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Effects of Whitening Mouthrinses on the Color Recovery of One-shade and Multi-shade Stained Composite Resins

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ABSTRACT

Aim: The aim of the present study was to evaluate the efficacy of mouthrinses on the color recovery of stained one-shade (Charisma Topaz One [CTO]) and multi-shade (Estelite Sigma Quick [ESQ]) composite resins.

Methodology: Sixty disc-shaped specimens (8-mm diameterx2-mm thickness) were prepared (n=30 for each composit resin). After polishing (Sof-Lex), the specimens were stored in 37°C for 24h. The specimens were stained by coffee immersion for 168h at 37°C, and then randomized into three subgroups based on the type of mouthrinse (n=10): LAW: Listerine Advanced White; CPWC: Colgate Plax White+Charcoal Capitano Whitening; LTC: Listerine Total Care. Colorimetric measurements were performed at baseline (T0), after staining (T1) and after mouthrinse immersion for 12h at 37°C (T2) with a spectrophotometer (VITA Easy shade). CIELab parameters were used for the analysis. Color change expressed by ΔE and ΔL, Δa, Δb were calculated. The data were subjected to two-way ANOVA, post hoc Tukey, Student t tests ($p<0.05$).

Results: All samples demonstrated clinically unacceptable color change after coffee-discoloration (ΔE>3.3). CTO showed significantly higher ΔE (12.16±1.37) than ESQ (7.48±0.95) ($p=0.001$). The mouthrinses led to a distinct increase in the L and decrease in the a and b after staining. LAW and CPWC resulted in significant differences in ΔL ($p=0.001$), Δb ($p=0.031$) and ΔE ($p=0.002$) of ESQ, while causing significant difference in Δb of CTO ($p=0.037$) at T2-T0.

Conclusion: Whitening mouthrinse may reduce the discoloration of coffee-stained composite resins, but not match the initial colour. It provides a better whitening effect in multi-shade composite resin than one-shade composite resins.

Ağartma Etkili Ağız Gargaralarının Renklendirilmiş Tek-renk ve Çoklu-renk Sistemli Kompozit Rezinlerin Renk Geri Kazanımı Üzerine Etkileri

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ÖZET

Amaç: Bu çalışmanın amacı, ağartma etkili ağız gargaralarının renklendirilmiş tek-renk (Charisma Topaz One [CTO]) ve çoklu-renk sistemli (Estelite Sigma Quick [ESQ]) kompozit rezinlerin renk geri kazanımı üzerine etkilerini değerlendirmektir.

Gereç ve Yöntemler: 60 adet disk şeklinde (8 mm çap x 2 mm kalınlık) örnekler hazırlandı (her bir kompozit reçine için n=30). Örnekler, cilalandıktan (Sof-Lex) sonra 24 saat 37°C'de saklandı. Sonrasında 37°C'de 168 saat kahve solüsyonunda renklendirildi ve ardından ağız gargaralarına göre rastgele üç alt gruba ayrıldı (n=10): LAW: Listerine Advanced White; CPWC: Colgate Plax White+Charcoal Capitano Whitening; LTC: Listerine Total Care. Renk ölçümleri başlangıçta (T0), kahvede reklendirme sonrası (T1) ve 37°C'de 12 saat ağız gargarasında bekletildikten sonra (T2) spektrofotometre cihazı (VITA Easy shade) ile gerçekleştirildi. Analizler için CIELab parametreleri kullanıldı. Renk değişimlerini belirlemek için ΔE ve ΔL, Δa, Δb hesaplandı. Veriler two-way ANOVA, post hoc Tukey, Student t testleri ile analiz edildi ($p<0,05$).

Bulgular: Kahve ile renklendirme sonrası tüm örneklerde klinik olarak kabul edilemez (ΔE>3,3) renk değişiklikleri saptanmış olup CTO kompozit rezinin ΔE değeri (12,16±1,37) ESQ' den (7,48±0,95) anlamlı düzeyde yüksektir ($p=0,001$). Renklendirme sonrasında ağız gargaraları, L'de belirgin bir artışa, a ve b parametrelerinde azalmaya neden olmuştur. LAW ve CPWC, ESQ kompozit rezinin ΔL ($p=0,001$), Δb($p=0,031$) ve ΔE ($p=0,002$) değerlerinde anlamlı farklılığa neden olurken CTO kompozit rezinin Δb ($p=0,037$) değerinde anlamlı farklılık göstermiştir.

Sonuç: Ağartma etkili ağız gargaraları, kompozit rezinlerin kahve renklenmelerini azaltsa da başlangıç renk değerlerine ulaştıramamaktadır. Çoklu-renk kompozitlerin rengini geri kazandırmada tek-renk kompozitlere göre daha iyi bir beyazlatma sağlamaktadır

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INTRODUCTION

The structural and optical matching of the restorative material with the tooth structure and adjacent teeth plays a critical role in achieving an esthetically result. Multi-shade layering techniques using composite resins (CRs) of various opacities as well as colors have been demonstrated to imitate the natural tooth appearance. Restorative dentistry requires a high level of technical skill and accurate shade matching, frequently increasing the time spent in the chair and the cost of treatment.[1-2] A new concept of 'monochromatic' or 'one-shade' CRs has recently been developed to describe resin-based composites formulated to esthetically simulate all shades with a single nominal shade by a color adjustment potential or blending effect (BE).[3-4] The BE is believed to be caused by the change in shade due to the reflection from the surrounding dentition and is influenced by the translucency parameter and the size of the cavity.[5] One-shade CRs based on this principle aim to simplify shade selection, minimize technical sensitivity, and reduce treatment time.[6] Despite these advantages, studies have addressed concerns about color stability and vulnerability to staining from beverages.[7-12]

Discoloration of CRs is an undesirable, although unavoidable, effect in the oral environment. Several factors can affect the color match, including the composition and size of the filler and the matrix structure, the size of the restoration, the placement of the CR, and the color and brand of the CR.[13] Additionally, discoloration can be attributed by external factors, such as plaque accumulation, tobacco, diet, oral care and internal factors related to the characteristics of the teeth, and resin.[14]

Tooth whitening is a cosmetic, safe and effective dental treatment. Non-professional bleaching products such as over-the-counter strips, pens, mouthrinses and toothpastes are available for use.[15] Mouthrinses have gained popularity for both plaque removal and teeth whitening due to their price, accessibility and simplicity. They contain a whitening agent that creates an optical illusion of whiter teeth.[16] However, the efficacy of whitening mouthrinses is often debated due to insufficient evidence on the effect of CRs. Therefore, this in vitro study aims to evaluate the effects of whitening mouthrinses on the color recovery of stained one-shade and multi-shade CRs. The hypotheses tested were that: (1) There would be no significant difference in the discoloration of between the CRs after immersion in the coffee solution. (2) There would be an efficacy of whitening mouthrinses in terms of color recovery of CRs.

MATERIAL AND METHODS:

One-shade (Charisma Topaz One [CTO], Heraus Kulzer) and multi-shade (Estelite Sigma Quick [ESQ], Tokuyama) CRs were used in this *in vitro* study (Table 1). Thirty disc-shaped specimens from each CR were prepared using teflon molds of 8-mm diameter x 2-mm thickness (N = 30 for each composite type). Moulds were placed on a microscopic slide, filled with CR, covered with a mylar strip and compressed with a second slide. After light-curing (Elipar S10; 3M ESPE), top surfaces of the samples were polished with Sof-Lex disc (3M ESPE), rinsed with distilled water for 30 s, blot-dried with paper towels and stored in distilled water at 37°C for 24 h. Color measurement of the all specimens was then performed at baseline (T0).

The samples were stained with coffee solution by 3.6 g of powder (Nescafe Classic, Nestl´e) in 300 ml of boiling distilled water. After being filtered, the specimens were incubated in coffee solution, which was refreshed daily, for 168 h at 37°C, equivalent to six months of clinical ageing in vivo. Then, gently rinsed and air-dried before a second color measurement (T1). After, randomized into three subgroups based on the type of mouthrinse used

(n=10): Two of them have a whitening effect- Listerine Advanced White (LAW) and Colgate Plax White+Charcoal (CPWC)- and the other has most complete effect- Listerine Total Care (LTC) (Table 2). The samples were immersed in 20 mL of the relevant mouthrinses for 12 hours in an incubator set at 37°C, and then rinsed with distilled water for 10 sec. and dried with towel paper. Then a third color measurement was done (T2). A spectrophotometer (VITA Easy shade, Vita Zahnfabrik, Germany) was used to record the CIE L*a*b* parameters on a gray ceramic background. The colorimetry procedures were carried out at baseline (T0), after staining (T1), and after using the mouthrinse (T2).

Table 1. The composition and manufacturer of the composite resins

Material	Type	Content	Filler load	Batch number
Charisma Topaz One- [CTO] Heraeus Kulzer, Hanau, Germany.	Nanohybrid	Matrix: TCD-DI-HEA UDMA, TEGDMA Filler: Silica -Barium aluminium fluoride glass filler (5 nm-5 µm) - Titanium dioksit	Wt.74% Vol 59%	E8743
Estelite Σ Sigma Quick [ESQ] Tokuyama Dental, Tokyo, Japan	Supra-nanohybrid	Matrix: BIS-GMA, TEGDMA, photoinitiators Filler: Silica-zirconia, silica-titania	Wt. 82% Vol 71%	K010201

Table 2. Details of Tested Whitening Mouthrinses

Mouthrinse	**Composition**
Listerine Advanced White [LAW] Johnson&Johnson SPA Pomezia, Italy	Aqua, Sorbitol, Propylene Glycol, Tetrapotassium Pyrophosphate, Pentasodium Triphosphate, Citric Acid, Poloxamer 407, Aroma, Sodium Methyl Cocoyl Taurate, Caprylyl Glycol, Eucalyptol, Thymol, Sodium Saccharin, Menthol, Sodium Fluoride, Sucralose.
Colgate Plax White+ Charcoal [CPWC] Colgate Palmolive, İstanbul, Türkiye	Aqua, Glycerin, Propylene Glycol, Sorbitol, Tetrapotassium Pyrophosphate, Polysorbate 20, Tetrasodium Pyrophosphate, Zinc Citrate, PVM/MA Copolymer, Aroma, Benzyl Alcohol, Sodium Fluoride, Sodium Saccharin, Bambusa Vulgaris Shoot Extract, Charcoal Powder
Listerine Total Care [LTC] Johnson&Johnson SPA Pomezia, Italy	Water (Aqua), Sorbitol, Propylene glycol, Poloxamer 407, Sodium sulfate, Phosphoric acid, Eucalyptol, Methyl salicylate, Thymol, Sodium benzoate, Sodium saccharin, Menthol, Sucralose, Disodium phosphate, Hydrogen peroxide

The CIELab system is composed of three axes: L* is the lightness from 0 (black) to 100 (white), a* is the red (+a) and green (−a), and b* is the blue (−b) and yellow (+b). The color change (ΔE*) was calculated using the equation:

$$\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

$\Delta L^* = L$ (after) – L (before);

$\Delta a^* = a$ (after) – a (before);

$\Delta b^* = b$ (after) – b (before)

Statistical Analysis: IBM SPSS Statistics 22 was used for statistical analysis of the results obtained in the study. After the determination that the parameters had a normal distribution, the Student t test was used between the parameters of the composite groups. Two-way ANOVA test and post hoc Tukey test were used for composites and mouthrinses. Significance was assessed at $p<0.05$ level.

RESULTS:

The mean color changes in ΔE and standart deviation (SD) of the color parameters ΔL*, Δa* and Δb* at all time periods are shown in Tables 3, 4, 5.

In the current research, the immersion in coffee solution resulted in a decrease of L and an increase of a and b values. Statistical analysis showed significant differences between the composite resins. The statistically highest color changes ΔE01, ΔL, Δa, Δb were obtained in the CTO group ($p<0.05$). (Table 3).

Table 3. Means and standard deviations of color changes after immersion in the coffee solution

	ESQ	CTO	
Baseline-Staining T1-T0	Mean ± SD	Mean ± SD	**p**
ΔL	-6.45±0.75	-9.61±1.21	0.001*
Δa	1.74±0.28	2.96±0.37	0.001*
Δb	3.29±0.92	6.78±1.03	0.001*
ΔE	7.48±0.95	12.16±1.37	0.001*

Student t test *p<0.05

In the T2-T1 period; there was a statistically significant difference between composites and among mouthrinses in terms of mean ΔL (p:0.012; p:0.048); Δa (p:0.001; p:0.024); Δb (p:0.003; p:0.003) at T2-T1 period. There was a statistically significant difference between composites in terms of mean ΔE in T2-T1 period (p:0.001) (Table 4). The interaction effect of CR and mouthrinses on the average ΔL, Δa, Δb was not statistically significant (p:0.206; p>0.05).

For the T2-T0 period; Two-way ANOVA tests, revealed significant differences between the composite resins for ΔL, Δa, Δb parameters (p=0.001), and among the mouthrinses for ΔL and Δb parameters (p:0.038 and p:0.002). Based on the ΔE; no differences were found among the mouthrinses (p=0.110) and no significant composite-mouthrinses interactions (p=0.114). However, statistically difference was found between the composite resins (p =0.001) (Table 5).

Table 4. Means and standard deviations of color changes at T2-T1

Mouthrinse-Staining		**ESQ**	**CTO**	
(T2-T1)		**Mean±SD**	**Mean±SD**	**p**
ΔL	LAW	3.73±0.64	3.99±3.22	0.840
	CPWC	3.11±0.75	4.36±1.76	0.111
	LTC	1.21±0.60	3.69±0.90	0.001*
	p	0.001*	0.848	
Δa	LAW	-1.13±0.24	-1.56±0.28	0.010*
	CPWC	-0.90±0.28	-1.69±0.42	0.001*
	LTC	-0.77±0.26	-1.29±0.34	0.008*
	p	0.058	0.126	
Δb	LAW	-2.51±0.67	-3.04±0.41	0.100
	CPWC	-1.54±0.61	-2.19±1.12	0.205
	LTC	-2.29±0.91	-3.47±0.93	0.033*
	p	0.060	0.038*	
ΔE	LAW	4.65±0.87	5.71±2.17	0.253
	CPWC	3.61±0.91	5.22±1.95	0.072
	LTC	2.72±1.06	5.30±0.95	0.001*
	p	0.005*	0.854	

Two-way ANOVA Test *p<0.05

Table 5. Means and standard deviations of color changes at T2-T0

Mouthrinse-Baseline		**ESQ**	**CTO**	
(T2-T0)		**Mean±SD**	**Mean±SD**	**p**
ΔL	LAW	-3.06±0.32	-5.16±2.53	0.045*
	CPWC	-3.19±0.23	-5.80±1.03	0.001*
	LTC	-5.06±1.26	-5.86±1.47	0.296
	p	0.001*	0.723	
Δa	LAW	0.73±0.15	1.26±0.24	0.001*
	CPWC	0.80±0.13	1.46±0.41	0.005*
	LTC	0.89±0.50	1.64±0.33	0.006*
	p	0.646	0.121	
Δb	LAW	1.29±0.64	3.67±0.92	0.001*
	CPWC	1.60±0.39	4.63±0.37	0.001*
	LTC	0.63±0.81	3.34±1.17	0.001*
	p	0.031*	0.037*	
ΔE	LAW	3.43±0.54	6.63±2.15	0.002*
	CPWC	3.67±0.31	7.58±1.06	0.001*
	LTC	5.22±1.39	7.01±1.59	0.045*
	p	0.002*	0.573	

Two-way ANOVA Test *p<0.05

DISCUSSION

The present study evaluated the efficacy of whitening mouthrinses on the color recovery of stained one-shade CRs. The first null hypothesis stating that there would be no significant difference in the discoloration between the CRs after immersion in the coffee solution was rejected.

Nanohybrid composite resins have gained popularity because of their superior mechanical, physical, and esthetic qualities. However, the accuracy of the color match to the surrounding dental tissues is a challenge due to various factors influencing tooth color.[17] In recent years, composite resins labeled as "universal-shade or one-shade" have been developed to address this issue.[4] However, the role of one-shade CR on color stability has been the subject of research in the literature. A clinical study conducted by Anwar et al. [7] revealed a statistically significant change in one-shade CR color match scores over time. Furthermore, Abreu et al. [8] demonstrated that multishade CR surpassed one-shade CR regarding color matching. In addition, in vitro studies have noted that one-shade CRs are prone to staining from typical intakes.[9-12]

In the present study, the samples exposed to coffee exhibited a decrease in the L parameter and an increase in the a and b parameters. It was shown that the lightness of the samples decreased and the color saturation increased. One-shade CR (ΔE=12,16±1,37) showed significantly more color change than multi-color CR (ΔE=7,48±0,95) in this study. The research by Fidan et al.[11] revealed that coffee immersion causes the most significant color change in one-shade CR, which supports our results. Moreover, this finding is aligned with the studies by Khayat et al.[9], and Aydın et al.[10], considered that one shade CRs exhibited more color changes than multi-color CRs. The color stability varies depending on the properties of the CRs; inorganic content, resin matrix volume and the monomer they contain.[6,13] In the current research, this difference may be due to CTO containing different resin monomers (bis-acryloyloxymethyl-tricyclododecane; TCD-DI-HEA) and a lower filler load. A previous study by Korkut et al. [12] reported that, due to its significant affinity for the low-polarity colorants in coffee, the TCD-DI-HEA monomer might be responsible for the lower color stability.

In the current study, a spectrophotometer and CIELAB color system were utilized. The color change value represents with E, only

demonstrates changes in the esthetic properties, but does not specify the type of changes.[18] Therefore, to calculate whether the material is lighter or darker, yellowed or green, ΔE*ab was used in this study. ΔE > 3.3 was considered clinically unacceptable.[19]

Extrinsic staining can be caused by adsorption and absorption of colorants. Surface quality is dependent on the finishing and polishing of the CR, which has an effect on its optical properties and durability. It was reported that untreated composite surfaces are more susceptible to staining.[6,20] A multi-stage Sof-Lex disc (3M ESPE) was therefore used in this study after composite discs were prepared.

According to the results of the study, a clinically unacceptable discoloration of the CRs was observed after immersion in coffee (ΔE > 3.3). This result is consistent with previous studies reporting that coffee causes significant discoloration of CRs.[21-23] Surface or subsurface color change may occur due to staining agents, pigments through absorption and/or adsorption mechanism.

Immersion period was a significant factor for color recovery. Mouthrinsing is recommended twice a day for 2 minutes. In view of this situation, the samples were kept in the solutions for 12 hours to obtain an effect that was equivalent to daily use of mouthrinse for one year.[24]

Whitening mouthrinses contain various bleaching agents such as peroxides, sodium citrate, sodium hexametaphosphate, pyrophosphates and activated charcoal.[25] These agents have either a bleaching or a stain removal effect. The effectiveness of hydrogen peroxide as a bleaching agent is supported in the literature. However, there are some risks associated with its uncontrolled use at home.[26] Thus, none of the mouthrinses tested in this study contain hydrogen peroxide.

In the present study, the mouthrinses led to increase in the L parameter and decrease in the a and b parameters for stained CR (T2-T1). Lima et al. [27] stated that increasing lightness (positive ΔL) and decreasing yellowness (negative Δb) are the main factors in tooth whitening, while decreasing redness (negative Δa) plays a minor role. This may explain the results of our study on the efficacy parameters of whitening. Whitening mouthrinses caused a significant difference in the ΔL (p=0.001), Δb (p=0.031) and ΔE (p=0.002) values for ESQ, while the Δb (p=0.037) value for CTO showed a significant difference. In this respect, the whitening mouthrinses reduced the discoloration of the CRs, but it was not a clinical acceptance level. Thus, the second null hypothesis was rejected. For the ESQ, LAW (ΔE=3,43±0,54) and CPWC (ΔE=3,67±0,31) improved the color compared more than the others. Similar to our findings, studies investigating the color changes of CRs did not find any significant difference between CRs and mouthrinses.[28-30]

The brand of mouthrinse and its ingredients may affect the color recovery of the CR. In the present study, LAW contains Tetrasodium pyrophosphates, and CPCW has pyrophosphates and charcoal whereas LTC has total effect without bleaching.[31] However, LTC had similar results in color recovery of CTO when compared LAV and CPCW, but no such effect was seen with ESQ. Differences are thought to be caused by material properties exposed to mouthrinses. In addition, mouthrinses are marketed in two forms of alcohol content which functions as solvent. Low pH and alcohol have been reported to affect the surface integrity and make it susceptible to coloration. Several studies have reported no clinically detectable discoloration of composite resins with alcohol-containing mouthrinses, while other studies have reported similar effects to alcohol-free mouthrinses.[31] Similarly, when reviewing studies on charcoal, the component of CPCW, one *in vitro* study [32] found no effect on discoloration, while one clinical study [33] reported dissatisfaction and minor effect.

The main limitations of this study were the *in vitro* setting and the use of only one type of one-shade CR. Further, *in vivo* studies are

required to assess the whitening effects of mouthrinses on different restorative materials.

CONCLUSION

All samples showed clinically unacceptable color change values after immersion in coffee solution but significantly higher in one-shade CR. None of the whitening mouthrinses was able to reduce coffee staining to a clinically acceptable level. However, the whitening mouthinses improved the color of multi-shade CR compared to one-shade.

Ethical Approval

Since sources obtained from humans or animals were not used in this study, ethics *committee* approval was not obtained.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: GYY, Data collection and processing: GYY, Analysis and interpretation: GYY, Literature review: GYY, Writing: GYY.

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