The Journal of Turkish Dental Research
Türk Diş Hekimliği Araştırma Dergisi

e-ISSN: 2822-4310, Cilt 3, Sayı 3, Eylül - Aralık 2024
Volume 3, Number 3, September - December 2024

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Universal Kompozit Rezinlerin Yüzey Pürüzlülüğü ve Renk Değişikliği Üzerinde Farklı Beyazlatıcı Diş Macunlarının Etkisi

Roughness and color interaction of toothpastes

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Makale Bilgisi / Article Information
Makale Türü / Article Types: Araştırma Makalesi / Research Article
Geliş Tarihi / Received: 10-06-2024
Kabul Tarihi / Accepted: 01-09-2024
Yıl / Year: 2024 | **Cilt – Volume:** 3 | **Sayı – Issue:** 3 |**Sayfa / Pages:** 398-408

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https://doi.org/10.58711/turkishjdentres.vi.1498740

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ÖZET

Amaç: *Çalışmamızın amacı, farklı diş macunları ile fırçalandıktan sonra kahve ile renklendirilmiş iki farklı universal rezin kompozitin yüzey pürüzlülüğü ve renk stabilitesini değerlendirmektir.*

Gereç ve Yöntem: *İki farklı rezin kompozitten (Zenchroma ve Neo Spectra ST) toplam 120 örnek (n=10) hazırlanmıştır. Renk değerleri (CIELAB) başlangıçta, 6 günlük simüle edilmiş kahve daldırmasından sonra ve diş fırçalamadan sonra spektrofotometre ile ölçülmüştür. Başlangıç pürüzlülük (Ra0) ölçümleri bir profilometre ile yapıldıktan sonra, örnekler diş fırçalama simülasyonuna tabi tutulmuş ve son değerler (Ra1) kaydedilmiştir. Farklı kompozitlerin ve diş macunlarının renk ve pürüzlülük değişkenleri üzerindeki etkileri İki Yönlü ANOVA yöntemi ile analiz edilmiştir. İstatistiklerin anlamlılık düzeyi $p<0.01$ olarak kabul edilmiştir.*

Bulgular: *Örneklerin kahveye batırıldıktan sonra ortalama ΔE001 değerleri karşılaştırıldığında, Zenchroma daha fazla renk değişimi gösterdiği ortaya çıkmıştır. Hem Zenchroma hem de Neo Spectra ST yüzey pürüzlülüğündeki en yüksek artış Opalescence Whitening diş macunu/OW diş macunu grubunda, en az artış ise distile su grubunda gözlenmiştir.*

Sonuç: *Kahve lekelenmesinde, en az renk değişikliği çok renkli nano-hibrit kompozit reçinede, en fazla renk değişikliği ise tek renkli mikro-hibrit kompozit reçinede gözlenmiştir. Test edilen kompozit reçine örneklerine göre, en önemli renk değişikliği, silika içeren OW diş macunu kullanıldıktan sonra meydana gelirken, en az renk değişikliği beyazlatıcı olmayan bir diş macunu Colgate Total 12/CT kullanıldıktan sonra gözlenmiştir. Yüzey pürüzlülüğü çalışmada kullanılan beş farklı diş macunu grubunda artmış olup, en yüksek artış OW diş macunu grubunda gözlenmiştir.*

Anahtar Kelimeler: *Yüzey Pürüzlüğü, Renk Stabilitesi, Rezin Kompozit Beyazlatıcı, Diş Macunu*

ABSTRACT

Aim: *The aim of our study is to evaluate the surface roughness and color stability of two different universal resin composites colored with coffee after brushing with different toothpastes.*

Materials and Methods: *A total of 120 samples (n=10) were prepared from 2 different resin composites (Zenchroma, and Neo Spectra ST). Color values(CIELAB) were measured with a spectrophotometer at baseline, after 6 days of simulated coffee immersion and after tooth brushing. After initial roughness (Ra0) measurements were performed with a profilometer, the samples were subjected to toothbrushing simulation, and final values (Ra1) were recorded. The effects of different materials and toothpastes on color and roughness variables were analyzed by the Two-Way ANOVA method. The significance level of the statistics was $p<0.01$.*

Results: *The average ΔE001 values of materials after soaking in coffee were compared, revealing that Zenchroma material exhibited more discoloration. The highest increase in surface roughness in both Zenchroma and Neo Spectra ST materials was in the Opalesencence Whitening toothpaste/ OW toothpaste group, while the least increase was in the distilled water group.*

Conclusion: *In coffee staining, the least color change was observed in multishahe nano-hybrid composite resin, while the greatest color change was observed in single shade micro-hybrid composite resin. The most significant color change, based on the tested composite resin samples, occurred after using silica-containing OW toothpaste, while the smallest color change was observed after using a non-whitening toothpaste Colgate Total 12/CT. Surface roughness increased in all five different toothpaste groups used in the study, with the highest increase observed in the OW toothpaste group.*

Keywords: *Surface Roughness, Color Stability, Resin Composite, Whitening Toothpaste*

https://doi.org/10.58711/turkishjdentres.vi.1498740

Introduction

As the interest in aesthetics has increased, patients' demand for longer-lasting aesthetic restorations has also risen.[1] Therefore, composite resins compatible with tooth color have gained popularity among dental practitioners. Nowadays, the use of highly aesthetic supra-nano, submicron hybrid, nanohybrid, nanoceramic, and micro-hybrid composites has become widespread in the treatment of anterior and posterior teeth.[2,3] Currently, universal resin composites are widely used thanks to their ability to be used in both anterior and posterior group teeth, to meet aesthetic and functional expectations, and to provide convenience to clinicians in color selection. Recently, companies have added improved color properties to universal resin composites and claimed that sufficient aesthetic results will be obtained in every tooth with fewer color options, and even single color options in some products. The color stability of the composite resin used for a successful aesthetic restoration is very important. Many internal and external factors affect coloration such as insufficient polymerization, water absorption, chemical reaction, dietary habits, oral hygiene, and surface smoothness of the restoration.[4,5] Surface roughness has an important role in the aesthetic success of composite resins as well as color stability. A rough restoration surface can lead to discoloration, abrasion, plaque accumulation, loss of gloss, and gingival irritation.[6]

As the demand for white teeth has increased, and aesthetics have come to the forefront, the importance of whitening toothpaste has also grown. In recent years, kinds of toothpaste have been divided into two categories: therapeutic toothpaste that reduces plaque, tartar, caries, and dentin sensitivity, and cosmetic toothpaste that whitens teeth by removing stains on the teeth.[7-10] Whitening toothpaste works by enhancing the cleaning effectiveness of the paste, or by whitening the teeth. To this end, they may contain hydrogen peroxide (HP) and carbamide peroxide (KP), sodium bicarbonate, silica, or aluminum oxide.[10] The vast majority of whitening toothpastes lighten the color of the teeth by eliminating stains, rather than whitening the teeth.[11] Apart from abrasives, titanium dioxide particles in the paste also create the illusion that the tooth looks whiter by filling the pores on the tooth surface.[10-12] The degree of abrasiveness of the toothpaste depends on the structure of the abrasive particles as well as the shape and size of the particles.[10,11,13] Studies have also demonstrated that chemically different abrasives, such as hydrated silica and calcium carbonate, have different cleaning and abrasion values.[10,11,14] In the literature, it has been reported that abrasive particles contained in whitening toothpastes may cause roughening of the composite resin material surface.[15] It has also been reported that increased surface roughness may have negative effects on the color of the composite material, leading to the deterioration of its aesthetic properties.[16] During the brushing of composite resins, the soft polymer matrix of the resin is eroded, leaving the inorganic structure behind.[17] There are several clinical and laboratory studies in the literature examining the effect of whitening toothpastes on the surface roughness and discoloration of composite resins. However, the recent development of new materials and new agents has limited the available information on this subject.[16-18] The aim of our study is to evaluate the surface and color stability of two different universal resin composites colored with coffee, after brushing with different toothpastes. The null hypothesis of our study is that four different whitening toothpastes and a non-whitening toothpaste will not make any difference in terms of roughness and color changes on the universal composite groups tested.

Material and Method

In this in vitro study 4 different whitening toothpastes (Opalescence Whitening, p Colgate Optic White, Curaprox White is Black, Colgate Total 12 and Foramen Whitening) and two different universal composite resins (Zenchroma and Neo Spectra ST) were used. The toothpastes used in the study, their ingredients, abbreviations (Opalescence Whitening-OW, p Colgate Optic White-COW, Curaprox White is Black-CW, Colgate Total 12-CT and Foramen Whitening-FW) and the RDA (Relative Dentin Abrasivity) and Ph values of the pastes are indicated in Table I. The lot numbers, brand names, manufacturers, shades, types, composite structure (filler composition/size, monomers), and filler w/V% loadings of the composite resins are shown in Table II.

A total of 120 disk-shaped samples, 60 of each

Table I. Toothpastes used in the experiment and their RDA and pH values

Toothpastes/ Manufacturer	Ingreditions	RDA	pH	Code
Opalescence Whitening Toothpaste (Ultradent Products, Inc. Utah, ABD)	Glycerin, distilled water, silica, sorbitol, xylitol, poloxamer sodium lauryl sulfate, carbomer, sodium benzoate, sodium fluoride, sodium hydroxide sucralose, xanthine gum	90	7	OW
Colgate Optic White (Colgate-Palmolive Company, İstanbul, Turkey)	Sodium monofluorophosphate, glycerin, calcium pyrophosphate, propylene glycol, peg/ppg-116/66 copolymer, peg-12, pvp, tetrasodium pyrophosphate, sodium lauryl sulfate, silica, aroma, sodium saccharine, phosphoric acid, hydrogen peroxide, bht, limonene	100	5,6	COW
Curaprox White is Black (Curaden, ABD)	Activated carbon, water, sorbitol, hydrated silica, glycerin, carbon black, bentonite, aroma, decyl-glucoside, sodium monofluorophosphate, cocamidopropyl betaine, tocopherol, mica, xanthan gum, hydroxyapatite(nano), tiatnium dioxide, microcrystalline cellulose, maltodextrin, potassium acesulfame, sodium benzoate, potassium chloride, potassium sorbate, menthyl lactate, methyl diisopropyl propionamide,	50	6,1	CW
Colgate Total 12 (Colgate-Palmolive Company, İstanbul, Turkey)	Glycerin, Aqua, Hydrated Silica, Sodium Lauryl Sulphate, Arginine, Aroma, Zinc Oxide, Cellulose Gum, C 77891, Poloxamer 407, Tetrasodium Pyrophosphate, Zinc Citrate, Benzyl Alcohol, Xanthan Gum, Cocamidopropyl Betaine, NaF(1450ppm), Sodium Acid, Phosphoric , Sucralose	70	7,03	CT
Foramen Whitening (Kibar Dental, Turkey)	Aqua,Hydrated silica, Sorbitol, Glycerin, Sodium Lauryl Sulfate, Xanthan Gum, Aroma, Titanium Dioxide, Potassium Sorbate, Sodium Fluoride, Sodium Benzoate, Sodium Saccharin, Maltodextrin, Citric Acid, PVM/MA, Copolymer, Papain, Ammonium Sulfate, Sodium Phosphate, Limonene	*	*	FW
Distilled water			6,3	DW

Table II. Properties of composite resin materials used in the study

Material	Manufacturer	Lot Number	Type	Monomer	Filler Composition/Size	Filler w/V%	Code
Zenchroma	President Dental, Germany	2023001245	Microhybrid	UDMA Bis-GMA TEMDMA	Glass powder, silicon dioxide inorganic filler / (0.005–3.0 µm)	75/53	ZC
Neo Spectra ST HV A2	Dentsply, North Carolina, USA	2110000874	Nanohybrid	Bis (4-methyl-phenyl) iodonium hexafluorophosphate	Spherical, pre-polymerized SphereTECfillers, Methacrilate-modified polysiloxane barium glass, and ytterbium flüoride/ (3 µm-7 µm)	79/61	NS

https://doi.org/10.58711/turkishjdentres.vi.1498740

composite material, were prepared. Using the Minitab 16.0 program, it was calculated that, based on surface roughness comparison data from similar studies, with a Type I error rate of 5% and a study power of 80%, the expected standard deviation was 0.8, and the difference between the largest and smallest means was assumed to be 1.93. Consequently, the minimum number of samples required per group was calculated to be 8. Considering potential data loss, the sample size was increased by 20%, resulting in 10 samples per group. The sample diameter was set to 8 mm, which is smaller than the diameter of the light device used for equal polymerization of each region, and the thickness was set to 2 mm according to the instructions of the manufacturer. Transparent tape (Universal Strips, Extra Dental, Istanbul, Turkey) was positioned under these molds before the composite resins were inserted. The composite resins were positioned in the slots in the molds, the transparent tape was overlaid and the overflowing composite material was then removed by applying finger pressure with a 1 mm thick thin glass coverslip. The tip of the Woodpecker LED-E (Woodpecker Medical Instrument Co., Guilin, China) LED light device with a light power of 1200 mW/cm^2 and a wavelength of 450-470 nm was placed on the glass coverslip perpendicular to each sample and the composite resins were polymerized for 20 seconds in accordance with the instructions of the manufacturer. The power of the light device was checked with a radiometer (Hilux, Benlioglu Dental Inc, Ankara, Turkey) before the polymerization of each specimen. All samples were then placed in an oven at 37°C in distilled water for 24 hours.

In accordance with the manufacturer's recommendations, Minitech 233 polishing machine (Presi, Grenoble, France) was used for polishing while submerged in running water (170 rev/min, 15s). 120 samples were prepared with two different composites (n = 60). Each composite group (Zenchroma and Neo Spectra ST) was distributed into 6 different subgroups. (n=10)

Group 1: Opalescence Whitening Toothpaste Group (OW)
Group 2: Colgate Optic White Toothpaste Group (COW)
Group 3: Curaprox White is Black Toothpaste Group (CW)
Group 4: Colgate Total 12 Toothpaste Group (CT)
Group 5: Foramen Whitening Toothpaste Group (FW)
Group 6: Distilled Water Group (DW)

Initial surface roughness measurements of the samples were performed with a Perthometer M2 device (Mahr, Germany). The device was calibrated before the measurements. The samples were placed on the table perpendicular to the reader end of the device. Surface roughness measurements were performed by applying the device 3 times to different areas of the sample with a 0.25 mm "cut-off" value and a 5.5 mm tracking path. For each sample, these 3 measurements were averaged to obtain the 'average roughness value' expressed as 'Ra'.

After the surface roughness measurements, initial color measurements of the samples were made. A spectrophotometer (SpectroShade, MHT Optic Research, Niederhasli, Switzerland) was used for color measurement. Initial color measurements were made and each sample was numbered. Then coffee solution was prepared for coloring the samples.

The coffee solution was made by mixing 300 ml of heated distilled water with 3.6 g of coffee (Nescafe Classic, Nestle, India). After being let to wait for ten minutes, the solution was run through filter paper.[19] The samples were then placed in the molds prepared according to the sample numbers without changing their order and the coffee solutions were added to them. These molds were then kept in an oven (EN025, Nüve, Turkey) at 37°C for 24 hours. The samples were removed from the oven, washed with distilled water, and dried with blotting paper.

Then, the second color measurements of the samples were recorded as average L_1*, a_1*, and b_1* values in accordance with the CIELAB color system by repeating each measurement three times using the SpectroShade device. The device was calibrated every 10 samples during the measurements. The calibration of the device was done by measuring the white and green colored plates in the device set in accordance with the manufacturer's instructions. To ensure standardization during the color measurements of the samples, the measurements were adjusted so that the entire surface of the samples was measured.

The colored samples were subjected to a brushing cycle to evaluate the effectiveness of the whitening toothpastes. To mimic the daily routine toothbrushing

procedure, the samples were brushed twice a day for 2 min in continuous mode using an electric toothbrush (Braun, Oral B Smart 4) and Oral-B Cross Action brush head. Toothpastes were mixed 1:1 by weight with artificial saliva to form a slurry and the fixed samples were brushed with this slurry. During the brushing cycle, the brush was changed in each group (every 10 samples) and the toothpaste slurry was changed in each sample.

Individuals brush their teeth twice a day for 2 minutes each time, totaling 240 seconds of tooth brushing per day. A person with a total of 32 teeth averages 8 seconds of tooth brushing per tooth per day.[20] Clinical procedures evaluating the effectiveness of whitening toothpaste recommend using it for 2-6 weeks to remove stains.[11] Therefore, in our study, to simulate one month of tooth brushing, all samples were brushed for 4 minutes.[21]

ΔE001 (Coffee hold) from L*, a* and b* and L1*, a1*, and b1*, and ΔE002 (Coffee hold) from L*, a* and b* and L2*, a2*, and b2* was calculated from using CIEDE2000 color formulation. The following formula was employed to calculate the amount of color change ΔE_{00} between the obtained measurements.[22] The color change differences of the composites used in the study were examined comparatively with whitening toothpastes. In this study, the detectable threshold value of ΔE00 was determined as 0.8 and ΔE00>0.8 was accepted as a visually detectable color change. The acceptable threshold value for ΔE00 was determined as 1.8, and ΔE00 >1.8 values were considered clinically unacceptable discoloration.[22]

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}$$

Statistical analysis

The color and roughness variables were checked by skewness and graphically (histogram) and were found to conform to a normal distribution. The effects of different materials and paste on color and roughness variables were analyzed by the Two-Way ANOVA method. Duncan's multiple comparison tests were used to compare the different groups. The materials were compared in terms of roughness for each paste with Independent Samples T-Test. The significance level was $p<0.01$.

Results

The values of roughness change caused by different toothpastes on the surface of ZC and NS materials were obtained by subtracting the initial roughness value from the final roughness value and given in Table III. The highest increase in surface roughness in both ZC and NS materials was in the OW toothpaste group, while the least increase was in the distilled water group.

As a result of the performed statistical analyses, the amount of discoloration of the two different restorative materials, the mean ΔE_{00} values of the groups and the statistical comparison results are given in Table IV.

After exposure to coffee, when the mean $\Delta E_{00}1$ values for both ZC and NS materials were compared, the ZC restorative material became more colored. After brushing, when the mean $\Delta E_{00}2$ values for ZC and NS materials were compared, a statistically significant difference was

Table III. Roughness change values of different toothpaste groups

	Zen Chroma	**Neo Spectra ST**		
	Mean ± SD	Mean ± SD	t	p
Opalescence Whitening	0.626±0.197^{a}	0.606±0.187^{a}	0.224	0.825
Curaprox White is Black	0.326±0.353^{bc}	0.516±0.255^{a}	-1.378	0.185
Foramen Whitening	0.166±0.094^{cd}	0.284±0.266^{ab}	-1.321	0.203
Colgate Total 12	0.418±0.199^{abc}	0.421±0.380^{a}	-0.21	0.984
Colgate Optic White	0.474±0.198^{ab}	0.446±0.248^{a}	0.272	0.789
Distilled water	0.069±0.049^{d}	0.068±0.0254^{b}	0.080	0.937
p	<0.001	<0.001		

a,b,c,d: Same row different superscripts indicate statistically significant difference.(p<0.01)

https://doi.org/10.58711/turkishjdentres.vi.1498740

Table IV. Showing the mean and standard deviations of the ΔE_{00} values of the experimental groups
Different letters in the same column indicate significant differences between the toothpastes.

	$\Delta E_{00}1$ (Coffee hold)	$\Delta E_{00}1$(Coffee hold)	$\Delta E_{00}2$ (Brushing)	$\Delta E_{00}2$ (Brushing)
	Zen Chroma	Neo Spectra ST	Zen Chroma	Neo Spectra ST
Opalescence Whitening	3.331 ± 0,284	2.454±0,215	1.299±0,435^{c}	1.539±0.32^{BC}
Curaprox White is Black	3.476 ± 0,322	2.461±0,192	1.566±0,266^{c}	1.372±0.129^{C}
Foramen Whitening	3.498 ± 0,311	2.434±0,277	2.449±0,212^{b}	1.589±0.236^{BC}
Colgate Total 12	3.470 ± 0,294	2.583±0,349	2.647±0,297^{b}	1.668±0.126^{B}
Colgate Optic White	3.432 ± 0,359	2.398±0,267	2.345±0,154^{b}	1.755±0.232^{B}
Distilled water	3.598 ± 0,212	2.515±0,264	3.254±0,358^{a}	2.242±0.212^{A}
p	0.524	0.692	<0.001	<0.001

found between the whitening paste groups. The distilled water group was significantly more colored than the other paste groups ($p<0.001$).

In all groups, it was determined that the coloration of the samples after soaking in coffee decreased after brushing.

Discussion

The aim of our study is to evaluate the surface and color stability of two different universal resin composites colored with coffee, after brushing with different toothpastes. In the study, the physical properties of colored composites were evaluated after brushing with toothpaste. There are no studies in the literature that comparatively evaluate the effects of whitening toothpastes on the physical properties of colored Zenchroma and Neo Spectra universal composites. This in vitro study aimed to assess both the discoloration of composite resins and the impact of toothpaste on the color stability and surface roughness of composite resins. Since whitening mechanisms, pH, and RDA values of toothpastes are known to affect composite materials differently, five different toothpastes with different whitening mechanisms were used.[23-25]

In our study, the effect of whitening toothpaste on multi shade and single shade composite materials has been tested and compared. Color stability is one of the most significant factors affecting the clinical life of the restoration.[26,27] Discoloration of the restoration surface, depending on the properties of the material, may be caused by water and dye absorption of the restorative material, surface roughness, diet, and oral hygiene habits.[5, 28-30]

Spectrophotometers and the CIEDE2000 system were used to measure color changes, providing a more accurate assessment of the perceptibility and acceptability of existing color differences.[31-33] In this study, the CIEDE2000 formula was used for the determination of color changes in accordance with the current literature.

Tea, coffee and wine, which are commonly consumed daily beverages, cause the most color change.[34] Ertaş et al.[19] reported that keeping samples in coffee for 24 hours mimicked approximately 1 month of coffee consumption. The samples were subjected to long-term coloring by soaking them in coffee for 6 days in an oven at 37°C.

The determination of color change depends on the visual perception of the change in the color values of an object and the determination of the amount of color change that influences the aesthetic appearance.[35] A color change that is noticeable to the eye by 50% of observers is defined as a 50:50% perceptibility threshold. A color change value that is clinically acceptable by 50% of observers is defined as a 50:50% acceptability threshold.22 In this study, ΔE_{00}>0.8 values were considered as visually perceptible color changes and ΔE_{00} >1.8 values were considered as clinically unacceptable color changes based on the study of Paravina et al.[22] According to the results of our study, both ZC and NS composites showed clinically unacceptable color changes after coloring with coffee. ZC composite showed clinically acceptable color change after OW and CW brushing. NS composite showed clinically acceptable color change after brushing in all toothpaste groups.

The discoloration of composite resins depends on the water absorption properties of the monomers used; TEGDMA causes more discoloration due to its high water absorption, while UDMA and resins without TEGDMA discolor less.[36] In our study, it was the NS multi shade universal resin composite group that showed the least color change. This may have been because NS does not contain TEGDMA.

Silva et al.[37] and Roselino et al.[38] both found that nanohybrid composite resins exhibited the highest discoloration, with Silva's study showing this after exposure to a coffee solution and brushing, and Roselino's study observing it after tooth brushing with whitening toothpaste. The highest coloration was observed in the micro-hybrid composite ZC in our study. This is thought to be caused by the difference in the type and amount of filler particles in the material. The fact that the nanohybrid composite did not contain TEGDMA in our study led to a decrease in water absorption and may have reduced polymer solubility.

In general, composite resins with low filler content have higher color changes.[39] The results of our study showed that the ZC material with low filler content was more colored after soaking in coffee. It has been reported in the literature that nanofiller resin composites show more coloration when exposed to coloring solutions than microfiller and hybrid resin composites.[40] It has been reported that higher surface gloss and polishability due to the reduction in the particle size of nanofiller resin composites have a positive effect on the appearance and aesthetic properties of restorations.[41] Filler ratios of resin composites are also one of the parameters used to evaluate aesthetic properties such as color and roughness.[42] As the filler ratio decreases, the water absorption of the resin increases and the resin structure becomes softer and therefore more prone to abrasions and discoloration.

The five distinct brand-name whitening toothpastes used in this study included titanium dioxide, enzymes, activated carbon, calcium pyrophosphate, blue pigment, tetrasodium pyrophosphate, hydrogen peroxide, and silica as chemical whitening agents.

Mehrgan et al.[43] investigated the effects of brushing with different whitening toothpaste on Spectrum TPH composite samples exposed to coffee stains over a two-week period. According to their results, a whitening toothpaste containing 2% hydrogen peroxide (Colgate Optic White) was more effective than abrasive-containing and charcoal-containing whitening toothpaste formulations. According to the results of our study, the impact of COW toothpaste on color change was statistically similar to FW and CT toothpaste groups in ZC composite; however, in NS composite, it was found to be statistically different from CW and DW groups.

Regarding surface roughness values, some previous studies reported that restorative materials with Ra values between 0.7-1.4 µm do not pose a risk in regards to plaque accumulation, while current studies indicate that restorative materials with Ra values less than 1 µm exhibit a smooth surface.[44,45]

Today, as oral aesthetics become more crucial, whitening is one of the key characteristics demanded from toothpastes. With different formulations, both effective cleaning and effective whitening are expected.[15] Abrasives in toothpastes can affect the surface properties

https://doi.org/10.58711/turkishjdentres.vi.1498740

of the material. Abrasive content can result in greater surface roughness and deterioration of the surface properties of the material. Toothpaste slurry, brush type, hardness and number of bristles, and brushing time are effective on the obtained findings. When these parameters are considered in the literature, it may be difficult to compare studies.[46] Camargo et al.[13] stated that as the size of abrasive particles in the paste content increases, the abrasiveness and stain removal efficiency will increase.[13] In the present study, a standard brush type was selected and the brush was renewed in each group and at the beginning of each cycle.

In this in vitro study, 5 different toothpastes and two different universal composite resins were used. The roughness change values caused by different toothpastes on the surface of ZC and NS materials were obtained by subtracting the initial roughness value from the final roughness value. The highest increase in surface roughness was seen in both ZC and NS materials, the least increase was seen in the OW toothpaste group, and the distilled water group. Looking at the results, it was seen that composite resins were affected by the abrasiveness of toothpastes in terms of roughness change.

The Ra value of each toothpaste group increased and there was a significant difference between the initial values and the roughness values obtained after brushing in all groups. This suggests that the roughness may increase further when brushing with toothpaste is continued for a longer period of time.

The inorganic matrix, known as the filler system, is added to the organic phase to prevent direct abrasion of the organic matrix against the forces acting on the restoration, to improve surface properties such as hardness, the wear resistance of the composite, and to improve the aesthetic appearance of the biomaterial. Tooth brushing also alters the balance between organic matrix and filler particles. Surface roughness is also reported to depend on the microstructure of the used composites. Soliman et al. indicated that surface roughness is associated with composite resin filler particle size.[47] Composites with low filler content tend to exhibit higher surface roughness and color change. The results of our study revealed that the ZC material, which has low filler content, showed greater surface roughness after being stained with coffee and brushed with different toothpastes. These findings are consistent with the study by Soliman et al., which indicated that surface roughness is associated with the filler particle size of composite resins.

Whitening toothpastes containing silica and calcium carbonate have been reported to abrade resin-based composites less than those containing sodium bicarbonate.[13] This may be because calcium phosphate has less abrasiveness and internal hardness and its solubility is higher.

Senawongse et al.[6] compared the surface roughness of nanofillers, nanohybrid, and micro-hybrid composite resins and observed an increase in the surface roughness of all composite samples brushed with toothpaste.[6] Demir et al.[48] investigated the impact of brushing with different toothpastes on the color stability and surface roughness of colored composite disc samples. According to the results of this study conducted on colored composite disc samples, the highest color change was observed in Colgate Optic White, but the surface roughness of the samples in this group increased. In our study, the surface roughness of all groups increased.

There are studies indicating that tooth brushing alone can have a roughening effect on the roughness of dental restorative materials by abrading the softer polymer matrix and leaving filler particles.[17] This is consistent with the results of our study. Only brushing was applied to the composite materials in the distilled water group. There are studies showing that abrasives contained in whitening toothpastes, in addition to the brushing effect, can also remove residues on the surface physically or chemically by means of peroxides.[9]

In this study, the roughness values of samples brushed with both distilled water and toothpaste increased after brushing. The increase in roughness values caused by brushing appears to be only minimal. There are effects of whitening toothpaste on the surface roughness of the composite resin. In this study, it was reported that there was no statistically significant difference between the groups in the color measurements of the composite resin before and after brushing and it was concluded that effective tooth brushing is more important than the type of toothpaste used.[49] Contrary to the results of this study, a significant difference was detected between the groups

in color measurements according to the toothpaste used.

We used five different toothpastes in our study. Colgate Total 12, the traditional toothpaste, has no whitening content and contains silica as an abrasive particle.

In our study, we used toothpastes with different whitening mechanisms but similar abrasive particles and moderate abrasiveness. This approach minimized the whitening effect through abrasion, allowing us to measure color change and roughness based on the whitening agents.

In vitro studies cannot fully replicate intraoral conditions. They only provide insights into the clinical performance of materials and methods. Factors such as temperature, humidity, microorganisms, saliva composition and quantity, tongue and cheek movements, dilution of staining beverages by saliva, and changes in temperature and pH levels can all affect the properties of composite restorations. Additionally, while our composite specimens have smooth surfaces, not all resin restorations in clinical practice do. Therefore, extensive in-vivo and in-vitro studies on new composite resins with various compositions are necessary to understand their full range of properties.

Conclusions

Within the limitations of this in vitro study, it was concluded that all five toothpaste brands led to an increase in surface roughness in coffee-stained composite samples and were effective in removing discoloration. The highest increase in surface roughness was observed in the OW toothpaste group. All tested toothpaste brands caused a change in the color of the samples. OW demonstrated the highest effectiveness as a whitening toothpaste. These results indicate that all the toothpaste brands used in the study increased the surface roughness of composite samples and achieved noticeable whitening in all toothpaste groups. Therefore, it may be recommended for individuals who frequently consume coffee to use whitening toothpaste.

https://doi.org/10.58711/turkishjdentres.vi.1498740

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https://doi.org/10.58711/turkishjdentres.vi.1498740