

Effects of Mouth Rinses on Color Stability of Resin Composites

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ABSTRACT

Objectives: The aim of this study was to evaluate the effects of 3 commercially available mouth rinses on the color stability of 4 different resin-based composite restorative materials.

Methods: Forty disc-shaped specimens (10x2 mm) were prepared from each of the following materials: A nanofill composite Filtek Supreme XT (3M/Espe, St. Paul, MN, USA); a packable low-shrinkage composite, AeliteLS Packable (BISCO, Inc, Schaumburg, IL, USA); nanoceramic composite resin Ceram-X (Dentsply, Konstanz, Germany); a microhybrid composite, and Aelite All-Purpose Body (BISCO). The specimens were then incubated in distilled water at 37°C for 24 hours. The baseline color values (L*, a*, b*) of each specimen were measured with a colorimeter according to the CIELAB color scale. After baseline color measurements, 10 randomly selected specimens from each group were immersed in 1 of the 3 mouth rinses and distilled water as control. The specimens were stored in 20 mL of each mouth rinse (Oral B Alcohol-free, Listerine Tooth Defense Anti-cavity Fluoride Rinse and Klorhex) for 12 hours. After immersion, the color values of all specimens were remeasured, and the color change value ΔE^*_{ab} was calculated. Data were analyzed using a 2-way analysis of variance at a significance level of .05.

Results: All specimens displayed color changes after immersion, and there was a statistically significant difference among restorative materials and mouth rinses ($P < .05$); however, the change was not visually perceptible ($\Delta E^*_{ab} < 3.3$). The interaction between the effect of mouth rinses and type of restorative materials was not statistically significant ($P > .05$).

Conclusions: It may be concluded that although visually nonperceptible, all resin restorative materials tested showed a color difference after immersion in different mouth rinses. (Eur J Dent 2008;2:247-253)

Key words: Mouth rinse; Resin composites; Color.

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INTRODUCTION

Tooth-colored restorative materials have been widely used to meet patients' esthetic demands in dental practice. Various types of composite resins with different physical characteristics are available on the dental market, and they are classified by particle size, shape, and distribution of fillers.¹ Since nanotechnology was introduced to dentistry, nanocomposites with filler sizes ranging from 0.01 to 0.04 mm have been developed.² Nanocomposites have many advantages, such as reduced

polymerization shrinkage, increased mechanical properties, improved optical characteristics, and better gloss retention.²⁻⁵ Wear resistance of nanocomposites has been shown to be comparable or superior to that of microfill and microhybrid composite resins.^{6,7}

The organically modified, ceramic-based, nanoceramic composite also was developed using the same technology. It contains a methacrylate-modified silicon-dioxide-containing nanofiller and resin matrix that is replaced by a matrix full of highly dispersed methacrylate-modified polysiloxane particles.⁸ Recently, low-shrinkage composites with reduced polymerization shrinkage were introduced for clinical use. They have a high elastic modulus because of their high filler content.⁹

Discoloration of tooth-colored, resin-based materials may be caused by several intrinsic and extrinsic factors. Intrinsic factors involve the discoloration of the resin material itself, such as alteration of the resin matrix and changes in the interface of matrix and fillers.¹⁰ The resin matrix has been reported as being critical to color stability, and staining may be related to a high resin content and water absorption.¹¹ Color matching plays an important role in achieving good results. However, discoloration of composite resin restorations may occur from time to time, and this unacceptable color change may lead to replacement of these restorations.¹²⁻¹⁴

Extrinsic factors for discoloration of resin composites include staining by adsorption or absorption of colorants from exogenous sources such as coffee, tea, nicotine, beverages, and mouth rinses.^{11,15,16}

The use of antimicrobial mouth rinses is an approach to limiting the accumulation of dental plaque, with a primary objective of controlling the development and progression of periodontal diseases and dental caries.^{17,18} However, frequent use of mouth rinses may have detrimental effects on oral and dental tissues.^{19,20} Despite the increased use of mouth rinses, research comparing resin composite color changes associated with use of mouth rinses is limited.^{21,22} The effect of alcohol-containing, chlorhexidine-gluconate-containing, and hybrid mouth rinses on the color stability of glass ionomer, compomer, and microhybrid composite resin materials have been evaluated in previous studies.^{21,22} To the best of our knowledge,

however, there has been no study comparing the effect of commercially available mouth rinses on newly developed resin composite materials.

Discoloration can be evaluated with different instruments and techniques. In assessing chromatic differences, the Commission Internationale de l'Eclairage (CIE L*, a*, b*) system was chosen for the present study. According to this system, L* represents the lightness of the sample, a* describes green-red axis (-a=green; +a=red) and b* describes blue-yellow axis (-b=blue; +b=yellow).²³ It is also possible to calculate the total color change (ΔE^*ab), which considers the changes of L*, a* and b*.²⁴ Various studies have different thresholds of color difference values which is perceptible to the human eye. However, the clinically acceptable value for color changes in dental materials is assumed to be $\Delta E^*ab \leq 3.3$.²⁵⁻²⁸

The aim of this study was to evaluate the effect of alcohol-containing, alcohol-free, and chlorhexidine-gluconate mouth rinses on color stability of a nanofill, a packable low-shrinkage, a nanoceramic, and a microhybrid resin-composite material. The null hypothesis tested in the present study was that daily use of mouth rinses affects the staining ability of resin composites and the color differences will be perceptible.

MATERIALS AND METHODS

The restorative materials used in the present study included a nanofill composite, Filtek Supreme XT; a packable low-shrinkage composite, AeliteLS Packable; nanoceramic composite resin Ceram-X; and a microhybrid composite, Aelite All-Purpose Body of A2 shade (Table 1). Forty disk-shaped specimens from each restorative material, 10 mm in diameter and 2 mm thick, were prepared in a polytetrafluoroethylene ring covered with a celluloid matrix and glass slides. Composite resins were polymerized with an LED unit (Elipar Freelight 2, 3M ESPE, ST Paul, MN, USA) in standard mode (20 seconds) for two cycles with a light intensity of 400 mW/cm² from the upper and lower surfaces of the specimens. The output of the curing units was checked with a radiometer (Kerr, Demetron, Orange, CA, USA). The distance between the light and the specimen was standardized by using a 1-mm glass slide. After polymerization, the upper surfaces of the specimens were ground with 1200-grit silicone carbide paper under running water.

The specimens were incubated in distilled water at 37°C for 24 hours. Then, the baseline color values (L*, a*, b*) of each specimen were measured with a colorimeter (Minolta Chroma Meter CR-321, Minolta Co, Osaka, Japan) against a white background. Quality of color was examined using the Commission Internationale de l'Eclairage (CIE Lab) system as tristimulus values and reported as color differences (ΔL^* , Δa^* , and Δb^*) compared with standard conditions.²³

Before each group of specimens was measured, the colorimeter was calibrated with a standard white card. Measurements were repeated 3 times in each sample and mean values were calculated.

Treatment groups were commercially available mouth rinses (Oral B Alcohol-free, Listerine Tooth Defense Anti-cavity Fluoride Rinse, Klorhex) and distilled water as a control (Table 2). Forty specimens of each restorative material group were randomly divided into 4 subgroups (n=10), and each subgroup was stored in 20 mL of one of the mouth rinses for 12 hours, which was reported as the equivalent of 2 mouth rinses per day for 1 year.²⁹ Specimens were kept at 37°C throughout the study, and test solutions were shaken every 3 hours to provide homogeneity. At the end of the test period, the specimens were removed and submerged in distilled water. After the immersion, the color values of each specimen were remeasured, and the color change value ΔE^*_{ab} was calculated

according to the following formula:²⁴

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

where L* stands for lightness, a* for green-red (-a=green; +a=red) and b* for blue-yellow (-b=blue; +b=yellow).

Statistical analyses were performed using a 2-way analysis of variance and Tukey's HSD (Honestly Significant Differences) test at a significance level of 0.05.

RESULTS

Table 3 and Figure 1 present the mean and standard deviations of color change values ΔE^*_{ab} in restorative materials after immersion in 3 different mouth rinses and distilled water as control.

All samples displayed color changes after immersion, and there was a statistically significant difference among the restorative materials and mouth rinses (P<.05); however, the interaction between the effect of the mouth rinse and the type of restorative material was not statistically significant (P>.05) (Table 4). The nanoceramic restorative material, Ceram-X specimens had the highest ΔE^*_{ab} values among the restorative materials tested, and there was a significant difference between the ΔE^*_{ab} values Ceram-X and Filtek Supreme XT, Aelite LS Packable, and Aelite All-Purpose Body (P=.014). The 2-way analysis of variance showed that there also was a significant difference between the ΔE^*_{ab} values among the

Table 1. Compositions of the restorative materials.

Restorative materials	Manufacturer	Lot Number	Filler weight (%)	Filler volume (%)	Filler Composition
Aelite All-Purpose Body	BISCO Dental Products, IL, USA	0600005269	73	53	Ethoxylated bisphenol A dimethacrylate Triethyleneglycol dimethacrylate Glass Filler Amorphous Silica
Aelite LS Packable	BISCO Dental Products, IL, USA	0600005264	86	74	Ethoxylated Bisphenol A dimethacrylate Bisphenol A diglycidylmethacrylate glass frit Amorphous Silica
Filtek Supreme XT	3M, ESPE, St. Paul, MN, USA	20070410	78.5	59.5	Nonagglomerated nanosilica filler (20 nm), Agglomerated Zirconia/silica nanocluster (0.6-1.4 μ m)
Ceram-X	Dentsply, Konstanz, Germany	0605001581	76	57	Ba-Al-Borosilicate glass filler (1-1.5 μ m), Silicone dioxide nanofiller (10 nm)

mouth rinses ($P=.046$). A post hoc Tukey honestly significant difference test revealed that the difference between the ΔE^*ab values of control group and the Oral B group was statistically significant ($P=.04$). There was no statistically significant difference among the mouth rinses (Listerine, Oral-B Alcohol-free, Klorhex) and between the groups Control/Listerine and Control/Klorhex ($P>.05$).

The ΔE^*ab values ≤ 3.3 were considered visually perceptible and clinically unacceptable in the present study.²⁵⁻²⁸ In Ceram-X group, the specimens immersed in Oral-B and Klorhex mouth rinses showed higher ΔE^*ab values than the other solutions. Although, these results were accepted visually perceptible, the ΔE^*ab values were very close to 3.3. In addition, the mean ΔE^*ab values

were also less than 3.3 in other groups, and the difference was not visually perceptible.

DISCUSSION

The present study evaluated the effects of three commercially available mouth rinses on the color stability of four different resin-based composite restorative materials. According to the results of the current study, the null hypothesis tested was partially accepted since, daily use of mouth rinses increased the staining ability of the resin composites however the color change was not perceivable.

Villalta et al³⁰ have shown that low pH and alcohol concentration of solutions might affect the surface integrity of composite resins and cause staining. In the present study, there was a statistically significant difference regarding color change values between the alcohol-free mouth rinse, Oral-B, and distilled water, but this difference was not visually perceptible. The alcohol concentration (21.6%) and pH value (3.5) of Listerine is very high, but the color stability of resin materials was not affected by this factor, and there was no significant difference among the mouth rinses tested. Asmussen³¹ reported that mouth rinses with high alcohol content might soften the composite resin material. Ethanol especially has a softening effect on BIS-GMA-based polymers. Therefore, Gürkan et al²⁹ showed that irrespective of alcohol concentration, both alcohol-containing and alcohol-free mouth rinses could affect the

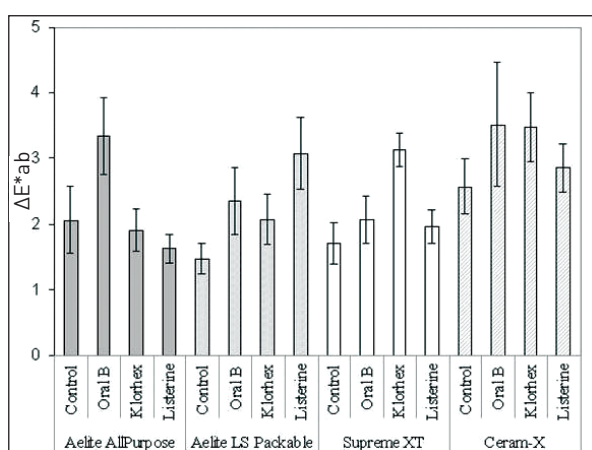


Figure 1. Color parameters of resin composites after immersion period in control and test solutions.

Table 2. Chemical compositions of the mouth rinses.

Mouthrinse	Manufacturer	Chemical composition	pH
Listerine Tooth Defense Anticavity Fluoride Rinse	Pfizer Consumer Healthcare, Morris Plains, NJ 07950, USA	sodium fluoride (0.0221%), water, sorbitol solution, alcohol (21.6%), flavors, poloxamer 407, sodium lauryl sulfate, phosphoric acid, sucralose, dibasic sodium phosphate, D&C red No. 33, FD&C blue No. 1	3.7
Oral-B Alcohol-free	Gillette Group Ltd, London, UK	glycerin, polysorbate 20, aroma, methyl paraben, etylpyridinium chloride, sodium fluoride, sodium saccharin, sodium benzoate, propylparaben CI42051	5.8
Klorhex	Drogsan, Ankara, Turkey	0.2% chlorhexidine gluconate	5.8
Distilled Water			6.7

hardness of resin-restorative materials.

The effect of staining solutions on color changes of composite resins may be material dependent, and the staining susceptibility of a restorative material may be attributed to its resin matrix or filler type. Scotti et al³² showed that the type of material had a significant role on stain resistance. According to the results of the current study, there were statistically significant differences between Ceram-X and the other resin composites. A nanoceramic resin composite, Ceram-X comprises organically modified ceramic (ormocer) nanoparticles and glass fillers (1.1-1.5 mm). Unlike conventional polymers, ormocers have an inorganic backbone based on silicon dioxide and are functionalized with polymerizable organic units to produce 3-dimensional compound polymers.³³ The filler concentration of Ceram-X is 76% by weight and 57% by volume. According to manufacturer's data, these nanoceramic

particles are inorganic-organic hybrid particles. Both, nanoceramic particles and nanofillers have methacrylate groups available for polymerization. Additionally, Ceram-X does not contain triethylene glycol dimethacrylate.⁸ The present study revealed that Ceram-X showed the greatest color change, and the change may be related to these structural differences.

In a previous study, Jung et al³⁴ demonstrated that Ceram-X did not yield better surface quality than did the other nanofill composites, Filtek Supreme and Tetric Evoceram. This difference was explained with the low volumetric filler content of the material and the porosities that were detected on the Ceram-X specimens. Rough surfaces have been shown to mechanically retain stains more than smooth surfaces.^{35,36} In many studies,²⁵⁻²⁸ discoloration will be referred to as acceptable up to the value $\Delta E^*ab=3.3$, which is considered to be the upper limit of acceptability in visual

Table 3. Mean values, standard deviations and standart errors of color change values (ΔE^*ab).

Restorative materials	Mouth rinses	ΔE^*ab	SD	SE
Aelite All-Purpose Body	Distilled water	2.06	1.61	0.510
	Oral B	3.34	1.85	0.587
	Klorhex	1.90	1.01	0.319
	Listerine	1.62	0.70	0.221
Aelite LS Packable	Distilled water	1.48	0.75	0.238
	Oral B	2.35	1.62	0.514
	Klorhex	2.07	1.20	0.380
	Listerine	3.08	1.71	0.540
Filtek Supreme XT	Distilled water	1.71	1.00	0.316
	Oral B	2.07	1.12	0.354
	Klorhex	3.13	0.78	0.247
	Listerine	1.97	0.80	0.252
Ceram-X	Distilled water	2.57	1.33	0.420
	Oral B	3.52	2.97	0.940
	Klorhex	3.48	1.64	0.519
	Listerine	2.86	1.16	0.368

Table 4. ANOVA results for color change (ΔE^*ab).

	Sum of squares	Mean square	F-value	P value
Material	22.93	7.64	3.68	.014
Solution	17.04	5.68	2.73	.046
Material-Solution	31.96	3.55	1.71	.091

* Statistically significant, $P < .05$

evaluations. The staining potentials of various mouth rinses have been already established for dental hard and soft tissues.³⁷⁻⁴¹ Also, the staining potentials of the mouth rinses were evaluated for many kinds of restorative materials. Gürdal et al²¹ have shown that the effects of the mouth rinses on the color stability are no different from those of distilled water. Similarly, Lee et al²² have found that although visually nonperceptible, mouth rinses affect color stability. In the current study, none of the restorative materials showed insufficient color stability and also presented visually perceptible discoloration after the immersion period.

In their study, because the effects of the mouth rinses were not different from those of distilled water, Geurtsen et al⁴² stated that the water component of the mouth rinses might affect the color shift and microhardness changes. In the current study, there were no statistically significant differences between the mouth rinses and distilled water except for Oral-B.

In clinical situations, how the effects of mouth rinses differ on esthetic restorative materials depends on many factors that cannot be simulated in vitro. Saliva, salivary pellicle, foods, and beverages may affect the color stability of resin restorative materials. Further in vivo studies are necessary to determine the staining potential of different types of mouth rinses.

CONCLUSIONS

According to the results of the present study, effects of the mouth rinses on the color change of the materials were not different from that of control solution. All resin restorative materials showed color difference after immersion in tested solutions but these differences were not visually perceptible. However, future studies should consider longer periods of immersion. Within the limitations of the current study, it may be concluded that aging of tooth-colored restoratives in different solutions may exert detrimental effects on these materials.

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