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G. Uzun & F. Keyf

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EFFECT OF DIFFERENT CEMENT COLORS ON THE FINAL COLOR OF IPS EMPRESS CERAMIC RESTORATIONS

G. Uzun[1], F. Keyf[2]
Hacettepe University, School of Dental Technology, Sıhhıye, Ankara, Turkey[1]
Hacettepe University, Faculty of Dentistry, Department of Prosthodontics, Sihhıye, Ankara, Turkey[2]
Correspondence to: Gülay Uzun
E-mail: vuzun@hacettepe.edu.tr

ABSTRACT

In this study, the effects of the color of different post-core materials and different colored cements on the color and esthetic of all-ceramic restorations were investigated.

Three groups of post-cores (ceramic, Cr-Ni and Cr-Ni + opaque), one sample per each group, were prepared as discs 14 ± 0.05 mm in diameter and 1.5 ± 0.05 mm in thickness. A total of 40 cement samples, 10 per each group (opaque white, white, yellow and brown) were prepared as discs 14 ± 0.05 mm in diameter and 0.1± 0.01 mm in thickness. Two samples of dental ceramics, 1 per each group (IPS Empress and IPS Empress 2), were prepared as discs in similar dimensions. The effect of different cement colors was evaluated on the final color of IPS Empress restorations.

In each group, while one post-core material and one all-ceramic material remained constant, 10 cement specimens which prepared from four different cement colors were studied. Bovine dentin was placed instead of post-core material as a control sample and colorimetric measurements were made. The color configurations were assessed with a colorimeter for each group.

In the evaluation of cement colors, for IPS Empress system, when only ceramic post-core material was used, white, yellow and brown cements were found to be clinically acceptable ($\Delta E<1$).

For IPS Empress 2 system, all colors for ceramic and Cr-Ni + opaque post-core were clinically acceptable but only opaque white cement for Cr-Ni post-core were found to be acceptable clinically ($\Delta E<2$). When ceramic post-core material was used, white, yellow and brown cements were more appropriate clinically than opaque white cement.

Keywords: All-ceramic materials, post-core, resin cement, color, colorimeter

Introduction

Metal ceramic restorations do have esthetic limitations inherent to the materials. First, unlike natural teeth, which reflect, absorb, and transmit light, the metal ceramic restoration results in mostly absorption and reflection. The metal substructure prevents the transmission of light in the body of the restoration, resulting in a material that looks more opaque and less vital (1). Second, the management of the facial marginal area can be an esthetic problem even for the most skilled clinicians and technicians. This is primarily related to the metal collar of these restorations. Esthetic concerns such as these have led to the introduction of a number of nonmetallic alternative materials, such as IPS Empress, In-Ceram, Dicor and Vita Hi-Ceram (2).

For many years, development of dental ceramics has centered on creating materials with the same optical properties as natural teeth. Clinicians have achieved excellent esthetic results in the anterior region using all-porcelain restorations. This was because the all-porcelain restoration most closely matched the translucency and value of the natural dentition (3).

The ideal esthetic restorative material should have optical properties similar to natural teeth. The critical optical properties are value and translucency. Clinical difficulties arise when there is a discolored tooth or a cast post and core. Most all-ceramic systems are not able to alter the translucency of the core to differentially mask discolorations (3).

TABLE 1

The types of materials used in this study

All ceramic material	IPS Empress	Ivoclar, Schaan, Liechtenstein
	IPS Empress 2	Ivoclar, Schaan, Liechtenstein
Post-core materials	Ceramic Post (IPS Empress Cosmo Ingot C)	Ivoclar, Schaan, Liechtenstein
	Chromium–Nickel	Kera-N, Eisen Bacher, Obernburg, Germany
	Ceramic opaque sintered on the Cr-Ni	Kera-N, Eisen Bacher, Obernburg, Germany
Resin cements	Variolink II opaque white	Ivoclar, Schaan, Liechtenstein
	Variolink II white	Ivoclar, Schaan, Liechtenstein
	Variolink II yellow	Ivoclar, Schaan, Liechtenstein
	Variolink II Brown	Ivoclar, Schaan, Liechtenstein

If all-ceramic crown is placed on an endodontically treated tooth and prefabricated or cast metallic post core used, metallic posts may produce a gray discoloration of translucent all ceramic crown and the surrounding gingival (4). A prefabricated ceramic post system has been introduced to be used in combination with adhesive materials to solve this problem (5).

The purpose of this study was to investigate the effects of the color of the different post-core materials and different colored cements on the color and esthetic of all ceramic restorations.

Materials and Methods

Three groups of materials were used in this study. The types of materials are presented in **Table 1**.

Specimen preparation

For IPS Empress specimens, a silicone mold was obtained from a metal disc which is 14 mm in diameter and 1.5 mm thick. 10 wax discs were obtained by using this mold. Wax pattern was inverted using a phosphate–bonded investment material (IPS Empress 2 Special Investment Material, Ivoclar, Schaan, Liechtenstein). IPS Empress ingot (IPS Empress TC1, Ivoclar, Schaan, Liechtenstein) was heated and pressed according to the manufacturer's instructions. IPS Empress disc was subjected to the stain technique, three times stain firing and twice glaze firing.

For IPS Empress 2 specimen, a silicone mold was obtained from a metal disc in 14 mm diameter and 0.7 mm thickness. Wax discs were prepared using this mold and inverted using investment material (IPS Empress 2 Special Investment Material, Ivoclar, Schaan, Liechtenstein). IPS Empress 2 ingots were heated and pressed according to the manufacturer's instructions. After wash firing, 8 mm thick dentin was applied to IPS Empress 2 core by using a blass mold.

In order to prepare the post-core specimens, 20 wax patterns were obtained by using silicone mold that was been prepared. Ten of these patterns were used for heating and pressing of ceramic core material (IPS Empress Cosmo Ingot C). The other 10 patterns were casted by Cr-Ni. One surface of Cr-Ni discs were air particle abraded with 250 µm aluminium oxide and the appropriate shade of opaque porcelain (Ceramco II Ultra-Pake, Ceramco Inc. Burlington, NJ, USA) was applied and fired according to the porcelain manufacturer's recommendations. The opaque layer's thickness was 0.3 ± 0.02mm.

For cement specimens, a disc in 14 mm diameter was obtained by using a plastic sheet in 0.1 mm thickness and silicone mold was prepared. In silicone mold, four gaps were made for cement excess. Cement was placed inside the space. On cement, first plastic sheet and then glass shield was put and cured for 30 sec. (Translux EC, Kulzer, Germany). A total of 40 cement specimen, 10 per each of color (opaque white, 110/A1 white, 210/A3 yellow, 340/A4 brown) were prepared as discs 14 mm in diameter and 0.1 mm in thickness.

As a control discs, bovine dentin was used, bovine central incisor was reduced to a section in 1.5 mm thickness and 14 mm diameter using a diamond instrument (Edenta, AC, Switzerland).

Color analysis

For color analysis, colorimetric assessments were made. Effect of different color cement materials was evaluated on the final color of IPS Empress and IPS Empress 2 all-ceramic materials. In each group, while one post-core material and one all-ceramic material remained constant, 10 cement specimens which prepared at four different colors (total 40) were studied. A total of 240 groups were established, in which each group contained a post-core, resin cement, and a ceramic disc. For control samples, the bovine dentin was placed instead of post-core materials without cement specimen.

For each combination, the color was measured (n=10) with a colorimeter (Minolta CR-300, Minolta Co. Ltd., Osaka, Japan). The colorimeter was calibrated according to the manufacturer's recommendations using the supplied white calibration standard. Colorimetric data were recorded with

TABLE 2

CIE-Lab color values and ΔE values of triple combinations and control specimens in IPS Empress all ceramic material

Postcore	Cement	L_1*	A_1*	b_1*	L_2	a_2	b_2	ΔL	Δa	Δb	ΔE
	Op.white	70.35	-0.70	17.99	72.81	-1.24	17.57	-2.46	0.52	0.41	2.56
Ceramic	White	70.35	-0.70	17.99	70.43	-0.78	17.77	-0.12	0.08	0.21	0.27
	Yellow	70.35	-0.70	17.99	70.45	-0.65	17.96	-0.10	-0.05	0.13	0.20
	Brown	70.35	-0.70	17.99	70.01	-0.44	17.85	0.40	-0.27	0.16	0.47
	Op.white	70.35	-0.70	17.99	72.14	-1.36	16.84	-1.74	0.68	1.12	2.19
Cr-Ni+Op.	White	70.35	-0.70	17.99	68.72	-0.77	16.12	1.51	0.06	1.85	2.40
	Yellow	70.35	-0.70	17.99	68.73	-0.69	16.26	1.60	-0.02	1.68	2.36
	Brown	70.35	-0.70	17.99	68.38	-0.56	16.20	1.98	-0.15	1.74	2.65
	Op.white	70.35	-0.70	17.99	71.72	-1.71	16.21	-1.38	1.02	1.77	2.48
Cr-Ni	White	70.35	-0.70	17.99	67.05	-1.45	13.83	3.29	0.74	4.18	5.33
	Yellow	70.35	-0.70	17.99	67.16	-1.39	14.10	3.23	0.69	3.89	5.09
	Brown	70.35	-0.70	17.99	66.91	-1.28	14.25	3.35	0.58	3.74	5.08

*mean values of control specimens

the Lab system based on the CIE light source with a 0-degree angle of view. The average value was calculated and used for analysis. By applying the following formula:

$$\Delta E = [(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2]^{1/2}$$

it was possible to calculate ΔE and compare the material combinations (6).

L: Brilliance

a and b: Chromatic values

1: Bovine dentin + all-ceramic

2: Post-core + cement + all-ceramic

Statistical analysis

After data collection, the mean values and standard deviations were calculated with the SPSS statistical software program. One way analysis of variance and Kruskal-Wallis analysis of variance were used to compare the difference between the groups. When statistically significant effects were detected, Tukey HSD test and the Mann-Whitney U test were used to determine which group means were different. Differences between means at $p \leq 0.05$ were considered statistically significant.

Results and Discussions

CIE Lab color values of triple combinations and control specimens used in this study are shown in **Table 2** and **Table 3**. Maximum, minimum, arithmetic mean and standard deviation at ΔE values of all groups are shown in **Table 4** and **Table 5**.

In the IPS Empress groups, Levene test was applied to determine if the variances are homogenized or not. One way analysis of variance (ANOVA) was applied in ceramic and Cr-Ni + opaque post-cores groups which variances are homogenized, whereas Kruskal-Wallis variance analysis was applied in Cr-Ni post-core group which variances are not homogenized ($p< 0.05$).

The groups which are the statistically significant difference between the groups in one-way analysis of variance were compared two by two with Tukey HSD test, whereas the group which is the statistically significant difference between groups in Kruskal-Wallis analysis of variance was compared two by two with Mann-Whitney U test.

In the ceramic post-core and the opaque ceramic coated Cr-Ni post-core groups, Tukey HSD test showed that there was a significant difference ($p<0.05$) between the groups in comparison two by two, except white-yellow group ($p>0.05$).

In the Cr-Ni post-core group, Mann-Whitney U test showed that the differences between the groups in comparison two by two were found statistically significant ($p<0.05$) except yellow-brown group ($p>0.05$).

In the IPS Empress 2 group, Levene test was applied to determine if the variances are homogenized or not. At the all of the groups, variances were homogenized ($p>0.05$) and one way analysis of variance was applied in all groups. The differences between the groups were found statistically significant ($p<0.05$).

Many new ceramic materials and techniques have been developed recently for both conservative and full-coverage all-ceramic restorations. Because of poor optical properties, conventional materials used for all-ceramic restorations have been fraught with problems (3).

It was the aim of the present study to evaluate the effect of the color of three different post-core materials and four different colored cements on the color and esthetic of IPS Empress and IPS Empress 2 restorations.

It might be necessary to use cast metal post-cores when a tooth is not round and it has large canal, where prefabric posts are contraindicated, and people with parafunctional habits (4).

In our study opaque ceramic coating was used on Cr-Ni post-core material in order to disguise the color of Cr-Ni. Usage of non precious metal alloys have been increased because of the high costs of precious metal alloys.

The other post-core material used in this study is IPS Empress Cosmo Ingot material. This material was used as Cosmo Post and IPS Empress Cosmo Ingot combination on patients and esthetic results were successful (4, 7).

Mc Lean (8) and Sorenson and Torres (9) emphasize that surface texture of opaque ceramic has positive effect on the ceramic crowns esthetically. The more textured the surface of the opaque ceramic, the less is the reflection, and it has better esthetical results. The opaque ceramic used in our study is textured because of the crystals on it and this yields positive results.

The optical properties of Variolink and Panavia 21 TC were found to be ideal for use with the In-Ceram system (10).

In our study Variolink II cement, dual curing composite luting cement, was used because it is translucent, highly stable and adhesive.

Vichi et al. (11) used in white, yellow and brown colors Variolink II cement in a study. In this study, all three colors can cause minor changes in the material of all ceramic crown ($\Delta E<1$) when the post-core material in the color of the tooth was used. To mask the color of the dark colored tooth, highly opaque white cement has been produced by a called Ivoclar.

In our study, opaque white cement was also used in addition to three colors used by Vichi et al. (11). Our results indicate that opaque white cement partially masks the color of Cr-Ni post-core material.

The fracture resistance of a glass ceramic plate cemented to a resin composite block as a function of the cement film thickness was used by Scherrer et al. (11). The findings of their study suggest that the resistance to fracture due to indentation of the glass ceramic may not be affected by the cement film thickness.

Since it might be difficult to adjust the cement thickness by dentist, we used only 0.1 mm thick cement.

Three different all-ceramic material as 1, 1.5 and 2 mm in thickness and white, yellow and brown cements to determine the reflection under all ceramic crown were used by Vichi et

TABLE 3

CIE-Lab color values and ΔE values of triple combinations and control specimens in IPS Empress 2 all ceramic material

Postcore	Cement	L_1*	A_1*	b_1*	L_2	a_2	b_2	ΔL	Δa	Δb	ΔE
	Op.white	72.40	-0.41	18.25	73.61	-0.75	19.51	-1.17	0.36	-1.26	1.74
Ceramic	White	72.40	-0.41	18.25	72.24	-0.49	18.48	0.26	0.13	-0.32	0.40
	Yellow	72.40	-0.41	18.25	72.23	-0.44	18.58	0.15	0.02	-0.38	0.39
	Brown	72.40	-0.41	18.25	71.97	-0.33	18.33	0.46	-0.12	-0.08	0.50
	Op.white	72.40	-0.41	18.25	73.33	-0.96	18.95	-0.89	0.56	-0.72	1.26
Cr-Ni+Op.	White	72.40	-0.41	18.25	71.22	-0.68	17.12	1.35	0.27	1.17	1.74
	Yellow	72.40	-0.41	18.25	71.18	-0.60	17.25	1.36	0.21	1.05	1.72
	Brown	72.40	-0.41	18.25	71.08	-0.55	17.10	1.42	0.14	1.21	1.81
	Op.white	72.40	-0.41	18.25	72.99	-1.24	18.38	-0.59	0.83	-0.16	1.01
Cr-Ni	White	72.40	-0.41	18.25	70.17	-1.33	15.60	2.32	0.90	2.62	3.60
	Yellow	72.40	-0.41	18.25	70.09	-1.34	15.58	2.31	0.92	2.64	3.65
	Brown	72.40	-0.41	18.25	70.15	-1.25	15.70	2.29	0.84	2.55	3.58

*mean values of control specimens

TABLE 4

Maximum, minimum, arithmetic mean, and standard deviation at ΔE values of all groups in IPS Empress

Groups		N	Max.	Min.	Arit. mean	St. dev.
	Op.white	10	2.72	2.01	2.56	0.07
Ceramic	White	10	0.44	0.18	0.27	0.02
	Yellow	10	0.42	0.06	0.20	0.04
	Brown	10	0.66	0.35	0.47	0.03
	Op.white	10	2.43	2.04	2.19	0.04
Cr-Ni+Op.	White	10	2.72	2.24	2.40	0.05
	Yellow	10	2.49	2.15	2.36	0.03
	Brown	10	2.89	2.46	2.65	0.04
	Op.white	10	2.54	2.36	2.48	0.02
Cr-Ni	White	10	5.56	5.19	5.33	0.03
	Yellow	10	5.33	4.84	5.09	0.06
	Brown	10	5.35	4.92	5.08	0.04

TABLE 5

Maximum, minimum, arithmetic mean, and standard deviation at ΔE values of all groups in IPS Empress II

Groups		N	Max.	Min.	Arit. mean	St. dev.
	Op.white	10	2.00	1.04	1.74	0.27
Ceramic	White	10	0.52	0.36	0.40	0.05
	Yellow	10	0.48	0.24	0.39	0.07
	Brown	10	0.65	0.24	0.50	0.07
	Op.white	10	1.41	1.05	1.26	0.13
Cr-Ni+Op.	White	10	1.93	1.52	1.74	0.14
	Yellow	10	1.95	1.48	1.72	0.14
	Brown	10	2.22	1.54	1.81	0.18
	Op.white	10	1.17	0.91	1.01	0.08
Cr-Ni	White	10	3.69	3.50	3.60	0.06
	Yellow	10	3.86	3.52	3.65	0.14
	Brown	10	3.95	3.41	3.58	0.16

al (11). According to them when all ceramic crown is 2 mm thick, it masks the metal completely, when it is 1.5 mm thick, the color change can be determined by measurement and when it is 1 mm thick is contraindicated to all ceramic crowns. Throughout our study all ceramic crown thickness was kept constant at 1.5 mm as producers suggested (3, 12, 13, 14).

In vitro colorimetry was used to measure the color difference in all ceramic crowns, which gave us quantitative results and that enabled us to make statistical calculation and an objective evaluation. In many studies concerning the color of the all ceramic crowns, colorimeter was used (15-19).

In dentistry, CIE Lab color system and Munsell color system were used at the color studies (8, 20). The most important feature of the CIE Lab system is its arrangement as an approximately uniform three-dimensional color space. The CIE Lab color difference formula is designed to provide numeric data (ΔE) that represents the magnitude of the color difference perceived between two objects. Because of these advantages, in many studies concerning the color of the ceramics, CIE Lab color system was used (15, 17-22). We used this system, too.

In our study, for IPS Empress group, to use with ceramic post-core material, the best cement color is yellow. To use with Cr-Ni post-core material, the worst cement color is white. In IPS Empress 2 group, the best value to use with ceramic post-core material was obtained with yellow cement. The worst value to use with Cr-Ni was obtained also with yellow cement.

In IPS Empress group, for the ceramic post-core and the opaque ceramic coated Cr-Ni post-core groups, there was a significant difference ($p<0.05$) between the groups in comparison two by two, except white-yellow group ($p>0.05$). For Cr-Ni post-core group, the differences between the groups were found statistically significant ($p< 0.05$) except yellow-brown group ($p>0.05$).

For IPS Empress 2 groups, in the all post-core materials, there was no significant difference ($p>0.05$) between the groups in comparision two by two except opague white groups ($p<0.05$).

Conclusions

In the evaluation of cement colors, for IPS Empress system, when only ceramic post-core material was used, white yellow and brown cements were found clinically acceptable ($\Delta E<1$). For IPS Empress 2 system, all colors for ceramic and Cr-Ni + opaque post-core were clinically acceptable but only opaque white cement for Cr-Ni post-core were found to be acceptable clinically ($\Delta E<2$). When ceramic post-core material was used, white, yellow and brown cements were more advantage than opaque white cement.

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