Comparison of Ceromers Color Stability to Hybrid Composites and Ceramics After Immersion in Different Beverages

Farklı İçecekler İçerisindeki Seromerlerin, Hibrit Kompozit ve Seramiklere Göre Renk Stabilitesinin Karşılaştırılması

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ABSTRACT Objective: The aim of this study was compare color stability of ceromers to hybrid composites and ceramics after immersion in different coloring solutions. **Material and Methods:** One kind of hybrid composite (Tetric Ceram, Ivoclar Vivadent, AG) (n=15), two kinds of ceromers (Tescera, Bisco, Inc., Schaumburg, IL, USA) (n=15), (Estenia, Kuraray, Okayama, Japan) (n=15) and two kinds of ceramic materials (E-max, Ivoclar Vivadent AG, AG) (n=15), (Finesse, Dentsply, USA) (n=15) were used for this study. Fifteen disks measuring 2 mm in thickness and 10 mm in diameter were fabricated for each material in shade A3. Composite specimens were fabricated using a polytetrafluoroethylene mold. Ceramic specimens were fabricated with same sizes round split polyvinyl siloxan putty molds. Specimens were immersed in tea, coffee and cola. Color changes were measured with spectrophotometer (Vita Easyshade, Germany) before immersion and after 1 day, 1 week, 2 weeks and 4 weeks of the immersion. Data were analyzed by one way analysis of variance and Scheffe tests (SPSS 12.0) (p=0.05). **Results:** According to solution type, ceromers' color change ($\Delta E_{estenia}$= 1.8, $\Delta E_{estenia\text{-}tea}$=11.4, $\Delta E_{estenia\text{-}coffee}$=14.1, $\Delta E_{estenia\text{-}cola}$=3.1, $\Delta E_{tescera}$=3, $\Delta E_{tescera\text{-}tea}$=7.5, $\Delta E_{tescera\text{-}coffee}$=8.3, $\Delta E_{tescera\text{-}cola}$=3.8), hybrid composite color change (ΔE_{tetric}= 0.7, $\Delta E_{tetric\text{-}tea}$=4.1, $\Delta E_{tetric\text{-}coffee}$=6.8, $\Delta E_{tetric\text{-}cola}$=1.5) and ceramics' color change ($\Delta E_{e\text{-}max}$=0.8, $\Delta E_{e\text{-}max\text{-}tea}$=2.9, $\Delta E_{e\text{-}max\text{-}coffee}$=3.8, $\Delta E_{e\text{-}max\text{-}cola}$=2.2, $\Delta E_{finesse}$=1.2, $\Delta E_{finesse\text{-}tea}$=3.6, $\Delta E_{finesse\text{-}coffee}$=3.9, $\Delta E_{finesse\text{-}cola}$=2.9) were statistically significant at the end of the 4 weeks ($p<0.005$). Color change occured in all beverages. Coffee, tea and cola were found to be more stained agents, respectively. **Conclusion:** Ceromers were the most coloring group amoung the examined aesthetic materials. Coffee was the most coloring agent amoung the tea, coffee and cola.

Key Words: Ceromer; beverages; prosthesis coloring; tooth discoloration

ÖZET Amaç: Bu çalışmanın amacı, farklı renklendirici solusyonlar içerisindeki seromerlerin, hibrit kompozit ve seramiklere göre renk stabilitesinin karşılaştırılmasıdır. **Gereç ve Yöntemler:** Bu çalışma için 1 çeşit hibrit kompozit (Tetric Ceram, Ivoclar Vivadent, AG) (n=15), 2 çeşit seromer (Tescera, Bisco, Inc., Schaumburg, ABD) (n=15), (Estenia, Kuraray, Okayama, Japonya) (n=15) ve 2 çeşit seramik (E-max, Ivoclar Vivadent AG, ABD) (n=15), (Finesse, Dentsply, ABD) (n=15) kullanıldı. Politetrafloroetilen bir kalıp yardımıyla 2 mm kalınlık ve 10 mm çapında 15 er adet disk şeklinde A3 renginde örnekler üretildi. Kompozit örnekler politetrafloroetilen kalıp kullanılarak hazırlandı. Porselen örnekler, aynı kalınlık ve çapta olmak üzere, polivinil siloksan ölçü maddesinden kalıp yapılarak üretildi. Örneklerin renk ölçümleri çay, kahve ve kola içerisinde bekletilmeden önce ve bekletildikten 1 gün, 1 hafta, 2 hafta ve 4 hafta sonra Spektrofotometre (Vita Easyshade, Almanya) ile yapıldı. Sonuçları analiz etmek için 1-yönlü varyans ve Scheffe analizleri kulanıldı (SPSS 12.0) (p=0,05). **Bulgular:** 4 hafta sonunda solusyon çeşidine göre seromerlerin renk değişiminde ($\Delta E_{estenia}$= 1,8, $\Delta E_{estenia\text{-}çay}$=11,4, $\Delta E_{estenia\text{-}kahve}$=14,1, $\Delta E_{estenia\text{-}kola}$=3,1, $\Delta E_{tescera}$=3, $\Delta E_{tescera\text{-}çay}$=7,5, $\Delta E_{tescera\text{-}kahve}$=8,3, $\Delta E_{tescera\text{-}kola}$=3,8), hibrit kompozitin renk değişiminde (ΔE_{tetric}= 0,7, $\Delta E_{tetric\text{-}çay}$=4,1, $\Delta E_{tetric\text{-}kahve}$=6,8, $\Delta E_{tetric\text{-}kola}$=1,5) ve seramiklerin renk değişiminde ($\Delta E_{e\text{-}max}$=0,8, $\Delta E_{e\text{-}max\text{-}çay}$=2,9, $\Delta E_{e\text{-}max\text{-}kahve}$=3,8, $\Delta E_{e\text{-}max\text{-}kola}$=2,2, $\Delta E_{finesse}$=1,2, $\Delta E_{finesse\text{-}çay}$=3,6, $\Delta E_{finesse\text{-}kahve}$=3,9, $\Delta E_{finesse\text{-}kola}$=2,9) anlamlı derecede farklılık gözlenmiştir ($p<0,005$). Bütün içecekler, örneklerde renk değişimine neden olmuştur. Sırasıyla kahve, çay ve kola en fazla renklendirici içecek olarak bulunmuştur. **Sonuç:** Seromerler, incelenen estetik materyaller arasında en fazla renk değişimi gösteren grup olmuştur. Çay, kahve ve kola arasında en fazla renklendirici ajanın kahve olduğu belirlenmiştir.

Anahtar Kelimeler: Seromer; içecekler; protezi renklendirme; dişte renk değişikliği

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The discoloration of tooth colored dental composite materials can be a reason for the replacement of dental restorations.[1] Maintenance of color is important for the longevity of a restoration but it is not constant among all dental materials.

Resin composites are tooth-colored restorations and they are popular among patients. Therefore, they are widely used by dentists. However, color stability is a major problem for the composites, which are subject to extrinsic or intrinsic discoloration. Intrinsic discoloration is not provisional and is related to filler type, amount, and polymer quality.[2,3] Extrinsic discoloration can be a result of plaque accumulation or staining within the superfacial layer of resin composite. This type is usually related to dietary and smoking habits.[4,5] Restorations replacement generally takes place on account of aesthetic failure, such as color change. So color stability is a very important factor for patient satisfaction.[6]

Color stability is an important factor to ensure the long-term clinical success of aesthetic restorations. Color stability of composite materials has been studied previously,[7] but studies about the color stability of indirect composites and how color is affected by staining solutions, such as cola, tea and coffee are limited.

ΔE values are used to describe whether the changes in the overall shade are perceivable to the people. ΔE values until 3.3, represent clinically acceptable range but 3.3 and higher are unacceptable under clinical conditions.[8]

Ceromers are indirect composites which have been induced as the second generation composites. New polymer formulations with improved filler particle distrubution was used in the laboratory to manufacture these composites. It contains silanized, microhybrid inorganic fillers embedded in an organic matrix.[9] They have been promoted as a ceramic technology ever though they are essentially still a composite resin matrix.[10,11] Nearly, all the ceramic polymers have superior flexural strength to feldspathic ceramic minimal polymerization shrinkage comparable to enamel.[12,13] Accordingly, ceramic polymers are used for inlays, onlays, veneering, and metal free single unit crowns.[14]

Ceramics are biocompatible, aesthetic and durable restorations.[15,16] The color stability of ceramics has been discussed in the literature, but has not been compared with ceromers. Several staining agents such as coffee, tea and cola are being comsumpted almost everday. The extent of staining produced by these staining solutions depends on their physical properties.[17,18]

Restorations; especially composites are frequently replaced because of aesthetic failures, such as color change. Therefore, color stability is a very important factor for both patient satisfaction and long-term clinical success of aesthetic restorations.[6,7]

Color stability of composite materials has been studied previously,[7] but studies about the color stability of indirect composites and how color is affected by drinks, such as cola, tea and coffee are limited.

The aim of this study was to evaluate the effects of cola, tea and coffee on the color stability of hybrid composites, ceromers, and ceramics. The null hypothesis tested was that unpolished ceromer specimens would have stained less than hybrid composite and more than ceramic specimens.

MATERIAL AND METHODS

One brand of hybrid composite (Estenia, Kuraray, Okayama, Japan), two brands of ceromers (Tescera, Bisco, Inc., Schaumburg, IL, USA) (n=15), (Tetric Ceram, Ivoclar Vivadent, AG) (n=15) and two brands of ceramic materials (E-max, Ivoclar Vivadent, AG) (n=15), (Finesse, Dentsply, USA) (n=15) were used for this study (Table 1). 15 specimens per restorative material were divided into 3 groups (tea, coffee and cola group). Five disks measuring 2 mm in thickness and 10 mm in diameter were fabricated for each group in shade A3 (Vita Lumin Shade Guide). Composite specimens were fabricated using a teflon mold because it would not adhere to the staining composites from the mold. Diameter of the politetraflouroethylene mold was 10 mm and thickness was 2 mm. The composite resin was packed into the teflon mold and clasped between two glass plates. Finger pressure was applied to extrude the excess resin. Then glass plates

TABLE 1: Materials used in the study.

Material	Content	Color	Manufacturer
E-max	Fluorapatite ceramic lithium disilicate glass-ceramic	A3	Ivoclar Vivadent AG,Schaan, Liechtenstein
Estenia(Ceromer)	Urethane tetramethacrylate (UTMA), Lanthanum Oxide (filler) (92 wt%) Alumina ultrafine filler, glass fiber	A3	Kuraray,Okayama, Japan
Finesse	Low-fusing, leucite-based ceramic, Na2O, K2O, Al2O3, SiO2 (8-10%) leucite	A3	Dentsply Ceramco R and D, Burlington, USA/Ceramco Finesse
Tescera/microhybrid indirect	81% glass frit and amorphous silica 19% ethoxylated bisphenol A dimethacryalte and Bis-GMA	A3	Bisco, Inc., Schaumburg, IL, USA
Tetric Ceram (Ceromer)	BisGMA, TEGDMA Hybrid 75 wt % Ba-Al-fluoroborosilicate glass filler	A3	Ivoclar Vivadent, Schaan, Liechtenstein

were removed and the tip of the light source (Bluephase Ivoclar Vivadent Schaan, Liechtenstein) was applied for 40 seconds (20 seconds from above and 20 seconds from below). Ceramic specimens were fabricated with round polyvinyl siloxane putty split molds. Same amount of ceramic and liquid were mixed and poured in to the mold. The specimens were removed from the mold and placed in a ceramic firing furnace (Multimat C, Dentsply, USA) according to the manufacturer's recommendations but were not polished or glazed. Finally, the specimens were immersed into three staining solutions: tea, coffee and cola.

PREPARATION OF STAINING SOLUTIONS

The tea solution was prepared by immersing five prefabricated tea bags (5x2 gr) (Lipton Yellow Label Tea, Unilever, Istanbul, Turkey) into 1000 ml of boiling water. To prepare the coffee solution, 20 g of coffee (Nescafe Classic, Nestle, Istanbul, Turkey) was poured into 1000 ml of boiling distilled water. Both solutions were stirred every 30 minutes for 10 seconds until they cooled to 37°C, and then filtered through a filter paper. The third staining solution was cola (Coca-Cola, Coca-Cola Co. Turkey), whereby 1000 ml of cola at room temperature was poured into a dish. Distilled water, as the fourth solution, was used as a control group.

COLOR MEASUREMENT

The restorative materials were divided in to three groups (n= 3). The colors of all specimens were measured initially with a spectrophotometer (Easyshade Vita Zahnfabrik H.Rauter GmbH& Co.Ke), using standart illuminant according to Commission Internationale d'Eclairage (CIE Lab) on the white baseline and L^*(lightness), a^*(red-green), b^*(yellow-blue) parameters were recorded.

The specimens were stored in distilled water at 37°C for 24 hours before being immersed in the solutions. The spectrophotometer head was placed on and touched on the center of the specimens. After the color measurement of each specimens were performed using the spectrophotometer (W_0), the specimes were put into staining agents. Consecutive color measurements were performed after 1 day (W_1), 1 week (W_2), 2 weeks (W_3) and 4 weeks (W_4). The data were expressed in the Commission Internationale d'Eclairage (CIE) Lab system coordinates.

Color change was measured using the $\Delta E^* [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2)]^{1/2}$ formula, and ΔE values were recorded. $\Delta L = (L2-L1)$, $\Delta a = (a2-a1)$, $\Delta b = (b2-b1)$. L_1, a_1 and b_1 coordinates imply first shade measurement values before immersion (W_o) and L2, a2, b2 imply shade measurement values after immersion (W_1,W_2,W_3,W_4), respectively.

The critical remarks of the color change were quantified by the National Bureau of Standarts rates the way that a color change is evaluated by the human eye (Table 2). The formula used for this conversion is National Bureau of Standards (NBS units)=$\Delta E \times 0.92$.

TABLE 2: National bureau of standard units.

NBC unit	Critical remarks of color differences
0.0-0.5	Excessively mere change
0.5-1.5	Mere:Mere change
1.5-3	Noticeable:Perceivable change
3-6	Appreciable:Prominent change
6-12	Much:Excessively marked change
12 or more	Very much:Change to other color

STATISTICAL ANALYSIS

Differences between the test groups were statistically analyzed by one-way analysis of variance (ANOVA) and Scheffe tests. Statistical differences were determined at a 95% confidence level. All statistical analyses were performed by Statistical Package for Social Sciences (SPSS.Vers.12.0 and Chicago, Il, USA).

RESULTS

A statistically significant difference was found between color changes, depending on the type of solution used in all types of composites and ceramics (Table 3).

A Scheffe test analysis was conducted to determine the source of the significant differences. Among the solutions used in this study, coffee was more discoloring agent than tea and cola. Also, tea caused more discoloration than cola (Table 4).

Depending on the immersion time, discoloration of Emax, Estenia, Finesse, Tescera and Tetric Ceram in all staining solutions were statistically significant. The Scheffe test revealed that the discolorations of these materials increased over time for all solutions (Tables 5-9).

Color changes of the composite and ceramic depended on the type of solution used after 4 weeks (Table 10).

At the end of 4 weeks a statistically significant difference was found between color changes of ceramic and composites depending on the type of solution they were immersed in.

A Scheffe test analysis was conducted to determine. The source of these significant differences and the findings were presented in Table 11.

At the end of 4 weeks, discoloration was evident in tea, coffee, and cola solutions. Estenia and Tescera had become more discolored than E-max, Finesse, and Tetric Ceram which was more discolored than E-max and Finesse.

DISCUSSION

New ceramic and composite technologies are being developed recently. Indirect resin composites have a higher density of inorganic ceramic filler than do traditional composites.[19] Ceromers are indirect resin composites containing silanized microhybrid inorganic fillers in the organic matrix.[9] These have, in the short-term, showed a longevity equal to ceramic restoration in terms of strength, wear resistance and marginal integrity.[20] Ceromer restorative materials combine the positive features of indirect resin composites, feldspathic ceramics, and cast-gold restorations.[21] Ceramic fillers have a high density, so their surfaces are much rougher than hybrid composites. Polished ceromers' physical properties have been found to be less than feldspathic porcelains and cast-gold restorations.[21] Results valid for

TABLE 3: Scheffe test results according to solution type.

		Sum of Squares	df	Mean Square	p
E-max					
	Between Groups	149	2	75	0.000
	Within Groups	135	72	1.88	
	Total	284	74		
Estenia					
	Between Groups	1145	2	573	0.000
	Within Groups	407	72	5.66	
	Total	1552	74		
Finesse					
	Between Groups	157	2	79	0.000
	Within Groups	143	72	1.99	
	Total	301	74		
Tescera					
	Between Groups	1203	2	602	0.000
	Within Groups	460	72	6.39	
	Total	1663	74		
Tetric Ceram					
	Between Groups	254	2	127	0.000
	Within Groups	157	72	2.19	
	Total	411	74		

TABLE 4: Results of Scheffe test for solutions.

Dependent Variable	(I)	(J)	Mean Difference (I-J)	p
E-max	1.00	3.00	1.08	0.025
	2.00	1.00	2.30	0.000
		3.00	3.38	0.000
Estenia	1.00	3.00	6.18	0.000
	2.00	1.00	3.24	0.000
		3.00	9.42	0.000
Finesse	1.00	3.00	1.22	0.012
	2.00	1.00	2.28	0.000
		3.00	3.50	0.000
Tescera	1.00	3.00	5.90	0.000
	2.00	1.00	3.84	0.000
		3.00	9.74	0.000
Tetric Ceram	1.00	3.00	2.80	0.000
	2.00	1.00	1.66	0.001
		3.00	4.46	0.000

TABLE 5: Scheffe test results for E-max.

		Sum of Squares	df	Mean Square	p
E-max tea					
	Between Groups	20.7	4	5.18	0.000
	Within Groups	0.00	20	0.00	
	Total	20.7	24		
E-max coffee					
	Between Groups	111	4	27.8	0.000
	Within Groups	0.00	20	0.00	
	Total	111	24		
E-max cola					
	Between Groups	3.44	4	0.86	0.000
	Within Groups	0.00	20	0.00	
	Total	3.44	24		

unpolished specimens and only color stabilities of the ceromers, hybrid composites and ceramics were evaluated for this study and color stability of the ceromers' were worse than ceramics' like physical properties at the end of the 1 month evaluation.[21]

In a recent study, 72 veneers, 36 ceromers and 36 ceramics were placed in 12 subjects and veneers were taken out from the mouth and SEM assessment was performed after 12 months. Ceromer's anatomical form was good, but marginal discoloration was seen during the observation period.[22]

In a study, forty-three Ceromer (Targis) inlay and onlay restorations were placed and evaluated in 25 patients. The recalls were performed at 6, 12, and 18 months. Marginal discoloration was 93%.[23]

Thirty-six ceramic and ceromer inlays were bonded on the same type of teeth in fifteen patients by Khairallah, et al. They were followed aproximately 60 months. The results showed that both materials were clinically acceptable for restoring posterior teeth, but ceramic yielded better results concerning color match.[24]

According to another study, the color stability of resin-based composites was less than that of ceramics.[25] Therefore, ceramics should be given preference in permanent dentures.

TABLE 6: Scheffe test results for Estenia.

		Sum of Squares	df	Mean Square	p
Estenia tea					
	Between Groups	188	4	47	0.000
	Within Groups	0.000	20	0.000	
	Total	188	24		
Estenia coffee					
	Between Groups	200	4	50	0.000
	Within Groups	0.000	20	0.000	
	Total	200	24		
Estenia cola					
	Between Groups	19	4	4.77	0.000
	Within Groups	0.000	20	0.000	
	Total	19.1	24		

TABLE 7: Scheffe test results for Finesse.

		Sum of Squares	df	Mean Square	p
Finesse tea					
	Between Groups	22.5	4	5.63	0.000
	Within Groups	0.00	20	0.00	
	Total	22.5	24		
Finesse coffee					
	Between Groups	117	4	29.2	0.000
	Within Groups	0.00	20	0.00	
	Total	117	24		
Finesse cola					
	Between Groups	4.34	4	1.09	0.000
	Within Groups	0.00	20	0.00	
	Total	4.34	24		

TABLE 8: Scheffe test results for Tescera.

		Sum of Squares	df	Mean Square	p
Tescera tea					
	Between Groups	209	4	52	0.000
	Within Groups	0.00	20	0.00	
	Total	209	24		
Tescera coffee					
	Between Groups	238	4	59	0.000
	Within Groups	0.00	20	0.00	
	Total	238	24		
Tescera cola					
	Between Groups	13.3	4	3.32	0.000
	Within Groups	0.00	20	0.00	
	Total	13.3	24		

TABLE 9: Scheffe test results for Tetric Ceram.

		Sum of Squares	df	Mean Square	p
Tetric Ceram tea					
	Between Groups	66.5	4	16.6	0.000
	Within Groups	0.00	20	0.00	
	Total	66.5	24		
Tetric Ceram coffee					
	Between Groups	84	4	21	0.000
	Within Groups	0.00	20	0.000	
	Total	84	24		
Tetric Ceram cola					
	Between Groups	7.24	4	1.81	0.000
	Within Groups	0.00	20	0.00	
	Total	7.24	24		

TABLE 10: Results of Scheffe test after four weeks of the immersion.

After 4 weeks		Sum of Squares	df	Mean Square	p
Tea					
	Between Groups	292	4	72.9	0.000
	Within Groups	0.00	20	0.00	
	Total	292	24		
Coffee					
	Between Groups	241	4	60.3	0.000
	Within Groups	0.00	20	0.00	
	Total	241	24		
Cola					
	Between Groups	10.8	4	2.69	0.000
	Within Groups	0.00	20	0.00	
	Total	10.8	24		

TABLE 11: Scheffe test results after four weeks of the immersion.

Dependent Variable of 4 weeks	(I)	(J)	Mean Difference (I-J)	p
Tea				
	Estenia	E-max	7.60	0.00
		Finesse	7.50	0.00
		Tetric Ceram	4.60	0.00
	Tescera	E-max	7.70	0.00
		Finesse	7.60	0.00
		Tetric Ceram	4.70	0.00
	Tetric Ceram	E-max	3.00	0.00
		Finesse	2.90	0.00
Coffee				
	Estenia	E-max	6.00	0.00
		Finesse	5.70	0.00
		Tetric Ceram	5.70	0.00
	Tescera	E-max	7.00	0.00
		Finesse	6.70	0.00
		Tetric Ceram	6.70	0.00
	Tetric Ceram	E-max	0.30	0.00
		Finesse	0.40	0.00
Cola				
	Estenia	E-max	1.50	0.00
		Finesse	1.60	0.00
		Tetric Ceram	1.00	0.00
	Tescera	E-max	1.30	0.00
		Finesse	1.40	0.00
		Tetric Ceram	0.80	0.00
	Tetric Ceram	E-max	0.50	0.00
		Finesse	0.60	0.00

Some studies,[26,27] have demonstrated coffee to be more coloring agent than tea and cola. Because coffee is non polar and hydrophilic, it adheres to other non-polar substances. However, tea is hydrophobic and polar, so it leaves the surface easily.[18] The outcomes of the present study showed as the same results with these studies.

Belli et al, prepared 72 discs using two different types of composite materials. Dental ceramic was divided in two groups and immersed into distilled water, tea and Turkish coffee solutions. The last group was also exposed to cigarette smoke.

Color differences were measured by colorimeter initially and after periods of 1 day, 1 week, and 1 month. It was found that cigarette smoke was the most significant staining agent, ceramic was the most color stable material, and the indirect composite material was more color stable than the direct material.[28]

One of the limitation of this study was that specimens were not polished. An occlusal adjustment might be required when the adaptation of the restorations (composites or ceramics) are not perfect. After recontouring, removal of the excess material is sometimes overlooked by the clinician. The preference of unpolishing the specimens were intentionally performed in the present study to simulate these conditions. Further studies should be conducted to evaluate ceromers' and other restorative materials' color stability.

CONCLUSION

Within the limitations of this study, the following conclusions were made:

1- Except for E-max, all the materials' color changes were unacceptable at the end of 4 weeks because they were higher than the acceptable limit (ΔE >3,3).

2- The color of restorations became darker by time in beverages; therefore, brushing should be turned out after drinking these beverages for minimal staining.

3- Ceramics are the most color stable materials and ceromers become more colorful than do hybrid composites.

4- Coffee is a more significant coloring agent than tea and cola.

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