

Effect of Universal Shade of Resin Cement on the Final Color of Ceramic Restorations

Üniversal Renk Rezin Simanın Seramik Restorasyonların Final Rengi Üzerine Etkisi

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Abstract

Objective: To investigate the effect of neutral (N) and universal (Un) shade resin cement on the final color of thin ceramic restorations.

Materials and Methods: Forty specimens (8×8×0.8 mm³) were sliced from five leucite reinforced glass-ceramic blocks. Another 40 rectangular composite specimens were prepared from a resin die material (8×8×4 mm³; IPS Natural Die Material, A1 and A 3,5 IvoclarVivadent) simulating prepared teeth and divided into two cement colors. (N and Un) After baseline color measurements, each slice was cemented to a composite resin specimen, and measurements were obtained with a spectrophotometer on a white background in daylight by a single experienced investigator. The difference between the baseline and final color measurements was calculated in accordance with the CIEDE2000 color measurement formula. The CIEDE2000 perceptibility and acceptability thresholds were set to 0.8 and 1.8. The data were statistically analysed with Shapiro-Wilk and Mann-Whitney U test.

Results: No significant difference was observed between Δ_{00} value in the N (1.18±0.40) and Un (1.26±0.52) groups for the light background. The mean differences between the N (0.74±0.31) and Un (0.88±0.55) groups were insignificant for the dark background (p>0.05).

Conclusion: The Un shade cement used in this study may mask the dark tooth structure when using 0.8 mm-thickness ceramic restorations. However, the results may not be clinically satisfying. The Un shade resin cement used in this study provided an improvement in color although it was insufficient to mask the underlying dark background completely. Using Un shade resin cement is a challenge under 0.8 mm-thickness ceramic restorations of dark-colored teeth. If preferred, the ceramic thickness should be increased.

Öz

Amaç: Çalışmanın amacı, nötral (N) ve üniversal (Un) rezin simanın ince seramik restorasyonlarının final rengine etkisinin değerlendirilmesidir.

Gereç ve Yöntemler: Çalışmamız için kırk adet lötis ile güçlendirilmiş cam seramik örnek (8×8×0,8 mm) elde edildi. Dental dokuyu taklit eden bir rezin kompozit malzemesinden (8×8×4 mm; IPS Natural Die Material, A1 ve A 3,5 IvoclarVivadent) kırk adet dikdörtgen altyapı örneği hazırlandı ve 2 rezin siman grubuna ayrıldı

(N ve Un). Başlangıç renk ölçümlerinden sonra, her seramik dilim bir kompozit rezin örneğinin üzerine yapıştırıldı ve deneyimli bir araştırmacı tarafından gün ışığında beyaz zemin üzerinde bir spektrofotometre ile ölçümler alındı. Başlangıç ve sonuç ölçümleri arasındaki farklılık CIEDE2000 renk ölçüm formülüne göre hesaplandı. CIEDE2000 renk ölçümü için algılanabilirlik ve kabul edilebilirlik eşik değerleri 0,8 ve 1,8 olarak ayarlandı. Veriler, Shapiro-Wilk ve Mann-Whitney U testi ile istatistiksel olarak analiz edildi.

Bulgular: Açık arka plan için N ($1,18 \pm 0,40$) ve Un ($1,26 \pm 0,52$) gruplarda Δ_{00} değerleri arasında anlamlı bir fark yoktu. Koyu arka plan için alınan değerlerde N ($0,74 \pm 0,31$) ve Un ($0,88 \pm 0,55$) gruplar arasında anlamlı bir fark bulunmamıştır ($p > 0,05$).

Sonuç: Bu çalışmanın sonuçlarına göre kullanılan Un renk rezin simanın, 0,8 mm kalınlığında seramik restorasyonlar altında koyu diş yapısını maskeleyebildiği, ancak sonuçların klinik olarak tatmin edici olmadığı görülmektedir. Bu çalışmada kullanılan rezin siman, alttaki koyu arka planı tamamen maskelemek için yetersiz olsa bile renkte bir iyileşme sağlamıştır. Koyu renkli dişlerde 0,8 mm kalınlığında seramik restorasyonların simantasyonunda Un renkte rezin siman tercih edilecek ise restorasyonun seramik kalınlığının artırılması gereklidir.

Introduction

Ceramic veneer restorations are an esthetic treatment option with a high clinical survival rate of up to 93.5% during long-term follow-up (1). In addition, this type of restoration, which aims to protect the dental tissue with minimal or no preparation, meets the patient's esthetic needs. Thanks to recently developed ceramic materials and adhesive systems, it has become easier to achieve superior esthetic results, especially with anterior restorations (2).

There are many causes of tooth discoloration, including trauma, intrapulpal hemorrhage, root resorption, and dental tissue after endodontic treatment (3). Ceramic restorations are one of the most common and preferred treatments to reestablish the esthetic appearance of discolored teeth. However, due to the translucent nature of ceramics, underlying dental background may reflect, which negatively impacts the esthetic outcome, especially if ultra-thin ceramic restorations are used. During the rehabilitation of a dark-colored tooth with ceramic restorations, it can be challenging to perfectly match an appropriate cement and ceramic thickness. To overcome this problem, newly developed resin cements and ceramics have been produced in order to mask dark-colored teeth (4-7).

Color measurement can be determined visually or with a device. The accuracy of color measurements may vary depending on the type of measurement. Color measuring devices, including spectrophotometers and colorimeters, provide more objective results compared to visual evaluation, and they are often preferred because they provide numerical color expression and standardization (8,9).

The International Commission on Illumination (CIE) mentioned different color determination systems.

One of them is the CIELAB formula (ΔE_{ab}^*) system. It was found that this formula measures the dimensions of color differences between initial and final color differences. These three measurements are related to three dimensions of the space in the coordinate axis (X, Y, Z, for L^* , a^* , b^*) and human color perception. The L^* axis measures lightness (vertical axis), where values from 0 to 100 represent the transition from black to white. The a^* axis measures the quantity of the red and green values, which refers to the transition from positive to negative from red to green. The b^* axis measures yellow and blue values, which represents the transition from positive to negative from yellow to blue. According to the CIELAB formula (ΔE_{ab}^*), new color-difference formulas, including CIEDE2000 (ΔE_{00}), have been developed and reinforce the importance of the original hue and value concepts used by Munsell (10). The Δ_{00} color-difference formula includes various revisions for CIELAB color values (weighting functions: SL, SC, SH, rotation term: RT, parametric factors: KL, KC, KH) (11). The perceptibility and acceptability thresholds of Δ_{00} were set to 0.8 and 1.8 (12).

The purpose of this study was to investigate the effect of neutral (N) and universal (Un) shade resin cement on the final color changes of thin ceramic restorations on light and dark backgrounds using the Δ_{00} color-difference formula. The null hypothesis was that the application of N and Un shade resin cement on light and dark background would be similar on final color thin ceramic restorations.

Materials and Methods

The materials used in this study have been listed Table 1. Five glass-ceramic blocks (IPS Empress A1-HT; Ivoclar Vivadent, Schaan, Liechtenstein) were used in this study. Thin ceramic slices (8×8×0.8 mm) were

Table 1. The materials used in this study

Materials	Shade	Codes	Manufacturer	Composition	Type
Variolink N LC	Neutral	N	Ivoclar Vivadent, Schaan, Liechtenstein	UDMA, methacrylate, ytterbium trifluoride and spheroid mixed oxide, autopolymerizing initiators, light-polymerizing initiators, stabilizer, pigments	Light-cure
ESTECCEM II	Universal	Un	Tokuyama Dental, Tokyo, Japan	Bis-GMA, TEGDMA, Bis-MPEPP, Peroxide, Camphorquinone and Silica-Zirconia Filler	Dual-cure
Ips Empress Material	A1	-	Ivoclar Vivadent, Schaan, Liechtenstein	Leucite-based Glass ceramic	-
Ips Natural Die	A1 A3,5	-	Ivoclar Vivadent, Schaan, Liechtenstein	-	Light-cure composite

obtained with a low-speed diamond saw (Isomet 1000; Buehler, Lake Bluff, IL, USA) under continuous water cooling ($n=40$). A resin die material (IPS Natural Die Material; Ivoclar Vivadent) in two shades (light background: A1, dark background: A3,5) was used to prepare rectangular-shaped ($8 \times 8 \times 4$ mm) tooth-shaded background specimens to simulate underlying dental substrates. A metal mold was prepared to obtain the resin composites ($8 \times 8 \times 4$ mm). The metal mold was placed on the glass surface, and the composite material was added to the metal mold without air gaps. A new glass surface was placed on the metal mold to obtain a smooth surface. The resin composite materials were polymerized for 40 seconds ($n=40$). Then, each group was divided into two different shades of resin cement: N (Variolink Esthetic LC, N; Ivoclar Vivadent) and Un (ESTECCEM II Un; Tokuyama Dental, Tokyo, Japan) ($n=20$).

One side of each ceramic and composite resin specimen was polished with 600-800-1,000-1,200 gradient silicon carbide abrasive papers sequentially (Leco VP 100; Leco Instrumente GmbH, Monchengladbach, Germany) under continuous water cooling for standardization. The thickness of each specimen was measured and controlled with a digital micrometer (Mitutoyo Corporation, Tokyo, Japan). All ceramic specimens were glazed with using Un Glaze Spray (Ivoclar Vivadent). Before cementation, 4.9% hydrofluoric acid (IPS Etching Gel; Ivoclar Vivadent) was applied to the ceramic surfaces for 60 seconds. After acid etching, etched surfaces were water-rinsed and air-dried. Then, silane (Monobond Plus; Ivoclar Vivadent) application was carried out onto

the surfaces of the ceramic and die materials for 60 seconds.

Before cementation, baseline color measurements were carried out with a digital spectrophotometer (VITA Easyshade; VITA Zahnfabrik, Bad Säckingen, Germany) on a standard white background ($L^*=90.9$, $a^*=0.3$, $b^*=4.9$). Resin cements were applied according to the manufacturer's instructions and light cured with an light-emitting diode light-curing device (Bluephase 1,200 mW/cm²; Ivoclar Vivadent AG) for 120 seconds while 250 g of load applying (Figure 1) (13). After cementation, excessive resin cement was removed and measurements were carried out with a digital spectrophotometer on a standard white background.

The ΔE_{00} color formula was used to calculate the color differences between the baseline and the final measurements (14).

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{K_L S_L}\right)^2 + \left(\frac{\Delta C'}{K_C S_C}\right)^2 + \left(\frac{\Delta H'}{K_H S_H}\right)^2 + R_T \left(\frac{\Delta C'}{K_C S_C}\right) \left(\frac{\Delta H'}{K_H S_H}\right)},$$

To decrease measurement uncertainty, the device was calibrated according to the manufacturer's instructions before and after measurement of each specimen. After the calibration was completed, the measurements were carried out at the center of each specimen by the same experienced investigator (Figure 2). The $L^*a^*b^*$ color measurements were made three times from each sample and recorded by taking the average values.

Statistical Analysis

According to a pilot study, for a power analysis with a 0.05 level and 80% power the required minimum sample size was $n=40$. Statistical analysis was performed using SPSS 19.0 for Windows software (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used to determine normality, and the test results showed that the data were not distributed normally therefore Kruskal-Wallis was performed. The Mann-Whitney U test was performed to determine whether color differences were significantly different between each group. The significance level was set at $p<0.05$ ($p<0.05$).



Figure 1. Resin cements were carried out onto dark and light background according to the manufacturer's instructions

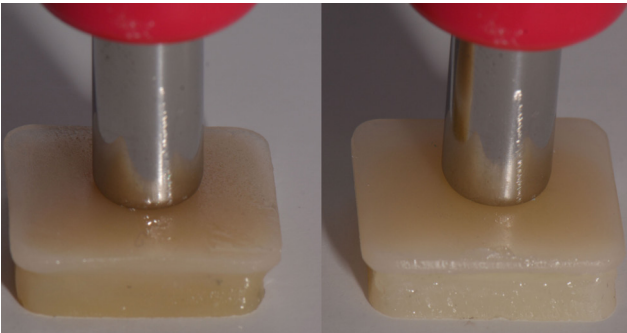


Figure 2. Measurements were recorded in CIELAB coordinates with using a spectrophotometer in dark and light substructure, respectively

Results

The Δ_{00} $\mu\text{m} \pm$ standard deviation values were shown in Table 2. There were no significant difference between Δ_{00} values in both the N (1.18 ± 0.40) and Un (1.26 ± 0.52) groups for the light background. Mean differences between N (0.74 ± 0.31) and Un (0.88 ± 0.55) were insignificant for the dark background ($p>0.05$).

For the N group, there was a statistically significant difference between light (1.18 ± 0.40) and dark (0.74 ± 0.31) backgrounds ($p<0.05$). There was no statistically significant difference between light (1.26 ± 0.52) and dark (0.88 ± 0.55) backgrounds for the Un group. All Δ_{00} values were between acceptability and perceptibility color thresholds ($0.8 < \Delta_{00} < 1.8$) except for the value obtained from the dark background of the N (0.74 ± 0.31) resin cement group ($\Delta_{00} < 0.8$).

Discussion

In this study, the effect of Un and N shade resin cements on the final color changes of thin ceramic restorations on light and dark backgrounds was investigated using Δ_{00} . There was no significant difference between Δ_{00} value in both the N and Un groups for the light and dark backgrounds. However, considering the results obtained, it was seen that while the N cement was not able to mask the dark substructure, the Un cement could. Therefore, the null hypothesis was particularly rejected.

A statistically significant difference was observed between the light and dark backgrounds for the N cement group. This study found that the underlying tooth color can be reflected under 0.8 mm thick ceramic restorations and affect the final color, which is consistent with the findings of previous studies (4,15-17).

From a clinical standpoint, successful color matching is an important aspect for obtaining esthetic restorations and must be attained with the

Table 2. The mean Δ_{00} values and levels of significance according to differing cements and backgrounds

	Δ_{00}	
Background (light)	N	1.18 ± 0.40
	Un	1.26 ± 0.52
Background (dark)	N	0.74 ± 0.31
	Un	0.88 ± 0.55

* $p<0.05$, N: Neutral, Un: Universal

optimal harmony of different variables. Ceramics type and thickness, adhesive resin cement, and underlying tooth color have an effect on the long-term color stability of esthetic restorations (16,18). Superior translucencies can be achieved with 0.3 mm to 1.0 mm thick, adhesively cemented ceramic laminate veneers with or without preparation. Thus, esthetically satisfying results can be obtained with ultra-thin ceramic restorations (2). However, resin cement polymerization can cause discoloration, which can negatively affect the final color beneath thinner and more transparent ceramic laminate restorations on dark underlying tooth structures (19,20). In the present study, it was concluded that the N shade cement applied with 0.8 mm thick ceramic restorations could not mask the underlying dark background. To overcome this problem clinically, use opaque and chromatic ceramic to cover the colorless substrate is recommended. Besides, clinicians should avoid to prefer minimal tooth preparation (4,8,15).

In the results of this present study, it was seen that Un shade resin cement, although clinically unsatisfactory, could mask dark background but it has not been found to be effective in achieving the final color (A1). A previous study evaluated the effect of different shades of resin cements (A1 and A3, opaque and translucent) on the final color of 1.0-mm A1-shade leucite reinforced ceramics, and it was observed that resin cements affect the final color of restorations (2). In another studies, the selected resin shades influenced the final color of leucite reinforced ceramics, and they could not be masked the dark background except for the opaque resin shade, and used resin shades made the ceramic specimens lighter or darker (7,15,21,22). Giti et al. (23) concluded that Un resin shade (A2) decreased the lightness of 0.5-mm thickness leucite reinforced ceramic. The results of another study also reported that Un shade of resin cement was not visually perceptible lithium disilicate ceramic in 1.5-mm thickness (14).

The Δ_{00} values obtained from the N resin cement group on dark background were under acceptability and perceptibility thresholds ($\Delta_{00} < 0.8$), but the others were between acceptability and perceptibility thresholds ($0.8 < \Delta_{00} < 1.8$). These results have shown that the Un cement group could mask the dark background but was slightly higher than the acceptable level. From a clinical point of view, we

think that using Un shade resin cement can change the underlying dark-colored background but cannot reach the desired shade.

In this study, the cement group Un showed higher Δ_{00} values in both light and dark backgrounds, but there was no statistically significant difference from the N cement group. This can be explained by the composition of various amounts of color ingredients in Un shade resin cement compared to N shade.

CIELAB is the most common system for color measurement in dental materials. Nevertheless, there are some shortcomings in the CIELAB color space system, especially about the hue value described by Munsell. In order to improve CIELAB (ΔE_{ab}), various color-difference formulas based on CIELAB have been developed, such as CMC, CIE94, and CIEDE2000 (Δ_{00}) (10). In color differences studies, the CIEDE2000 color-difference formula was found to be more accurate and represent the color differences perceived by the human eye (24,25). The value of Δ_{00} units showed the clinical influence of resin cements used on the final shade of the specimens. The results were evaluated according to the acceptability and perceptibility threshold ($0.8 < \Delta_{00} < 1.8$) values. Such numerical values can be used as a control vehicle to guide the selection of esthetic dental materials and to understand and interpret visual and instrumental results that affect clinical performance (12).

ESTECM II Un resin cement and leucite-based ceramic block were used in the current study because there are no previous *in vivo* studies evaluating the effect of the final color using those materials together. Besides this, further clinical studies considering the effect of Un shade resin cement on final color are needed.

The limitations of this study are that only two shades of luting cement were evaluated and no aging procedures were applied. Further studies should be conducted considering other shades of luting cement and changes recorded after aging procedures.

Conclusion

Within the limitations of this study, it can be concluded that background and luting cement color had significant effects on the final color of thin ceramic restorations. It was observed that the Un shade resin cement used in the study might mask the dark tooth structure when using 0.8 mm thickness

ceramic restorations. However, the results may not be clinically satisfying. Further clinical studies are needed in order to assess the effect of dual-curing Un resin cement, which was used in this study, on final color changes.

Ethics

Ethics Committee Approval: Since the materials used in this study do not related with any patient, ethical approval was not required.

Informed Consent: Since the materials used in this study do not related with any patient, informed patient approval was not required.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: G.P., Design: G.P., B.Y., D.R., Supervision: B.Y., Data Collection or Processing: D.R., Analysis or Interpretation: G.P., B.Y., Literature Search: G.P., D.R., Writing: G.P., B.Y., D.R., Critical Review: G.P., B.Y., D.R.

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