S_3), and different restorative materials (M_1, M_2 and M_3) at each time points (T_1, T_2, T_3) was represented by a minimum of 10 samples with a total sample readings of 270 sample readings. The sample size was calculated according to G*Power software version 3.1.9.3.

Selection of patients

The present study was conducted in the clinic of Department of Operative Dentistry, Faculty of Dentistry, Suez Canal University after the approval of Research Ethical Committee (REC) of Faculty of Dentistry, Suez Canal University with approval no. 200/2019.

Healthy adult patients, from among patients attending at the clinic of Operative Dentistry Department diagnosed with class V carious lesions in their anterior teeth and premolars required to be restored with direct composite resin were selected for this study.

- Inclusion criteria:

- Patients with class V lesions in their maxillary or mandibular anterior teeth and premolars with final cavity depth of no more than 1.5mm.
- Patients who are willing to attend the follow-up visits at the clinic of Operative Dentistry Department, Suez Canal University to receive treatment.

- Each patient signed an informed consent form before participating in the study.

- Exclusion criteria:

- Patients with extreme poor oral hygiene.
- Patients with heavy bruxism habits or periodontal problems.
- Patients with non-vital teeth.
- Patients who refused to participate in the study.
- Patients who refused to sign the informed consent form.
- Patients who were not able to attend the follow-up visits at the clinic of Operative Dentistry Department, Suez Canal University.
- Patients with teeth shades other than A2, A3 or A3.5 were excluded.
- Patients with very deep cavities that needed placement of liner or base materials were excluded as this may affect the final shade of the applied restoration.

Pre-operative procedures

All patients received oral-hygiene instructions before performing operative treatments. Teeth vitality was tested before operative procedures. Teeth were then polished and then the shade of each tooth was recorded using a spectrophotometer (VITA Easyshade® V, VITA Zahnfabrik, Bad Sackingen, Germany) which recorded the shade of the nearest sound tooth structure to the carious lesion present before beginning of cavity preparation [(3)]. According to the recorded shade, whether A2, A3 or A3.5, the teeth were assigned to the three main groups of the study; S_1, S_2 and S_3 respectively.

Allocation of samples

Simple randomization was assigned for teeth by generating numbers from 1:30 using Random Integer Set Generator, Randomness and Integrity Service Ltd (http://www.random.org). Within each shade group (S), teeth with numbers from 1:10 were restored with Omnichroma® (M_1), teeth with numbers from 11:20 were restored with Ceram.X® SphereTEC™ one (M_2), while teeth with numbers from 21:30 were restored with Filtek™ Z250 XT (M_3).

Operative procedures and restoration

Class V cavities were prepared on the buccal surface of the teeth of all patients using No.56 carbide fissure bur (Komet, Germany) in a high speed hand piece with a copious water spray with a copious water spray to remove all the caries present[(4)]. New burs were used after every five cavities in order to ensure high cutting efficiency [(5)]. Short bevel was performed at the incisal cavo-surface margin of the prepared cavities with diamond fissure bur (FG 110-014, Dentsply Sirona) to help masking the tooth-restoration interface [(6)].

For restoration of the prepared cavities, complete isolation of the teeth was performed using rubber dam and then each cavity was etched with 37% phosphoric acid etching gel for 20 seconds and was then rinsed with water spray for 30 seconds to ensure complete removal of the etching gel byproducts [(7)].

After rinsing and blotting excess moisture from the prepared cavity using a cotton pellet, a universal dentin bonding agent (Tetric® N-Bond Universal, Ivoclar Vivadent) was applied to the cavities with a micro brush according to manufacturer's instructions. An air flow for 2-5 seconds was applied and the bonding agent was then light cured for 20 seconds using blue-phase light curing unit with an output power of 800 mW/cm^2 power

density (Bluephase C8, Ivoclar Vivadent). All light curing procedures were performed from the buccal direction.

The class V prepared cavities were then restored with resin composite restorative material according to each group the tooth was classified. The teeth were restored incrementally with increments thickness of no more than 0.5 mm and no matricnig was applied. Each increment was light cured for 20 seconds (according to manufacturer's instructions) with the same light curing unit and the same power density. The curing distance was standardized through applying the tip of the curing unit on the buccal surface of the teeth.

The restorations were then finished with a sequential protocol using fine grit diamond burs and polishing discs (Soflex; 3M ESPE, St. Paul, MN, USA). In all cases the manufacturers' instructions for adhesive and restorative procedures were strictly followed (Figure 1b).

Follow up of cases

The shade reproduction of the restorations was recorded with a spectrophotometer (VITA Easyshade® V, VITA Zahnfabrik, Bad Sackingen, Germany) to detect any shade differences (ΔE) between the restoration and the surrounding tooth structures immediately after placement (T_1), after 6 months (T_2) and after 12 months (T_3) using the following equation

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where L^* represents the lightness of the color, a^* represents the redness-greenness of the color while b* represents the yellowness-blueness of the color.

Statistical analysis

All the obtained data were then recorded, tabulated, checked for normality and statistically analyzed using IBM SPSS for Windows version 20.0 software (SPSS, Chicago, IL, USA).

RESULTS

The effect of interaction between the three teeth

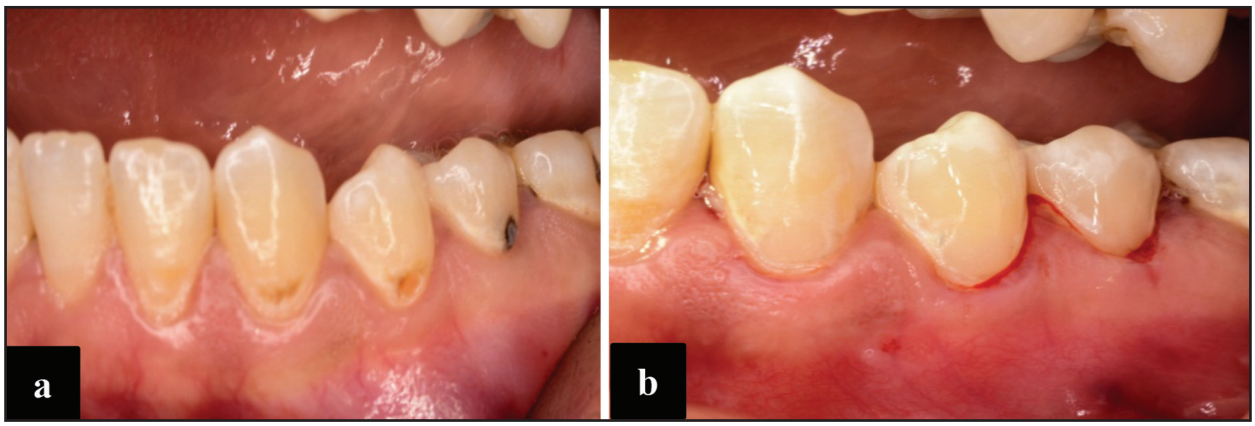

Fig. (1) (a) Class V Carious lesions in teeth no. 33, 34 and 35. (b) Teeth immediately after being restored, where tooth no. 33 was restored with Omnichroma®, tooth no. 34 restored with Ceram.X® SphereTEC™ one, while tooth no. 35 was restored with Filtek™ Z250 XT.

shades; A2 (S_1), A3 (S_2) and A3.5 (S_3) with the three restorative materials; Omnichroma® (M_1), Ceram. X® SphereTEC™ one (M_2) and Filtek™ Z250 XT (M_3) at the three time intervals; immediately after placement (T_1), after 6 months (T_2) and after 12 months (T_3) on ΔE values is presented in Table (1).

Regarding the interaction of each restorative material with three different teeth shades, data revealed that Omnichroma® (M_1) showed the lowest ΔE values wih S_1 followed by S_2 and S_3 respectively. The difference of values between the three shades was statistically significant. Similar trend was observed in the results of Ceram.X® SphereTEC™ one (M_2) with the three shades, however, ΔE values were higher than those of Omnichroma® (M_1) in S_1, and less in case of S_2 and S_3. The difference of values of Ceram.X® SphereTEC™ one (M_2) with the three shades was statistically significant. Data of the same table also showed that the least ΔE values were observed with Filtek™ Z250 XT (M_3) with the three teeth shades compared to the other two restorative materials. No statistically significant difference was observed between ΔE values of M_3 with the three shades.

Table (1) *ΔE values of the study and interaction between the variables.*

		Time (T)			Mean (μ)	Standard deviation (σ)
Shade (S)	Material (M)	T_1	T_2	T_3		
S_1	M_1	3.60 ^{Ag}	3.93 ^{Af}	3.96 ^{Afg}	3.83	0.45
	M_2	4.79 ^{Be}	5.02 ^{Bd}	5.11 ^{Be}	4.97	0.65
	M_3	3.44 ^{Cg}	3.91^{Cf}	4.05 ^{Cf}	3.80	0.62
S_2	M_1	6.14 ^{Dc}	6.21^{Dc}	6.55 ^{Dc}	6.30	0.72
	M_2	5.61 ^{Ed}	5.78 ^{Ec}	5.84 ^{Ed}	5.74	0.61
	M_3	3.32 ^{Fg}	3.60 ^{Ff}	3.71^{Ffg}	3.54	0.60
S_3	M_1	8.74 ^{Ga}	8.79 ^{Ga}	9.07 ^{Ga}	8.87	0.54
	M_2	7.57 ^{Hb}	7.78 ^{Hb}	7.74 ^{Hb}	7.70	0.90
	M_3	4.23 ^{If}	4.41^{Ie}	4.43 ^{If}	4.36	0.65
L.S.D (0.05) = 0.840						

ΔE	3-way ANOVA		
Source	Df	F-ratio	Significance
Corrected Model	26	36.25	<0.001
Time (T)	2	2.84	0.063
Shade (S)	2	198.34	<0.001
Material (M)	2	182.95	<0.001
Time x Shade (T x S)	4	0.12	0.974
Time x Material (T x M)	4	0.12	0.976
Material x Shade (M x S)	4	43.21	<0.001
Time x Material x Shade (T x S x M)	8	0.07	1.000

* *Capital letters indicate significance within each row while small letters indicate significance within each column.*

When the three restorative materials were compared within each shade, data showed that within S_1, no significant difference was found between M_1 and M_3. On the other hand, the differences in ΔE values between the three restorative materials in each of S_2 and S_3 was statistically significant.

Three-way ANOVA ($p \leq 0.05$) revealed that Omnichroma® (M_1) with shade A3.5 (S_3) recorded the highest ΔE values at T_3 (9.07), T_2 (8.79) and T_1 (8.74) respectively. However, the difference between T_3, T_2 and T_1 was not significant.

The data generally revealed that the time (T) had no significant effect on the interaction of each single shade with the three restorative materials.

DISCUSSION

This study was performed to assess and compare the differences between different tooth shade groups (S_1, S_2 and S_3) and different restorative materials (M_1, M_2 and M_3) at three time intervals (T_1, T_2 and T_3). **Abdelraouf and Habib**[8] visually assessed color matching and blending effect of a universal shade resin composite in resin-composite models and in natural teeth and recommended the assessment of color-matching and blending effect in vivo rather than in vitro. Thus this design was supposed to give more realistic results.

In the current study, three teeth shades were selected for each material to investigate the effect of teeth shade (light versus dark shades) on the color matching ability of each restorative material. The three selected shades; A2, A3 and A3.5 were used since these were demonstrated to be of the most frequent VITA shades for anterior teeth [9]. New burs were used after every five cavities in order to ensure high cutting efficiency and to protect the pulp from excessive heat generation as a result of using dull burs [7].

It has been reported that the color of the teeth is mainly determined by the dentin and not the enamel, with the latter having a minor influence on the teeth color but it's main influence on the color perception is in terms of lightness [10]. In the current study, to overcome this problem, class V cavities were chosen to be prepared in the tooth specimens since the minimal enamel thickness in this area allowed the restoration shade to be affected by the dentin color [11].

The procedure of shade determination can be done by visual or instrumental color determination. Visual shade determination performed by the use of shade guides is affected by many variables related to the shade guide, the observer, and the surrounding environment. In the last decade, electronic devices for determination of tooth color have been available for clinical use. These devices could be divided into colorimeters and spectrophotometers on the basis of their measurement principles. Colorimeters do not register spectral reflectance and can be less accurate than spectrophotometers [12]. In the present study, shade reproduction of all restorations was recorded with Vita Easyshade® V spectrophotometer device to exclude human variables in detecting shade differences.

Although there are several formulae for color difference calculation, the most commonly used system in dental research is obtained from the CIELab system as this approximates uniform distance among the color coordinates covering entirely the visual color space [8]. CIELab color differences were calculated as follows:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

where L^*, a^*, and b^* are the CIELab color coordinates.

Khashayar *et* al. [13] searched the dental literature to provide data on acceptability and perceptibility

thresholds and referred to the ΔE value of 3.7 as an acceptable threshold. This value has been used as a benchmark reference for several investigators.

The results of the present study showed that the best color matching was recorded with the multi-shaded resin composite at all tested shades indicating the best color matching with natural teeth. In the multi-shaded resin composite used in this study, the manufacturer improved the filler system with the addition of nanoparticles and nanoclusters which are bound in the resin matrix. The result is an optimized nanohybrid composite with a unique combination of fillers that made the system easy to be polished with good polish retention, providing predictable esthetic results. These results were in agreement with the results of **Loguercio *et* al.** [14] who evaluated the clinical performance of a nanohybrid composite resin (Filtek™ Z250 XT) against microfilled and nanofilled composite resins in class III cavities over a period of 12 months. He reported that the nanohybrid composite resin showed the best color match at baseline, after 6 months and after 12 months.

In the current study, the single-shade resin composite restorations showed good color matching with the lighter tooth shade S_1 (A2) while color matching ability decreased as the tooth shade became darker (S_2, S_3). The difference of color matching with the three tooth shades used in the current study was statistically significant. The superior color matching of the single-shade resin composite with light shades might be attributed to its high translucency reflecting the shade of the surrounding walls. This explanation was in agreement with **Abdelraouf and Habib**[8]. **Paravina *et* al.** [15] also reported that the blending effect increased with increasing the translucency. On the other hand, the decreased color matching ability with the darker shades may be attributed to the decreased amount of light that is reflected from the darker-shaded teeth through the restoration which may have affected the way by which the material shifts towards the tooth shade resulting in incomplete ability of the restoration to blend with the surrounding tooth structures.

In the present study, the color matching of the group-shaded resin composite with all tooth shades used was significantly inferior to that of the multi-shade resin composite. This may be attributable to the use of "cloud shades" which have to cover three to four shades resulting in no exact matching to any of them [16]. Moreover, the group-shade resin composite used is described by the manufacturer to have a single moderate translucency. This may attribute to their poor blending effect as **Paravina *et* al.**[15] reported that the blending effect increases with increasing the translucency of the resin composite. The color matching ability of group-shade resin composite was inferior to that of the single-shade resin composite at shade S_1 (A2) while it was superior to that of the single shade resin composite at shades S_2 (A3) and S_3 (A3.5).

The present study demonstrated that the color matching results of the single-shade resin composite were comparable to composites with multishades at lighter shades only with no statitistically significant difference between them, meanwhile, composites with multishades and composites with cloud shades showed more acceptable color matching in anterior class V restorations and over performed the single-shade resin composite in darker shades. The information provided is of great importance to fulfill partially the lack of data regarding the use of this new generation of universal composites in anterior restorations.

Time showed no significant change in the color matching of the different restorative materials used with the different shades of teeth neither after 6 months (T_2) nor after 12 months (T_3).

This may be attributed to the relatively short time period where only one year was not sufficient for significant color changes to take place in esthetic restorations. Moreover, the high polishability of the restorations may also have helped in maintaining a smooth surface of the restorations that was not easily stained. The results of this study were in agreement with **Demirci *et* al.** [17] who stated that no significant change in color matching of a nano-filled and a nano-hybrid resin had occured after one year. Their five-year clinical study showed some changes in color matching during the fourth and fifth years only. Generally, the one-year period was not sufficient for significant changes to occur in the restorations. Longer time periods may be more helpful to evaluate the effect of time on the color matching of the placed restorations.

CONCLUSIONS

Within the limitations of this study it can be concluded that:

The single-shaded resin composite showed more acceptable color matching at lighter teeth shades than at darker teeth shades.

Color matching of group-shaded resin composite is superior to that of single-shaded resin composite at darker shades.

Multi-shaded resin composite showed superior color matching ability at the three different teeth shades.

Time had no significant effect on the color matching of the tested resin composite materials.

ACKNOWLEDGEMENTS

The author is grateful to the Departmentment of Operative Dentistry, Faculty of Dentistry, Suez Canal University for the unlimited help and support throughout this study. This study was made as a part of the PhD Thesis of the corresponding author which was performed at Department of Operative Dentistry, Faculty of Dentistry, Suez Canal University.

REFERENCES

1. Pitel ML. Low-shrink composite resins: a review of their history, strategies for managing shrinkage, and clinical significance. Compend Contin Educ Dent. 2013;34:578-590.
2. Villarroel M, Fahl N, De Sousa AM, De Oliveira OB Jr. Direct esthetic restorations based on translucency and opacity of composite resins. J Esthet Restor Dent. 2011;23:73-87.
3. Ruschel VC, Martins MV, Bernardon JK, Maia HP. Color Match Between Composite Resin and Tooth Remnant in Class IV Restorations: A Case Series. Oper Dent. 2018;43:460-466.
4. Taha NA, Palamara JE, Messer HH. Assessment of laminate technique using glass ionomer and resin composite for restoration of root filled teeth. J Dent. 2012 ;40:617-23.
5. Plotino G, Buono L, Grande NM, Lamorgese V, Somma F. Fracture resistance of endodontically treated molars restored with extensive composite resin restorations. J Prosthet Dent. 2008;99::225-232.
6. Bagheri M, Ghavamnasiri M. Effect of cavosurface margin configuration of Class V cavity preparations on microleakage of composite resin restorations. J Contemp Dent Pract. 2008;9:122-129.
7. Deliperi S, Bardwell DN. Reconstruction of nonvital teeth using direct fiber-reinforced composite resin: a pilot clinical study. J Adhes Dent. 2009;11:71-78.
8. Abdelraouf RM, Habib NA. Color-Matching and Blending-Effect of Universal Shade Bulk-Fill-Resin-Composite in Resin-Composite-Models and Natural Teeth. Biomed Res Int. 2016:4183432.
9. de Abreu JLB, Sampaio CS, Benalcázar Jalkh EB, Hirata R. Analysis of the color matching of universal resin composites in anterior restorations. J Esthet Restor Dent. 2021;33:269-276.

10. Mourouzis P, Koulaouzidou EA, Palaghias G, Helvatjoglu-Antoniades M. Color match of resin composites to intact tooth structure. J Appl Biomater Funct Mater. 2015; 13:259-265.

11. Riad MI., Gamal WM., Morsy AS. Color Matching of a Single Shade Structurally Colored Universal Resin Composite With The Surrounding Hard Dental Tissues. EDJ. 2020;66:2721-2727.

12. Chu SJ, Trushkowsky RD, Paravina RD. Dental color matching instruments and systems. Review of clinical and research aspects. J Dent. 2010;38 Suppl 2:e2-16.

13. Khashayar G, Bain PA, Salari S, Dozic A, Kleverlaan CJ, Feilzer AJ. Perceptibility and acceptability thresholds for colour differences in dentistry. J Dent. 2014;42:637- 644.

14. Loguercio AD, Lorini E, Weiss RV, Tori AP, Picinatto CC, Ribeiro NR, Reis A. A 12-month clinical evaluation of composite resins in class III restorations. J Adhes Dent. 2007; 9:57-64.

15. Paravina RD, Westland S, Kimura M, Powers JM, Imai FH. Color interaction of dental materials: blending effect of layered composites. Dent Mater. 2006;22:903-908.

16. Iyer RS, Babani VR, Yaman P, Dennison J. Color match using instrumental and visual methods for single, group, and multi-shade composite resins. J Esthet Restor Dent. 2021 ;33:394-400.

17. Demirci M, Tuncer S, Sancakli HS, Tekçe N, Baydemir C. Five-year Clinical Evaluation of a Nanofilled and a Nanohybrid Composite in Class IV Cavities. Oper Dent. 2018;43:261-271.

18. Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, New Jerse: Lawrence Erlbaum Associates. 1988; 1: 490.