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Original Research

Effect of Different Colors of Resin Cement and Stainability on the Final Color of CAD/CAM Materials

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ABSTRACT

Objective: A computer-aided design/computer-aided manufacturing (CAD/CAM) system is the most popular technology that produces ceramics and has gained increasing popularity in dentistry. In the present study, we aimed to investigate the effect of four colors of resin cements and the stainability effect of hot coffee on the final color of glass ceramic (GC) CAD/CAM blocks.

Methods: Two colors of a CAD/CAM restorative material of 1 mm thickness with four colors of a dual–curing resin cement of 0.5 mm thickness were tested in this study (n=5). After cementation, the specimens were divided into two groups for thermocycling one half of them with coffee and the remaining without coffee. The first spectrophotometric measurement was applied after cementation and the second after thermocycling. Data were analyzed using the Statistical Package for Social Sciences software (SPSS®), and a p value of <0.05 was accepted as significant.

Results: The color of resin cement did not significantly affect the restoration of the final color of the GC. Statistically significant differences were found in white, transparent, and yellow colors of the resin cement after thermocycling with/without hot coffee.

Conclusion: The esthetic achievement of porcelain laminates can be affected by the color of the resin cements. The GC of 1 mm thickness was not affected by the resin cement color after cementation. The color of resin cement can change in the duration of its usage.

Keywords: Computer-aided design/computer-aided manufacturing, stainability, color change

INTRODUCTION

Modern healthcare has progressed due to developments in science and technology. A computer-aided design/computer-aided manufacturing (CAD/CAM) system is the most popular technology used for producing ceramics and has gained increasing popularity in the area of dentistry (1). There are many CAD/CAM blocks with advantages, such as biocompatibility; durability; esthetics; fewer clinical stages; rapid production, cost effectiveness; different contents; and physical properties, such as lithium disilicate glass ceramic (GCs), leucite-reinforced GCs, feldspathic GCs, aluminum-oxide, and yttrium tetragonal zirconia polycrystal (2).

GCs are the commonly used materials in dental prostheses, and CAD/CAM blocks provide thinner restorative materials with increased translucency, producing more conservative and esthetic restorations as laminate veneers. The surface texture, production steps of porcelain, and underlying resin cement could influence the optical properties of ceramics (3, 4). GC incontent of crystalline component has high light transmission and mechanical properties. Feldspathic porcelains (CEREC Blocs PC, Sirona) are fabricated using fine-grained powders to produce a nearly pore-free ceramic with fine crystals, which results in improved polish ability and decreased enamel wear (5). The polychromatic feature gives feldspathic ceramic a natural appearance in the anterior teeth with several layers of color.

Color evaluation can be performed using two basic methods: objective and subjective. Subjective measurement methods using porcelain or acrylic resin shade guides have some limitations, which affect the color perception lie. The color perception can be changed according to the lighting terms, age, conditions, experiences, and human eye strain (6). Spectrophotometry as an objective practice is more reliable and sensitive than the visual scale. A color difference (ΔE) between two measurements can be calculated within the CIELAB color system. The mechanism of a spectrophotometer is based on the CIELAB system, which has three axes: L* axis (from 0 to 100; black–white) representing clearness and a* and b* representing the redness–greenness and yellowness–blueness axis, respectively (7). Calculations are based on the following equation:

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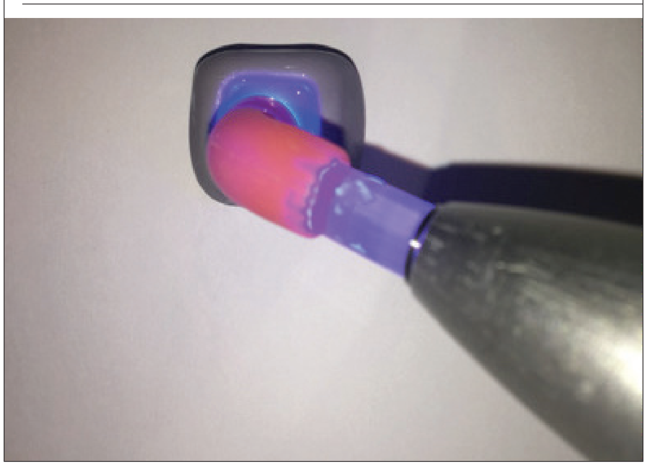
Table 1. Materials tested in the study and distribution of specimens

Resin cement		Glass ceramic		Termocycling			
Variolink N, base	Variolink N, catalist	A1	A2	A1 with coffee/without coffee		A2 with coffee/without coffee	
Bleach xl	Transparent low viscosity	n=10	n=10	n=5	n=5	n=5	n=5
White a1	Transparent low viscosity	n=10	n=10	n=5	n=5	n=5	n=5
Yellow a3	Transparent low viscosity	n=10	n=10	n=5	n=5	n=5	n=5
Transparant	Transparent low viscosity	n=10	n=10	n=5	n=5	n=5	n=5

Figure 1. Preparing for cementation of GC specimens in silicon mold
GC: glass ceramic

Figure 2. Light curing of GC specimens
GC: glass ceramic



ΔE (L,a,b)=[(L1–L2)2+(a1–a2)2+(b1–b2)2]1/2 (8).

The cement color, ceramic layer thickness, and tooth structure color identify the final color of ceramic veneer restorations (9, 10). Several studies that analyzed the effect of resin cement shades on veneer restorations have found that a variation in the thickness of the ceramic material and different shades of cement can lead to perceptible color differences in veneer restorations (9). The restoration of the final color is affected by the cement color; however, it seems to have less influence on the overall color of the definitive restoration compared to the other variables (3, 11).

The color stability of a material is important, as the mechanical features and many factors are related to the color change of the dental materials in the mouth (12, 13). Clinical usage may affect the color durability of restorations. The longevity of dental materials has been evaluated by artificial aging in many in-vitro studies. The null hypothesis of the present study was that different colors of the same resin cement do not affect the dyeability of the GC, and thermocycling with or without coffee does not affect the measured color change. The purpose of current study was to investigate the effect of four colors of resin cement and stainability of hot coffee on the final color of GC CAD/CAM blocks after thermocycling.

METHODS

Two colors of a CAD/CAM restorative material (CEREC Blocs PC, Sirona) with four colors of a dual–curing resin cement (Variolink N; Ivoclar Vivadent) were tested in this study (Table 1). Two groups of GC specimens (N=40/group), A1 and A2, were prepared using a slow-speed diamond blade (Buehler® Wafering Blades, series 15 LC diamond; Microstructural Analyses Division) and a cutting machine (Vari/cut VC-50; LECO Corp.) into rectangular plate slices of 1 mm in thickness (n=5). The GC samples were polished using 600, 800, and 1200 grit silicon carbide abrasive papers (3 M ESPE, St. Paul, MN, USA) for 15 s using a 170-rev/min grinding machine (Minitech 233; Presi, Grenoble, France) under running water. The GCs were then ultrasonically cleaned for 3 min in ethanol and deionized water and air-dried. The final thicknesses of each specimen was measured using a digital micrometer. Before the cementation and aging procedure, the color values of ceramic groups were measured under the standard illuminant D65 on a white background (14).

Cementation of Glass Ceramic with Resin Cement

Only one GC specimen was prepared with 1.0 mm thickness. The specimen was placed on a smooth plane and boxed with putty silicon (Zetaplus-Zhermack). A glass slab was placed on the specimen until the impression material solidified. A silicon rim was obtained with a height of 1.5 mm. The GC specimen surfaces were placed in the silicon box, and cement was applied in a standard condition by the rim (Figure 1). Therefore, the cement thickness was adjusted 0.5 mm.

Table 2. ΔE values, standard deviatians (SD) and mean values

			Subdivision		
Ceramic	**Resin cement**		**Coffee Mean±SD**	**Without coffee Mean±SD**	**p**
A1	Bleach XL	ΔE 1	6.84±0.67	5.67±1.11	0.087
		ΔE 2	6.74±1.00	6.52±1.25	0.750
		ΔE difference	2.34±0.80	1.74±0.66	0.238
	White A1	ΔE 1	9.48±0.84	11.00±1.57	0.106
		ΔE 2	9.23±0.68	9.29±2.49	0.964
		ΔE difference	3.40±1.02	5.83±0.72	0.011*
	Yellow A3	ΔE 1	13.66±0.48	13.47±1.93	0.838
		ΔE 2	13.26±1.40	11.44±1.51	0.123
		ΔE difference	4.61±2.28	7.63±1.15	0.086
	Transparant	ΔE 1	9.20±0.80	8.81±2.15	0.729
		ΔE 2	9.43±2.04	6.38±0.71	0.055
		ΔE difference	5.65±0.62	6.38 ± 1.19	0.338
A2	Bleach XL	ΔE 1	5.81±0.62	5.80±0.45	0.973
		ΔE 2	6.66±1.35	4.50±0.92	0.072
		ΔE difference	2.75±1.06	3.00±0.85	0.677
	White A1	ΔE 1	8.66±1.14	8.39±2.02	0.797
		ΔE 2	8.48±2.56	2.90±1.49	0.025*
		ΔE difference	4.28±0.83	6.75±2.49	0.176
	Yellow A3	ΔE 1	12.08±1.21	10.16±1.66	0.091
		ΔE 2	10.58±1.77	7.53±1.48	0.029*
		ΔE difference	4.13±1.12	5.57±1.61	0.171
	Transparant	ΔE 1	8.98±1.17	8.84±1.42	0.842
		ΔE 2	9.72±1.72	5.77±1.42	0.009*
		ΔE difference	5.20±1.50	3.82±0.36	0.130

ΔE: Color change; *: $p<0.05$

On each specimen, a hydrophilic acid (porcelain etch and silane, Ultradent, USA) was applied and rinsed for 20 s. After drying, bonding (monobond, Variolink N; Ivoclar Vivadent) was applied on each specimen. Four different shades of resin cement (yellow, white, transparent, bleach XL, base and transparent low viscosity catalyst) was applied in two groups of GC (A1 and A2) and cured for 20 s (Figure 2). After removing the mold, light polymerization was repeated for 40 s for both surfaces to ensure complete light curing. The measurement of color was performed using a color spectrophotometer for consistent and objective results for all specimens (15, 16).

Thermocycling

A coffee solution was prepared according to the manufacturer's instructions: 60 g coffee in 1 L of water placed in a hot tank. The coffee in the hot tank was refreshed every 8 hours. One-half of the cemented specimens from each group were subjected to 5,000 thermocycles (SD Mechatronik Thermocycler) between two water baths of 5°C and 55°C with a dwell time of 30 s at each temperature extreme in coffee and the remaining specimens were subjected to thermocycling in a bath without coffee water bath. After thermocycling, the specimens were washed and brushed with toothpaste 10 times and dried with paper (12). The samples were measured using a spectrophotometer after mechanical cycling with and without coffee. Thus, the color measurement was performed the second time in the same conditions of a white background because this is considered more suitable for the posterior teeth (17).

Color Measurement of Ceramic Specimens

A contact spectrophotometer (Vita Easyshade®, Vita-Zanhnfabrik®, Bad Säckingen, Germany) was used for measuring the color. The baseline color values were L*, a* and b*, in which L* represents the value from 0 (black) to 100 (white) and a* and b* represent the shade, where a* is the measurement along the red–green axis and b* is the measurement along the yellow–blue axis. The samples were placed in a 37.8°C water bath in dark for 24 h.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS®) software (SPSS, IBM Corp.; Armonk, NY, USA) was used for the analysis, and a p value of <0.05 was accepted as significant. The normality of the data distribution was tested using the Shapiro–Wilk test. Analysis of variance and the least significant difference (LSD) test were used to compare normally distributed data, which were reported as mean±standard deviation. The General Linear Model (Univariate) test was used for comparison of independent variables. Fisher's LSD and Bonferroni tests were used for post hoc analysis.

RESULTS

The mean and standard deviations of the color difference values between before (initial measurements) and after aging (with/without coffee; final measurements) are represented in Table 2. The statistical analysis of ΔE values is also shown (for each column), which corresponds to a comparison between the materials in each staining solution.

None of the resin cement colors affected the restoration of the final color. Statistically significant differences were found between the groups of A1 ceramic cemented with transparent resin and coffee thermocycling and A2 ceramic cemented with yellow resin and coffee thermocycling. Also, A1 and A2 ceramic cemented with white resin showed statistically significant difference between with and without coffee thermocycling.

DISCUSSION

In the present study, the effect of the resin cement color and two types of thermocycling (with and without coffee) on the final restoration of color were evaluated. Eight materials were tested: two colors of CAD/CAM GC blocks and four colors of resin cement. The GC blocks included a feldspathic ceramic incontent of the crystalline component (CEREC Blocs PC, Sirona). The monomer matrix of Variolink N resin cement is composed of bisphenol A-glycidyl methacrylate (BisGMA), urethane dimethacrylate, and triethylene glycol dimethacrylate. A spectrophotometer was preferred as an objective criterion instead of a visual examination (4).

Many methods, such as visual inspection using a standard shade guide, for evaluating the color effect are subjective, while objective methods include spectrophotometry, colorimetry, and analysis software usage. A spectrophotometer was used in the current study for calculating the differences in L*, a*, b* values and resulting color differences DE values because we decided to prefer well-known DE values as color measurement (15). Also, the background effect of color perception is controversial and white background has been used widely as a standard background, as in our study (16).

A ΔE value >3.7 is a clinically unacceptable color change. High ΔE values in this study may be based on the optical properties of the material, which is described as high translucency material due to the optical combination of a glass matrix that reduces internal scattering of the light as it passes through the material. Medium or high opacity that are designated for the fabrication of core structures might be a resolution for this situation (17). In the current study, resin cements did not affect the restoration of color in all the groups before the aging procedure. However, after aging, different color changes were observed. The water absorption of the composite resin can be a sign of color change when absorbing colored liquids in line with a study by Bagheri et al. (18). In the present study, the color change of materials was evaluated with/without coffee thermocycling.

The different shades of resin cement did not influence the overall color of porcelain veneer alone and may be related to the limited thickness and translucency of resin cement under the cemented veneers (19). The resin cement tested in the current study contains Bis-GMA, which is a monomer having chemical structure groups. The chemical groups are prone to hydrolysis and/or hydrogen bridging with water due to the hydroxyl in Bis-GMA. Hydrolytic degradation and hygroscopic effects of the materials are signs of color variation in resin-based materials (20). The present study supported the agreement that different resin cement colors do not affect the restoration of the final color but only the aging with coffee affects A1 ceramic cemented transparent and white resin cements, and A2 ceramic cemented yellow and white resin cements of specimens.

The thin layer of the agents bonded to ceramic disks with no dental structure involved limited the study, thereby lacking simulation to a clinical situation.

CONCLUSION

The esthetic achievement of porcelain laminates can be affected by the color of the resin cements. A GC of 1 mm thickness did not affect only resin cement color after cementation. The color of resin cements can change during its usage. The current results indicate that resin cements aging with coffee affect the final color of restoration for transparent, yellow, and white colors. The influence of abutment tooth color should be considered in future studies.

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Informed Consent: N/A.

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