ORIGINAL ARTICLE

Evaluation of Correlation between Composite Placement and Degree of Enamel Reduction in Anterior Incisors

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Abstract

Background: Incisors were sourced to evaluate the relationship between the placement thickness of resin increments and the enamel removed in anterior teeth. Color values were then taken after curing. **Methods:** A total of 40 sound human maxillary incisors recently extracted within the last month were sourced and used within the same month. The teeth were randomly divided into two groups. In Group A, a 0.5 mm composite increment was added to each tooth, whereas in Group B, a 1 mm composite increment was added to each tooth. Initial enamel color was recorded by cross-polarized light and the VITA Easy shade V digital spectrophotometer. Post-curing color values were also recorded. **Results:** Statistical analysis revealed a significant decrease in L with a corresponding increase in ΔE for both groups. **Conclusion:** The change was less marked in Group A than in Group B.

Key words: Cross polarization, digital colorimetry, restorative dentistry, VITA easyshade

INTRODUCTION

The most challenging shade matching is within the anterior region of restorative dentistry. Choosing the right shade is one thing, and getting the final restoration to match the adjacent dentition under different lighting conditions is quite another. Most people do not like restorations that are too dark or too light.[1] This latter aspect is rather difficult due to the intrinsic factors of teeth, such as enamel translucency, thickness, and shade of underlying dentin. Such mistakes usually lead to compromised esthetics and unhappy patients.[2] The outermost layer of the tooth is enamel; that part of the tooth through which light is transmitted within the structure of the tooth. It can also allow light to be transmitted through it and into the dentin, and then reflected from the dentin.[3] In perception relative to enamel thickness, it relates to the apparent color of the tooth. A tooth that has thin enamel will appear darker because most of the color is reflected from the dentin. A tooth with thick enamel will appear lighter. Other surface textures and morphologies of enamel also scatter light and can therefore affect the appearance of the tooth. The CIE Lab (CIELAB) color space is the system of color measurement used in dentistry. It is a three-dimensional system that defines color as L for lightness, a for the position between red and green, and b for the position between yellow and blue. This provides a system through which color difference can accurately be communicated between teeth and any other material. The color difference, or ΔE, is merely the straight-line distance between the two points in three-dimensional space. It is calculated from the L, a, and b values. It gives a number that tells how much two colors look different. The lower the ΔE, the more similar the compared colors. And this is very important for dental restorations to match the surrounding dentition.[3] Spectrophotometers measure light intensity over different wavelengths; thus, they provide accurate and objective color determination. For dental applications, they

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measure L, a, and b values of teeth and restorations.[4] This is especially important because surface reflections will distort color measurements if not removed; hence, with cross-polarization, the values obtained reflect actual colors in the underlying tooth structures and not surface gloss or texture-dependent.[5] This would justify an in-depth study of how the various composite placement techniques and the enamel removal involved may influence the final color result, considering the complexities of shade matching and the many aspects that influence the appearance of dental restorations. The study was carried out to find the relationship between composite increment thickness and enamel removed during the placement of anterior restorations. It would, therefore, allow for these factors to affect post-curing color values to be used to make adjustments to the technique of restoration for better esthetic results.[6]

MATERIALS AND METHODS

The research was carried out in the Department of Conservative Dentistry and Endodontics at Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai, India. The study was conducted in September 2022.

Inclusion criteria

Human permanent non-carious maxillary central incisors were freshly extracted for the present study. The teeth were pulled due to periodontal reasons, and selected if they had no fracture lines, crazing, or carious lesions; that is, their enamel, dentin, and root structures were intact.

Exclusion criteria

Caries lesions, developmental disturbances, abnormal root formation, attrition, and cervical abrasion were excluded. Sample size calculation was done using G Power for $P = 0.05$, 95% power, and an effect size of 0.636. A total of 40 teeth were included in this study, 20 in each group.

Specimen preparation

Forty teeth were collected and then cleaned manually using hand scalers to remove all adherent and stain material. Thereafter, the teeth were equally divided into two groups: Group A (0.5 mm composite increment) and Group B (1 mm composite increment). All samples were mounted as follows for standardization. Polyvinyl chloride tubing of 3 cm length and 2.5 mm diameter was used for this purpose. The mounting was standardized so that the cervical line of each sample was at the level of the poured acrylic resin. The edge of the tooth and tube was 90°. The roots of the mounted teeth were embedded in cold-cure acrylic resin using the dough technique.

Experimental procedure

Initial shade measurement

The L, a, and b values recorded were L = 57, a = 8, and b = 3. This is shown in Figure 1. The initial enamel shade of each tooth was registered. A VITA Easyshade V digital spectrophotometer (VITA Zahnfabrik, Germany) was used for this purpose. The initial shade was also confirmed with a cross-polarizer.[7]

Enameloplasty and group allocation

The bonding surface was prepared by removing the enamel from each tooth. The thickness of enamel reduction was kept at 0.6 mm, controlled with a vernier caliper. Then, the teeth were randomly assigned to one of the two groups. Group A: Composite was placed with a 0.5 mm increment. Group B: Composite was placed with a 1 mm increment.[1]

Etching and bonding

The enamel margins were etched with 35% phosphoric acid gel (Ivoclar N Etchant, Schaan, Liechtenstein) for 15 s and rinsed with water for 15 s. One-component total-etch adhesive (IvoclarVivadent Te-econom Bond, Schaan, Liechtenstein) was applied to each sample using an adhesive applicator tip according to the manufacturer's instructions. The adhesive was then light-cured for 20 s with an Ivoclar Bluephase PowerCure LED curing light (Ivoclar, Schaan, Liechtenstein) having an irradiance of 1,100 mW/cm^2.

Composite placement and curing

The restoration was performed using a Dentsply Neo Spectra ST (direct nanofilled composite) from Dentsply Sirona,

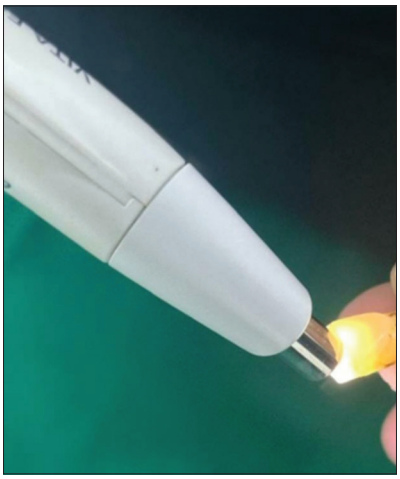

Figure 1: The measurement of laboratory values using the VITA Easyshade V digital spectrophotometer

Charlotte, NC, USA. In Group A, the composite was placed in a 0.5 mm increment; in Group B, it was placed in a 1 mm increment. Each increment was carefully packed and sculpted before curing with the Bluephase light-cure unit for 20 s per increment. This is shown in Figure 2.

Shade measurement post-curing

After post-curing, the L, a, and b values were measured again with the VITA Easyshade V spectrophotometer to check for color differences. Furthermore, the L, a, and b values were measured using the cross-polarizer on Adobe Photoshop software. This is shown in Figures 3 and 4.

Statistical analysis

Calculate Delta E values for color differences between initial and post-curing measurements for both groups. To compare the parameters L, a, and b, compute mean and standard deviation (SD) values. Analyze the Delta E values between the two groups using an independent *t*-test; consider $P < 0.05$ as significant.

RESULTS

It assessed color alteration subsequent to composite restoration with different increment thicknesses in two groups of teeth. Measurements were recorded in terms of L, a, and b in the CIELAB color system before and after curing. Table 1 demonstrates mean and SD values for parameters L, a, and b before and after the placement of the composite for both groups.

Calculation of color difference (ΔE)

The color difference (ΔE) between the initial and post-curing measurements was calculated for each sample according to the formula provided below:

ΔE = (ΔL)2 + (Δa)2 + (Δb)2\Delta E =\sqrt{(\Delta L)2 + (\Delta a)2 + (\Delta b)2}ΔE = (ΔL)2 + (Δa)2 + (Δb)2m Table 2 presents the mean ΔE values and standard deviations for both groups.

Statistical analysis

Normality testing

The Shapiro–Wilk test was used to check for normality of the data. Results of the test indicated that all the variables were normally distributed ($P > 0.05$); therefore, parametric statistical tests could be used.

Comparative analysis

An independent samples *t*-test was run to compare the mean ΔE values between Group A and Group B.

Figure 2: Post-operative image of the composite restoration

Figure 3: Cross-polarized image

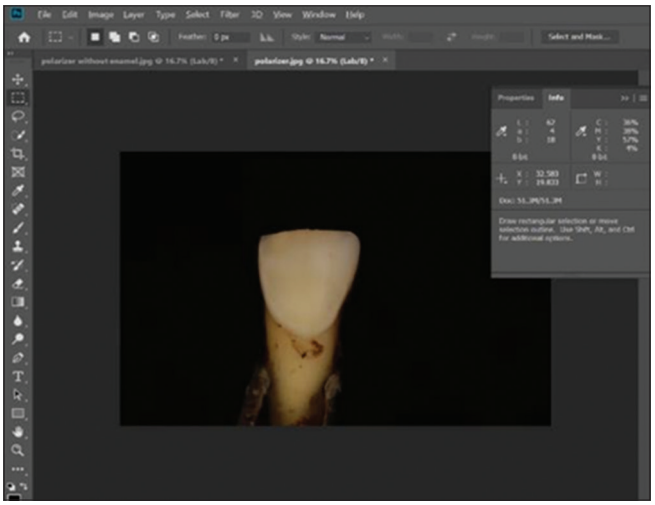

Figure 4: Laboratory values measured on Adobe Photoshop 20

ΔE comparison between groups

- *t*-value: 12.34
- Degrees of Freedom (df): 38
- *P*-value:<0.001.

Table 1: Mean and standard deviation of color parameters before and after composite placement

Parameter	Time point	Group A (0.5 mm increment)	Group B (1 mm increment)
		Mean±SD	Mean±SD
L	Before	57.00±0.50	57.00±0.50
	After	45.00±1.20	43.00±1.50
a	Before	8.00±0.30	8.00±0.30
	After	4.00±0.25	3.00±0.20
b	Before	31.00±0.60	31.00±0.60
	After	18.00±0.40	15.00±0.50

SD: Standard deviation

Table 2: Mean ΔE values between initial and post-curing measurements

Group	MeanΔE±SD
Group A (0.5 mm)	18.14±0.85
Group B (1 mm)	21.84±0.95

SD: Standard deviation

This result means that there was, indeed, a statistically significant difference in ΔE values between the two groups; Group B had a higher mean ΔE than Group A.

Intergroup analysis

A paired samples *t*-test was performed within each group for the comparison of the initial and post-curing L, a, and b values.

Group A (0.5 mm increment)

- L: 0.5
  t-value: 45.67
  df: 19
  $P < 0.001$
- a: 0.5
  t-value: 50.12
  df: 19
  $P < 0.001$
- b: 0.5
  t-value: 55.89
  df: 19
  $P < 0.001$.

Group B (1 mm increment)

- L: 1
  t-value: 48.23
  df: 19
  $P < 0.001$
- a: 1
  t-value: 52.76
  df: 19
  $P < 0.001$
- b: 1
  t-value: 58.34
  df: 19
  $P < 0.001$.

These results show a significant decrease in L, a, and b values after curing in both groups.

DISCUSSION

Correlate the thickness of composite increments during restoration to the color change of enamel in the anterior incisors. The thickness of composite increments potentially affects the final color of restorations; thicker increments are associated with significant color discrepancies compared to thinner ones. There was a significant decrease in L values after curing in both groups. The reduction was really higher in Group B than in Group A.[12] Thick composite increments will, therefore, produce restorations with lower brightness, probably appearing darker in the final restoration. This is how light absorption and scattering work in composite materials; thicker ones provide stronger light attenuation.[13-15] Both groups showed potent decreases in a and b values after placing the composite.[16] These changes reflect a trend toward the green and blue hues, in Group B more markedly. The color change is very important because it shows the interaction of the composite material with the tooth structure. A thick increment may do better in masking the natural tooth color for more predictable and potentially more esthetically pleasing outcomes.[17-19] The calculated "ΔE" values for both groups were higher than the clinically acceptable threshold. Group B had a potentially higher mean ΔE compared to Group A. The human eye can perceive a "Δ" E value above 3.3 by color matching standards; values above 5.5 are clinically unacceptable. Results of the present study indicate color changes that can be perceived and may be unacceptable from an esthetic perspective, as well as with thicker composite increments.[8] Some other studies have reported problems in matching shades with composite restorations, especially in the anterior teeth. Many factors influence the final shade of the restoration, including composite thickness, the shade of the dentin, and the optical properties of the enamel. This study also observed that thin composite increments, as was reported recently,[18] allow better light transmission and interaction with the natural structure of the tooth for an accurate color match. It transformed subjective observation in everyday practice into quantified and objectified color change.[19] The ΔE values between the two groups were significantly different, which underscores that composite thickness is a critical factor for shade matching, particularly in very esthetic cases. The clinical implications are quite

enormous for restorative dentists who want to achieve the best esthetic results. It is, therefore, logical to propose that reducing the thickness of composite increments would make color matching more predictable and reduce the chance for discrepancies to be seen.[20,21] This will enable practitioners to apply minute increments, particularly the final layers of anterior restorations, to ensure that the restoration very closely resembles the color of the natural tooth. Findings also stress the importance of careful case selection and handling the materials during restorative procedures. The dentist should be informed of the optical properties of the composite material to be used and how these properties interact with those of natural tooth structures.[22] This study provides valuable information on the relationship between composite increment thickness and color change, but it is limited. This study was conducted *in vitro,* which cannot be said to completely replicate the oral environment clinically due to the variabilities present within. It does not account for saliva, variations in temperature, and mechanical stresses, so it may impact how well the results can be extrapolated to other cases. Only two increment techniques were used. Thicknesses of more *in vivo* methodologies and future studies may consider the clinical implications.

CONCLUSION

This study was conducted to determine the effect of the thickness of composite increments on the final shade of anterior restorations in CIELAB color space values and "ΔE" metrics. A 1 mm thickness of composite increments resulted in a significantly different final shade, much lower in lightness, and more chromatic in color, specifically higher a and b values. All results ended up having "ΔE" values over the clinically acceptable threshold; thicker increments would lead to restorations with less favorable esthetic outcomes. The smaller 0.5 mm increments showed less color change with "ΔE" values closer to the acceptable range, but still visible. These results clearly indicate the impact of composite increment thickness on shade matching, especially for the esthetic anterior region. This would be an argument for the case of thinner composite layers in attempting to match natural tooth colors for optimal esthetic results. The dentist should consider the thickness of the composite layer in restorative work and how material properties will indirectly influence the final appearance of the restoration. In general, for better aesthetic results in anterior restorations, thinner composite increments are advised. Other areas that could be looked into involve more detailed research in the complex interaction between composite materials, increment thickness, and other factors, such as curing methods and natural tooth structure, to give more precise guidelines for restorative dentistry.

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REFERENCES

1. Joiner A. Tooth colour: A review of the literature. J Dent 2004;32:3-12.
2. Brewer JD, Wee A, Seghi R. Advances in color matching. Dent Clin North Am 2004;48:341-58.
3. Paul S, Peter A, Pietrobon N, Hammerle CH. Visual and spectrophotometric shade analysis of human teeth. J Dent Res 2002;81:578-82.
4. Chu SJ, Devigus A, Mieleszko AJ. Fundamentals of Color: Shade Matching and Communication in Esthetic Dentistry. Germany: Quintessence Publishing Co; 2004.
5. Paravina RD, Powers JM, Fay RM. Color comparison of two shade guides. Int J Prosthodont 2004;17:327-31.
6. Li Q, Yu H, Wang YN, Gao P. Effects of dehydration on light reflectance and transmittance of human dentine. Arch Oral Biol 2009;54:983-9.
7. Ragain JC, Johnston WM. Accuracy of a dental shade-matching instrument. J Prosthetic Dent 2001;86:402-6.
8. Ishikawa-Nagai S, Yoshida A, Sakai M, Kristiansen J, DaSilva JD. Clinical evaluation of perceptibility of color differences between natural teeth and all-ceramic crowns. J Dent 2010;38:e28-36.
9. Seghi RR, Johnston WM. Evaluation of a shade guide system for color matching restored teeth. Quintessence Int 1990;21:507-15.
10. Wee AG, Lindsey DT, Kuo S, Johnston WM. Color accuracy of commercial digital cameras for use in dentistry. Dent Mater 2006;22:553-9.
11. Dancy WM, Chafin MS, Johnson G. The effect of dehydration on the perception of enamel whiteness. J Esthetic Restorative Dent 2017;29:38-43.
12. Douglas RD, Steinhauer TJ. Intra oral determination of the optical properties of human dentin and enamel. J Prosthet Dent 2007;97:389.
13. Goodkind RJ, Loupe MJ. An analysis of two shade guides: The relationship between change in color difference and illuminance level. J Prosthet Dent 1992;67:612-5.
14. Hemalatha H, Sandeep M, Kulkarni S, Yakub SS. Evaluation of fracture resistance in simulated immature teeth using Resilon and Ribbond as root reinforcements--an *in vitro* study. Dent Traumatol 2009;25:433-8.
15. Tuncdemir AR, Yavuz MS. The effect of dehydration on shade selection of vital teeth. J Prosthodont 2008;17:415-9.
16. Pradeep S. Comparative evaluation of patients undergoing post treatment based on ferrule design in maxillary central incisor-a retrospective analysis. Int J Clin Dent 2022;15:441-7.
17. Rajagopal S, Sharma S. Comparative evaluation of retentive strength of different bevel designs using direct composite restoration on anterior teeth-an *in-vitro* study. J Clin Otorhinolaryngol Head Neck Surg 2023;27:5409-18.
18. Ranjan M, Hemmanur S. Sandeep AH. Survival rate of endodontically treated teeth with custom made cast post-a systematic review. Int J Dent Oral Sci 2021;8:2574-80.
19. Keerthika R, Sharma S, Sugumaran S. Assessing the influence of type of base materials on choosing permanent restoration in pulp capping-a retrospective analysis. J Contemp Issues Bus Gov 2021;27:434-42.

20. Garlapati TG, Krithikadatta J, Natanasabapathy V. Fracture resistance of endodontically treated teeth restored with short fiber composite used as a core material-an *in vitro* study. J Prosthodont Res 2017;61: 464-70.
21. ShahT, Adimulapu SH, Nivedhitha MS, Mehta A, Sugumaran S. The effect of surface treatments of tooth on the shear bond strength of direct composite veneers: An *in vitro* scanning electron microscope study. J Conserv Dent Endod 2023;26:539-43.
22. Aparna J, Maiti S, Jessy P. Polyether ether ketone - as an alternative biomaterial for metal Richmond crown-3-dimensional finite element analysis. J Conserv Dent 2022;24:553-7.

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