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Effects of Whitening Toothpastes on Microhardness and Surface Roughness of Composite Resins: An In Vitro Study

Beyazlatıcı Diş Macunlarının Kompozit Rezinlerin Mikrosertliğine ve Yüzey Pürüzlülüğüne Etkisi: Bir İn Vitro Çalışma

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ABSTRACT Objective: This study aimed to assess the effect of different types of whitening toothpastes on the microhardness and surface roughness of composite resins. **Material and Methods:** 120 disc-shaped samples each of Clearfil Majesty Esthetic and Gradia Direct Anterior composite resins were randomly assigned to 4 groups, based on the toothpaste used [three whitening toothpastes: Signal White Now (SWN), Colgate Optic White (COW), Ipana 3D White Luxe (IWL), and one non-whitening toothpaste: Sensodyne Promine (SP)]. The samples were brushed using an electrical toothbrush for 4 minutes. Before and after toothbrushing surface roughness (n=15) and Vickers microhardness (n=15) values were measured and the topography of the composite resins was observed using scanning electron microscopy. Data were analyzed using repeated measures analysis of variance and Bonferroni correction ($p<0.05$). **Results:** The surface roughness was significantly affected by the toothpastes ($p=0.013$) and there was a significant interaction between toothpastes and composite resins ($p<0.001$). The surface roughness of composite resins significantly increased after toothbrushing with all toothpastes. SWN and IWL showed significantly higher surface roughness values than SP ($p=0.024$ and $p=0.028$, respectively). There was a significant increase in the microhardness values for Gradia Direct Anterior after toothbrushing with SWN, IWL and SP ($p=0.003$, $p<0.001$ and $p=0.029$, respectively). **Conclusion:** In this study, it was determined that all toothpastes increased the surface roughness values of Clearfil Majesty Esthetic and Gradia Direct Anterior, and all toothpastes (except COW) increased the microhardness values of Gradia Direct Anterior. Clinicians should notify patients of the abrasive capacity of all toothpastes, especially those that are whitening.

Keywords: Composite dental resin; toothbrushing; toothpaste; surface properties

ÖZET Amaç: Bu çalışmada, farklı türde beyazlatıcı diş macunlarının kompozit rezinlerin mikrosertliği ve yüzey pürüzlülüğü üzerine etkisinin değerlendirilmesi amaçlandı. **Gereç ve Yöntemler:** Clearfil Majesty Esthetic ve Gradia Direct Anterior kompozit rezinlerinin her birinden elde edilen disk şeklinde 120 adet örnek, kullanılan diş macununa göre rastgele 4 gruba ayrıldı [3 beyazlatıcı diş macunu: Signal White Now (SWN), Colgate Optic White (COW), Ipana 3D White Luxe (IWL) ve bir beyazlatıcı olmayan diş macunu: Sensodyne Promine (SP)]. Örnekler 4 dk boyunca elektrikli diş fırçası kullanılarak fırçalandı. Fırçalamadan önce ve sonra örneklerin yüzey pürüzlülük (n=15) ve Vickers mikrosertlik (n=15) değerleri ölçüldü ve taramalı elektron mikroskobu kullanılarak kompozit rezinlerin yüzey topografyası gözlemlendi. Veriler tekrarlı ölçümlerde varyans analizi ve Bonferroni düzeltmesi kullanılarak analiz edildi ($p<0,05$). **Bulgular:** Örneklerin yüzey pürüzlülüğü diş macunlarından anlamlı şekilde etkilendi ($p=0,013$), diş macunları ve kompozit rezinler arasında anlamlı bir etkileşim gözlendi ($p<0,001$). Kompozit rezinlerin yüzey pürüzlülük değerleri, tüm diş macunları ile fırçalamadan sonra anlamlı olarak arttı. SWN ve IWL, SP'den daha fazla yüzey pürüzlülüğüne neden oldu ($p=0,024$ ve $p=0,028$, sırasıyla). Gradia Direct Anteriorun mikrosertlik değerlerinde SWN, IWL ve SP ile fırçalandıktan sonra anlamlı bir artış belirlendi ($p=0,003$, $p<0,001$ ve $p=0,029$, sırasıyla). **Sonuç:** Bu çalışmada, tüm diş macunlarının Clearfil Majesty Esthetic ve Gradia Direct Anteriorun yüzey pürüzlülüğünü ve COW hariç diğer tüm diş macunlarının Gradia Direct Anteriorun mikrosertlik değerlerini artırdığı belirlendi. Klinisyenler, özellikle beyazlatıcı diş macunları olmak üzere tüm diş macunlarının abraziv kapasiteleri konusunda hastaları bilgilendirmelidir.

Anahtar Kelimeler: Kompozit dental rezin; diş fırçalama; diş macunu; yüzey özellikleri

Tooth discoloration is one of the most frequently reported problems in patients with esthetic expectations.[1] In the last 2 decades, toothpastes have been used as over-the-counter (OTC) whitening products to respond to esthetic demand.[2] Toothpastes that are claimed to have teeth-whitening properties account

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for more than 50% of OTC products.[3] Abrasives found in formulations of toothpastes include calcium carbonate, hydrated silica, calcium pyrophosphate, dicalcium phosphate dihydrate, perlite, alumina, or sodium bicarbonate assist in the removal of plaque, stains, and debris. Chemical agents such as citrate, enzymes, hexametaphosphate, and peroxide added to whitening toothpastes increase abrasive cleaning by helping to prevent or remove extrinsic stains.[4] In whitening toothpastes containing blue covarine as an optical agent, acts through retention and deposition on tooth surfaces, resulting in a yellow to blue color shift, which leads to an increase in the perception of tooth color as white.[5,6]

Whitening toothpastes can cause minimal wear on the dental hard tissues while providing maximum cleaning.[4] It has been reported that increased abrasiveness of toothpaste causes damage to the enamel and exposed dentin, and wear restorations, subsequently, the esthetics of the restoration may be adversely affected.[2,6]

The surface roughness of a composite resin is known as a parameter with a high clinical significance that can influence surface gloss, surface wear, plaque accumulation, and discoloration.[7-9] Microhardness is one of the substantial properties of composite resin materials associated with wear resistance.[10] In the literature, several studies have evaluated the effects of different whitening toothpastes on surface properties of enamel and composite resins.[11-22] But, there has been a limited number of studies on the effects of current whitening toothpastes on composite resins. Therefore, this study aimed to determine the effects of currently used 3 different whitening toothpastes on the surface roughness and microhardness of composite resin materials compared to one non-whitening toothpaste.

The null hypotheses investigated are: (a) the whitening toothpastes tested would not affect the surface roughness of composite resins and there would be no significant difference among the tested toothpastes in terms of surface roughness; (b) the composite resins tested would present no roughness differences after simulated toothbrushing; (c) the whitening toothpastes tested would not affect the Vickers microhardness of the composite resins.

MATERIAL AND METHODS

PREPARATION OF SAMPLES

Composite resins listed in Table 1 were used in this study. A total of 240 acrylic resin blocks (12×20×10 mm) were prepared in teflon molds using self-curing acrylic resin (Imicryl, SC, Konya, Türkiye) and divided into 2 groups. A cylinder-shaped cavity with a diameter of 8 mm and a depth of 2 mm was formed in the center of the surface of each acrylic block. The cavities were filled using composite resin so that there were 120 samples from each composite resin. A Mylar strip (Universal Strip, DML, Germany) covered by a glass slide was applied over the composite resin, then the samples were light-cured using a LED light curing unit (Elipar S10, 3M ESPE, St. Paul, MN, USA, 1200 mW/cm²) in contact with the Mylar strip for 20 seconds. After 24 hours of storage (at 37 °C and 100% humidity), the samples were polished under running water using 1200-4000 grit silicon carbide abrasive papers then cleaned in an ultrasonic cleaner (UC-10, Jeiotech, Korea) using distilled water for 10 minutes.

TABLE 1: Composite resins used in the study.

		Content			Filler loading			
Composite resin	**Type**	**Organic matrix**	**Fillers**	**Particle size**	**(wt %)**	**(vol %)**	**Manufacturer**	**Batch number**
Clearfil Majesty Esthetic	Nanohybrid	Bis-GMA, hydrophobic aromatic dimethacrylate, dl-camphorquinone	Silanated barium glass filler, pre-polymerized organic filler	0.7 µm	78	66	Kuraray Medical, Okayama, Japan	BE0203
Gradia Direct Anterior	Microhybrid	UDMA, dimethacrylate comonomers	Silica, prepolymerized filler	0.85 µm	73	64	GC, Tokyo, Japan	201203A

Bis-GMA: Bisphenol A-glycidyl methacrylate; UDMA: Urethane dimethacrylate.

SIMULATED TOOTHBRUSHING

120 samples prepared from each composite resin were randomly assigned to four groups (n=15). They were brushed using an electrical toothbrush (Genius 8900, Oral B Braun, Germany) for 4 minutes.[23] People perform toothbrushing 2 times a day for 2 minutes, which is equivalent to 240 seconds. The duration of toothbrushing for each tooth of a person with 32 teeth is an average of 8 seconds a day. Therefore, each sample was brushed for 4 minutes (240 seconds) to simulate 1 month (30 days) of brushing time.[23] Toothpastes [3 whitening toothpastes: Signal White Now (SWN) (Unilever, France), Colgate Optic White (COW) (Colgate-Palmolive, Poland), Ipana 3D White Luxe (IWL) (Procter & Gamble, Germany), and one non-whitening toothpaste: Sensodyne Promine (SP) (GlaxoSmithKline, EU)] listed in Table 2 were used in this study. Slurries were prepared with toothpaste and distilled water (1:1). The electrical toothbrush settled on a custom-made holder with a standardized force of 2 N was used in “standard mode”.[24] After brushing, the samples were washed in distilled water. The independent variables of surface roughness (n=15) and microhardness (n=15) were tested.

SURFACE ROUGHNESS MEASUREMENT

Before and after toothbrushing, surface roughness values were measured using a surface profilometer (MarSurf PS 10, Mahr, Göttingen, Germany). The tracing length was 4 mm, stylus speed was 0.5 mm/s, and cut-off length was 0.8 mm. Three measurements were obtained by rotating the specimen 45°, and the average roughness (Ra) was derived from 3 readings.

MICROHARDNESS MEASUREMENT

Before and after toothbrushing, the Vickers microhardness number (VHN) values of the samples were measured (Duramin Microhardness Tester, Struers, Cleveland, USA) with a 50 g/15 s load. Three indentations were performed at equal distances on each sample and the mean VHN values of the samples were calculated.

SCANNING ELECTRON MICROSCOPE ANALYSIS

Five separate samples from each composite resin were prepared. One sample from each group (before and after toothbrushing) were randomly selected and evaluated using scanning electron microscope (SEM) (EVO LS10, Zeiss, Oberkochen, Germany). They were covered with gold in a sputter-coater (SPI-Module Sputter Coater, Structure Probe Inc., PA, USA). The SEM images were taken at x5000.

STATISTICAL ANALYSIS

The data were analyzed using the SPSS Statistical Software (SPSS version 23.0 software, SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used

TABLE 2: Toothpastes used in the study.

Toothpastes	Compositions	Manufacturer
Signal White Now	Aqua, hydrogenated starch hydrolysate, hydrated silica, PEG-32, zinc citrate, sodium lauryl sulfate, aroma, cellulose gum, sodium fluoride, sodium saccharin, PVM/MA copolymer, trisodium phosphate, sodium hydroxide, glycerin, sodium laureth sulfate, lecithin, limonene, CI 74160, CI 77891	Unilever
Colgate Optic White (Expert White)	Glycerin, propylene glycol, calcium pyrophosphate, PEG/PPG-116/66 copolymer, PVP, PEG-12, tetrasodium pyrophosphate, sodium lauryl sulfate, silica, aroma, sodium monofluorophosphate, sodium saccharin, phosphoric acid, hydrogen peroxide, BHT, limonene	Colgate-Palmolive
Ipana 3D White Luxe (Perfection)	Glycerin, hydrated silica, sodium hexametaphosphate, aqua, PEG-6, aroma, trisodium phosphate, sodium lauryl sulfate, carrageenan, cocamidopropyl betaine, mica, sodium saccharin, sodium fluoride, PEG-20M, xanthan gum, CI 77891, sucralose, limonene, sodium benzoate, sodium hydroxide, silica, CI 74160, citric acid, sodium citrate, BHT, potassium sorbate	Procter & Gamble
Sensodyne Promine	Aqua, sorbitol, hydrated silica, glycerin, potassium nitrate, PEG-6, cocamidopropyl betaine, aroma, xanthan gum, sodium fluoride, sodium saccharin, titanium dioxide, sodium hydroxide, limonene, anise alcohol	GlaxoSmithKline

PEG: Polyethylene glycol; PVM/MA: Polyvinyl methyl ether/maleic acid; PPG: Polypropylene glycol; PVP: Polyvinylpyrrolidone; BHT: Butylated hydroxytoluene.

for testing normality. The results showed that the data of the roughness and microhardness exhibited normal distribution. Microhardness data of each composite resin were separately analyzed using one-way repeated measures analysis of variance (ANOVA). Roughness data were examined by two-way repeated measures ANOVA. Pair-wise comparisons were examined using Bonferroni correction. p<0.05 was considered significant.

RESULTS

SURFACE ROUGHNESS

The mean Ra values for the 2 composite resins before and after toothbrushing are given in Table 3. A statistically significant difference was detected among toothpastes (p=0.013) and in the interaction between composite resins and toothpastes (p<0.001). However, there was no statistically significant difference between composite resins (p=0.372). There was a significant increase in surface roughness for both composite resins after toothbrushing with all toothpastes. When comparing toothpastes, SWN and IWL caused significantly higher surface roughness compared to SP (p=0.024 and p=0.028, respectively).

MICROHARDNESS

The mean VHN values for the composite resins before and after toothbrushing are given in Table 4. After toothbrushing with all toothpastes, VHN values of Clearfil Majesty Esthetic, a nanohybrid composite resin, increased, but the difference was not found to be significant (p>0.05). When comparing toothpastes, the whitening toothpastes SWN, COW, and IWL caused a greater change in VHN compared to non-whitening toothpaste SP (p<0.001, p=0.003 and p=0.007, respectively).

There was a significant increase in VHN values for Gradia Direct Anterior, a microhybrid composite resin, after toothbrushing with SWN, IWL, and SP (p=0.003, p<0.001 and p=0.029, respectively). When comparing toothpastes, there was no significant difference among them (p>0.05).

SEM ANALYSIS

Representative SEM images of each composite resin: Clearfil Majesty Esthetic (A-E) and Gradia Direct Anterior (F-J) before and after toothbrushing are presented in Figure 1. Before toothbrushing (A, F), both composite resins showed a flat surface. Micromorphological changes were observed on the composite

TABLE 3: Descriptive analysis of surface roughness values ($\bar{X}$±SD) of the used composite resins before and after toothbrushing.

		$\bar{X}$±SD	
Composite resin	**Toothpaste**	**Before**	**After**
Clearfil Majesty Esthetic	SWN	$0.16±0.01^{A,a}$	$0.19±0.01^{B,a}$
	COW	$0.16±0.02^{A,a}$	$0.20±0.02^{B,a}$
	IWL	$0.13±0.03^{A,b}$	$0.18±0.03^{B,a}$
	SP	$0.12±0.03^{A,b}$	$0.16±0.02^{B,b}$
		p=0.001	p<0.001
Gradia Direct Anterior	SWN	$0.16±0.03^{A,a}$	$0.18±0.03^{B,a}$
	COW	$0.13±0.03^{A,b}$	$0.17±0.03^{B,a}$
	IWL	$0.16±0.03^{A,a}$	$0.20±0.02^{B,b}$
	SP	$0.15±0.03^{A,ab}$	$0.18±0.03^{B,a}$
		p=0.036	p=0.030
Total	SWN	$0.16±0.02^{a}$	$0.18±0.02^{a}$
	COW	$0.14±0.03^{ab}$	$0.18±0.03^{a}$
	IWL	$0.15±0.03^{ab}$	$0.19±0.03^{a}$
	SP	$0.14±0.03^{b}$	$0.17±0.03^{b}$
		p=0.056	p=0.003

Different superscript capital letters (A,B) in each column and lowercase letters (a,b) in each row indicate statistically significant differences (p<0.05); SD: Standard deviation; SWN: Signal White Now; COW: Colgate Optic White; IWL: Ipana 3D White Luxe; SP: Sensodyne Promine.

TABLE 4: Descriptive analysis of VHN values (X̄±SD) of the used composite resins before and after toothbrushing.

Composite resin	Toothpaste	Time	X̄±SD	p[a]
Clearfil Majesty Esthetic	SWN	Before	38.8±3.4	p=0.068[a]
		After	40.5±3.9	
	COW	Before	36.3±3.6	p=0.087[b]
		After	37.9±2.8	
	IWL	Before	36.0±3.2	p=0.066[b]
		After	37.8±3.4	
	SP	Before	33.5±1.7	p=0.521[c]
		After	34.1±1.5	
Gradia Direct Anterior	SWN	Before	27.8±3.8	p=0.003[a]
		After	31.0±3.3	
	COW	Before	29.0±4.7	p=0.133[a]
		After	30.5±4.0	
	IWL	Before	27.6±3.4	p<0.001[a]
		After	33.8±6.1	
	SP	Before	28.0±1.8	p=0.029[a]
		After	30.3±4.7	

[a]Bonferroni correction test results. Different superscript letters (a,b,c) indicate statistical differences among toothpastes (p<0.05); VHN: Vickers microhardness number; SD: Standard deviation; SWN: Signal White Now; COW: Colgate Optic White; IWL: Ipana 3D White Luxe; SP: Sensodyne Promine.

resin surfaces after toothbrushing compared with the initial morphologies: SWN (B and G), COW (C and H), IWL (D and I), and SP (E and J).

DISCUSSION

According to the results, the first null hypothesis that whitening toothpastes tested would not affect the surface roughness of composite resins and there would be no significant difference among the tested toothpastes in terms of surface roughness was rejected. All toothpastes caused an increase surface roughness on composite resins. However, whitening toothpastes (except COW) produced higher surface roughness. The second null hypothesis that the composite resins tested would present no roughness differences after simulated toothbrushing was accepted. The third null hypothesis that whitening toothpastes tested would not affect the Vickers microhardness values of the composite resins was partially accepted, since whitening toothpastes (except COW) produced an increase in the microhardness values of Gradia Direct Anterior.

In this study, surface roughness was increased in all groups after toothbrushing (Table 3, Figure 1). This result is in agreement with previous studies.[15-17] When composite resins are subjected to abrasion, the organic matrix surrounding the fillers becomes to wear out, which causes the protrusion of the fillers and the creation of bumps on the surface of the composite resin. Finally, the entire filler particle is ripped off the surface, and craters are formed. These formations induce an increase in surface roughness.[8] In our study, wear of organic matrix and significant change in the surface texture for all groups after toothbrushing were shown in SEM images (Figure 1). SEM images corroborate the surface roughness findings.

The abrasion produced by toothpastes is thought to be due to the abrasive components of toothpastes and the hardness of the toothbrush bristles.[11] In this study, a soft-bristled toothbrush was used to eliminate the possibility of the abrasiveness of the toothbrush.

In the present study whitening toothpastes (except COW) caused higher surface roughness than SP.

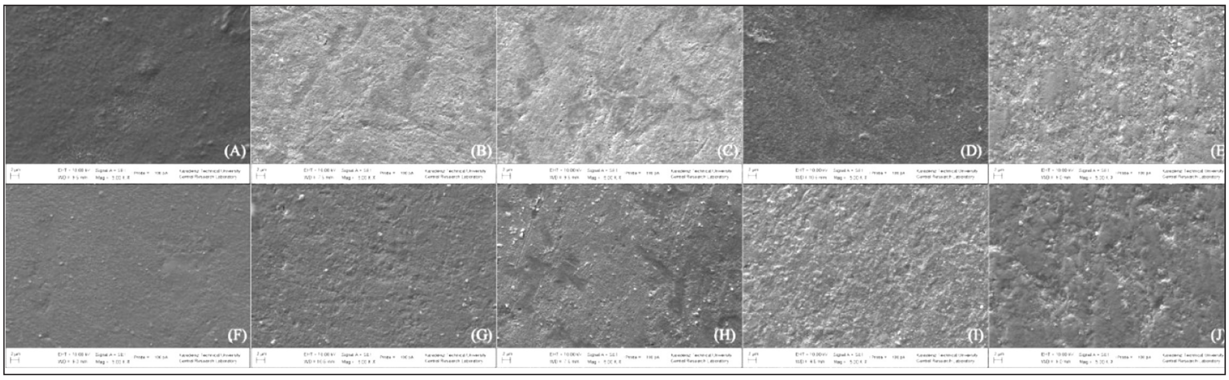

FIGURE 1: Representative SEM images (x5000) of each composite resin: Clearfil Majesty Esthetic (A-E) and Gradia Direct Anterior (F-J) before (A, F) and after toothbrushing: SWN (B and G), COW (C and H), IWL (D and I) and SP (E and J).
SEM: Scanning electron microscope; SWN: Signal White Now; COW: Colgate Optic White; IWL: Ipana 3D White Luxe; SP: Sensodyne Promine.

Whitening toothpastes often contain more and harder abrasives compared with the conventional toothpastes.[6] High amounts of abrasive found in toothpastes may damage tooth tissues and restorations.[12,15,16,18] Previous studies have reported different results of whitening toothpastes on composite resins in terms of surface roughness.[14-21] However, only one of the cited studies used the same 2 kinds of toothpaste used in this study.[21] In addition, some of the studies did not provide information about the toothpastes compositions they used.[14,15,17,19] The differences in the results of the studies may be related to the different types of toothpaste used, the hardness of the toothbrush bristles, the brushing cycles, the time of the brushing, and the ratios of the prepared slurry.

It is very difficult to explain the different abrasive potentials among toothpastes because of their complex components. Abrasiveness is affected by the type, shape, amount, hardness, size, size distribution, concentration of abrasive, and the presence of some active compounds (pyrophosphate).[4,25] In the present study, 4 different commercial toothpastes containing silica or hydrated silica as abrasive agent and whitening agents such as tetrasodium pyrophosphate, calcium pyrophosphate, titanium dioxide and hydrogen peroxide were used; however, size distribution, concentration and shape of such particles were not reported by the manufacturers.[21] The toothpastes in the present study contained silica is one of the most used abrasive agents.[11] Silica is known to have strong abrasive properties.[13] If silica and moderate abrasive titanium dioxide are found together in a toothpaste, it is thought that the abrasiveness of that toothpaste increases.[11,18] The SWN, IWL, and SP used in the study contain silica and titanium dioxide. When these toothpastes are used, significant changes on the surfaces of composite resins may be related to their composition of silica and titanium dioxide abrasives. In addition to these explanations, we have no information about the amount and properties of silica particles, so it is difficult to estimate how much the relationship between the components has promoted the results. It is thought that the abrasiveness of toothpaste increases when silica and sodium phosphate are used together.[18] SWN and IWL contain trisodium phosphate in their composition. When SWN and IWL are used, the increase in surface roughness may be related to silica and trisodium phosphate particles. In addition, IWL contains mica, known as an abrasive agent.[20] Mica may have been effective in increasing the surface roughness of composite resins after toothbrushing with IWL. It has been stated that not only abrasives but also detergents in toothpastes can cause dental wear.[26] All whitening toothpastes used in the present study contain sodium lauryl sulfate as detergent.

The combination of pyrophosphate and abrasive particles is known to contribute to the increased abrasiveness of some whitening toothpastes.[25] COW is comprised of silica, calcium pyrophosphate, tetrasodium pyrophosphate, and hydrogen peroxide. Hydrogen peroxide has the ability for oxidation and reduction and can form free radical species. Therefore, hydrogen peroxide can harm the resin-filler interface and lead to filler-matrix debonding. This can increase surface roughness.[27] In a previous study reported that hydrogen peroxide, which is found in a low concentration (1% or less) in toothpastes, does not damage the dental hard tissues and does not have long-term adverse effects.[28] In an another study, it was reported that whitening toothpaste containing 3.6% hydrogen peroxide did not significantly affect the surface roughness of composite resin.[14] In addition, it has been reported that the effect of peroxide in toothpastes is limited due to the short contact time of the paste on the teeth surface.[19] Therefore, in this study, hydrogen peroxide containing COW did not cause a significant increase in surface roughness compared to non-whitening toothpaste SP.

The roughness of composite resins is directly related to the properties of filler particle systems, that is, the size, hardness, quantity, and shape.[29,30] It has been stated that composites containing smaller average fillers show less increase in surface roughness compared to composites containing larger fillers.[15] Small fillers improve the packing of particles, present reduced interparticle spacing. Thus, the organic matrix is less affected by brushing wear.[29,31] It has been reported that the composite resin with lower filler loading offers higher surface roughness and wear as the resin matrix is less preserved against abrasion.[32] In the present study, Clearfil Majesty Esthetic and Gradia Direct Anterior composite resins were used. There was no significant difference between the composite resins in terms of surface roughness. Although Gradia Direct Anterior has a relatively larger average filler size and lower filler loading compared to Clearfil Majesty Esthetic, these values are similar between composite resins. This may explain the similarity of surface roughness values of composite resins. However, it can be assumed that other factors affect the roughness, such as the resin matrix composition, degree of conversion of polymer of composite resin matrix, and chemical bonds between the organic matrix and fillers.[33] In addition, the size and number of filler particles of composite resins have been explained, but their spatial conformation has not been indicated by the manufacturers. Therefore, due to the specific definition of the material being ambiguous, it is difficult to predict the effect of each exclusive compound on the material's final properties.[34]

In the literature, different results were obtained regarding the surface microhardness of composite resins after toothbrushing with whitening toothpastes.[17,22,35] In the present study, although an increase was observed in the microhardness values of both composite resins after brushing with all toothpastes, the increase in microhardness values of Gradia Direct Anterior was found to be significant (except COW). The possible low percentage of hydrogen peroxide present in the COW and the short contact time of the paste with the samples may explain the non-significant effect of COW on the surface hardness of composite resins.[19] The increase in microhardness of composite resins after toothbrushing can be explained by the abrasive particles contained in the toothpastes. Abrasive particles can play a role in the wear of the surface layer of the organic matrix and in exposing particles that are harder than the organic matrix.[35]

The first limitation of this study is that the component properties and concentrations of the toothpastes were not disclosed by the manufacturers. Therefore, it was difficult to predict how much the components would affect the results. The second limitation is that distilled water was used to dilute the toothpastes. In the clinic, toothpastes are diluted by saliva, which can change the effect of toothpastes. The role of saliva could not be imitated because distilled water was used in this study. To better understand the potential for the abrasiveness of whitening toothpastes, clinical studies are needed in which more types of whitening toothpastes are used, and longer periods of use are simulated.

CONCLUSION

Within the limitations of this in vitro study, all of the toothpastes tested increased the surface roughness of composite resins after simulated toothbrushing, but whitening toothpastes (except for COW) caused a greater roughness on composite resins. Clearfil Majesty Esthetic and Gradia Direct Anterior composite resins showed similar surface roughness after simulated toothbrushing. A significant increase was found in the microhardness values of Gradia Direct Anterior after brushing with SWN and IWL. Patients should be informed by clinicians that toothpastes, especially those that are whitening, have the effect of increasing the surface roughness of composite restorations.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Pınar Naiboğlu, Tuğba Koşar; **Design:** Pınar Naiboğlu; **Control/Supervision:** Tuğba Koşar; **Data Collection and/or Processing:** Pınar Naiboğlu; **Analysis and/or Interpretation:** Pınar Naiboğlu, Tuğba Koşar; **Literature Review:** Pınar Naiboğlu, Tuğba Koşar; **Writing the Article:** Pınar Naiboğlu; **Critical Review:** Tuğba Koşar; **References and Fundings:** Pınar Naiboğlu, Tuğba Koşar; **Materials:** Pınar Naiboğlu, Tuğba Koşar.*

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