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The Effects of Home and Over-The-Counter Whitening Agents on Surface Roughness and Microhardness of High Aesthetic Composites

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Research Article

History

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ABSTRACT

Introduction: The aim of this in-vitro study is to compare the effect of the newly released peroxide-free over-the-counter whitening products and the home whitening material containing carbamide peroxide, on high aesthetic composites.
Materials and methods: In our study, 4 different composites were used: supra-nano(Tokuyama Estelite Asteria), submicron hybrid(Brilliant Ever Glow), nanofil(Filtek Universal Restorative) and finally nano-ceramic(Ceram.x SphereTEC one). A total of 200 disc-shaped composite specimens with 2 mm thickness and 8 mm diameter were prepared using metal molds(n=10). One surface of the samples was polished using Sof-Lex™ XT discs. Composite groups were divided into 5 subgroups as 4 experimental and 1 control groups (n=10) . Four whitening products, namely Opalascence Home Type, Mr. Blanc, I-White, Cali White, were used in the experimental groups. It was kept in a drying oven at 37°C to imitate the temperature of the mouth on certain days and hours in accordance with the instructions written in the whitening products prospectus. The surface roughness of the samples was measured with a profilometer and the microhardness values were measured with a fully automatic Micro Hardness Tester. The surfaces were examined with a Scanning Electron Microscopy. Data were evaluated with two-way Variance Analysis and Tukey Test as statistical methods.
Results: According to the surface roughness data, Filtek Universal Restorative's I-White subgroup showed the highest average surface roughness value, and Tokuyama Estelite Asteria's I-White subgroup showed the lowest value. There was a significantly difference between the composite main groups and the experimental subgroups($p<0.05$). According to microhardness data, I-White subgroup of Tokuyama Estelite Asteria showed the highest average microhardness value and the lowest value was Brilliant Ever Glow's I-White subgroup. A significantly difference was observed between the composite main groups and the experimental subgroups($p<0.05$). Although OTC whitening products did not significantly change the surface roughness and microhardness values of composite resins, when SEM analyses were examined, it was observed that all OTC whitening products caused more cleft, crack and defect-like changes on the composite surfaces compared to Opalescence home whitening agent.
Conclusions: It can be stated that Filtek Universal Restorative material is the composite that is most negatively affected by whitening materials, while Tokuyama Estelite Asteria composite is the least affected.

Keywords: Aesthetic composite, microhardness, surface roughness, whitening.

Yüksek Estetiğe Sahip Kompozitlere Uygulanan Ev Tipi ve Tezgah Üstü Beyazlatma Ajanlarının Yüzey Pürüzlülüğü ve Mikrosertlik Üzerine Etkisi

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ÖZ

Giriş: Bu in-vitro çalışmanın amacı, piyasaya yeni çıkan, peroksit içermeyen tezgah üstü beyazlatma ürünleriyle, karbamid peroksit içerikli ev tipi beyazlatma materyalin, yüksek estetiğe sahip kompozitler üzerindeki etkisini karşılaştırmaktır.
Gereç ve Yöntemler: Çalışmamızda supra-nano(Tokuyama Estelite Asteria), submikron hibrit(Brilliant Ever Glow), nanofil(Filtek Universal Restorative) ve son olarak nano-seramik(Ceram.x SphereTEC one) olmak üzere 4 farklı kompozit kullanıldı. Metal kalıp kullanılarak 2 mm kalınlığında 8 mm çapında toplam 200 adet disk şeklinde kompozit örnek hazırlandı(n=10). Örneklerin bir yüzeyine Sof-Lex™ XT diskler kullanılarak polisaj işlemi uygulandı. Kompozit grupları 4 deney ve 1 kontrol grubu olmak üzere 5 alt gruba ayrıldı (n=10). Deney gruplarında Opalascence Ev Tipi, Mr.Blanc, İ-White, Cali White, olmak üzere dört adet beyazlatma ürünü kullanıldı. Beyazlatma ürünleri prospektüsünde yazan talimatlar doğrultusunda belirli gün ve saatlerde ağız sıcaklığını taklit edecek şekilde 37°C'de etüvde bekletildi. Örneklerin yüzey pürüzlülüğü profilometre cihazı, mikrosertlik değerleri tam ttomatik Mikro Sertlik Ölçüm Cihazı ile bakıldı. Taramalı Elektron Mikroskobu ile yüzeyleri incelendi. Veriler, istatistiksel yöntem olarak iki yönlü Varyans Analizi ve Tukey Testi ile değerlendirildi.
Bulgular: Yüzey pürüzlülüğü verilerine göre, en yüksek ortalama yüzey pürüzlülüğü değerini Filtek Universal Restorative'in İ-White alt grubu, en düşük değeri Tokuyama Estelite Asteria'ın İ-White alt grubu gösterdi. Kompozit ana grupları ve deney alt grupları arasında fark anlamlı bulundu($p<0,05$). Mikrosertlik verilerine göre, en yüksek ortalama mikrosertlik değerini Tokuyama Estelite Asteria'ın İ-White alt grubu, en düşük değeri Brilliant Ever Glow'un İ-White alt grubu gösterdi. Kompozit ana grupları ve deney alt grupları arasında fark anlamlı bulundu($p<0,05$). OTC beyazlatma ürünleri, kompozit rezinlerin yüzey pürüzlülük ve mikrosertlik değerlerini anlamlı derecede değiştirmemesine rağmen, SEM analizleri incelendiğinde tüm OTC beyazlatma ürünlerinin Opalescence ev tipi beyazlatma ajanına göre kompozit yüzeylerinde daha fazla yarık, çatlak ve defekt benzeri değişimlere uğrattığı görülmüştür.
Sonuçlar: Beyazlatma materyallerinden olumsuz yönde en çok etkilenen kompozit Filtek Universal Restorative materyali iken, beyazlatma ürünlerinde en az etkilenen materyal ise Tokuyama Estelite Asteria kompozitin olduğu söylenebilir.

Anahtar kelimeler: Beyazlatma, estetik kompozit, mikrosertlik, yüzey pürüzlülüğü.

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Introduction

In recent years, with the increasing desire for whiter teeth, teeth whitening has become a popular treatment option among patients. Today, teeth whitening options include professional in-office whitening performed by a dentist, home whitening performed at home under the supervision of a dentist, and self-administered whitening with over-the-counter (OTC) products.[1] The availability and easy access to OTC whitening products have increased their popularity. This option is less time-consuming, more cost-effective, and eliminates the need for extra appointments with the dentist compared to a professionally prescribed home whitening product.[2] Unattended whitening with an OTC whitening product can have potentially harmful effects on general health and dental health in particular.[3-5]

Today, composites are among the most commonly used restorative materials. There are different types of composites on the market, which vary mainly according to filling technologies. Among these, micro-filled (MF), micro-hybrid (MH) and recently nano-hybrid (NH) composites are widely used in the clinical setting.[6] Whitening products can also change the roughness, hardness, flexural strength and colour stability of restorative composites.[7] Since whitening products cannot affect the optical properties of restorative materials, they should be replaced in anterior teeth if they are not aesthetically satisfactory.[8]

Most whitening products use hydrogen peroxide as the active ingredient.[9] Home whitening has become a preferred treatment method for patients and dentists due to its excellent clinical efficacy, easy application, low cost and safety of the materials used. One of the products used for this procedure is carbamide peroxide at concentrations of 10-16%, which converts to free radicals (OH-) when it comes into contact with saliva.[7] During the whitening process, carbamide peroxide is separated into hydrogen peroxide and urea, with the concentration of hydrogen peroxide being approximately one third of the original carbamide peroxide concentration. Therefore, a 15 percent carbamide peroxide product is approximately 5 per cent hydrogen peroxide.[10]

EU Council Directive 2011/84/EU entered into force on 31 October 2012. It states that products containing more than 0.1% or less than 6% hydrogen peroxide present or released in tooth whitening agents shall only be sold to dentists. As a result of Directive 2011/84/EU, there has been an increase in "non-hydrogen peroxide" products entering the market. These products contain a range of active ingredients with limited research on their safety and efficacy.[11]

Teeth whitening systems that do not contain peroxide are available as over-the-counter products in the form of gels, mouthwashes, chewing gums, toothpastes, and whitening strips.[9] Other concerns about over-the-counter products are the risk of misuse, overuse and abuse due to self-administration.[11]

The aim of this study was to evaluate in vitro the effects of home whitening and three different peroxide free over-the-counter (OTC) whitening products on the surface roughness and microhardness of composites applied to four different high aesthetic composite materials.

Materials and Methods

Preparation of Composite Samples

The study was started with the approval of Sivas Cumhuriyet University Non-Interventional Clinical Research Ethics Committee dated 18.03.2020 and decision number 2020-03/12. The composites samples were prepared using a metal mould made of stainless steel with a diameter of 8 mm and a depth of 2 mm to ensure standardisation (Figure 3.10). The colour of all composites was chosen A2 for standardization. A total of 200 discs were prepared, 10 discs for each group. Sof-Lex™ XT polishing discs (3M ESPE, St. Paul, USA) were used for polishing the prepared samples and only one surface of the samples was polished. All prepared samples were placed in white containers with distilled water, out of sunlight, with 10 composite samples in each container. To prevent dehydration of the composite samples, distilled water was placed on the bottom of the cell culture dishes with a 5 mm syringe. The white containers were labeled to indicate which group they belonged to.

Experimental Groups

The composites used were divided into 4 main groups according to their content. For each main group, 50 samples were used. In this study, the composites tested and their composition information are given in Table 1.

Asteria Composite Group: Tokuyama Asteria composite (Tokuyama Dental Tokyo, JAPAN) specimens were prepared using cylindrical metal molds and subjected to processes as described above.

Filtek Universal Restorative Group: Filtek Universal Restorative composite (3M ESPE, St.Paul, MN, USA) specimens were prepared using cylindrical metal molds and subjected to processes as described above.

Brilliant Ever Glow Group: Brilliant Ever Glow composite (Coltene/Whaledent AG Altstatten, Switzerland) specimens were prepared using cylindrical metal molds and subjected to processes as described above.

Ceram.x SphereTEC Group: Ceram.x SphereTEC one composite (Dentsply Sirona, Germany) specimens were prepared using cylindrical metal molds and subjected to processes as described above.

Table 1. Composites tested and their composition

Trade Name	Type	Color	Content	Manufacturer
Estelite Asteria	Supra-nano spherical	A2	**Matrix:** Bis-GMA, Bis MPEPP, UDMA, TEGDMA **Filler:** Silica and Zirconia (200 nm) Weight 82%, Volume 71	Tokuyama Dental, Tokyo, Japan
Brilliant Ever Glow	Submicron hybrid	A2	**Matrix:** Bis-GMA, Bis-EMA, TEGDMA **Filler:** Silica glass,Zinc oxide 0.02-1.5 µm Weight 74%, Volume 56%	Coltene/Whaledent AG Altstatten, Switzerland
Filtek Universal Restorative	Nanofil	A2	**Matrix:** AUDMA, AFM, Diurethane-DMA, 1,12-dodecane-DMA **Filler:** Clustered and non-clustered zirconia/silica 20nm silica, 4-11 nm zirconia 100 nm stacked ytterbium trifluoride Weight 76.5%, Volume 58.4	3M ESPE, St. Paul, MN, USA
Ceram.x SphereTEC one	Nano-seramic spherical	A2	**Matrix:** Poly-urethane methacrylate, Bis EMA, TEGDMA **Filler:** Prepolymerized spherical fillers (15 µm), 0.6 µm barium glass fillers, 0.6 µm ytterbium fluoride, silicon dioxide nano fillers (10 nm). Weight 77-79%, Volume 59-61	Dentsply Sirona, Germany

Table 2. Whitening products used in the study and their ingredients.

Whitening Product	Type	Ingredient	Manufacturer
Opalescence teeth whitening gel PF	Home Whitening Agent	16% Carbamide Peroxide, Deionized Water, 0.5% Potassium Nitrate, 0.11% Sodium Fluoride, Carbopol, Glyceri	Ultradent Products Inc, South Jordan, Utah, USA
Mr Blanc Teeth Professional Teeth Whitening Kit	Over-the-Counter Whitening Product	Whitening Gel, Glycerin, Aqua, Cellulose Gum, Sodium Chloride, EDTA, Citric Acid, DlMenthol	Mr Blanc Teeth LTD, United Kingdom
Cali White Botanical Whitening System	Over-the-Counter Whitening Product	Glycerin, Sodium Bicarbonate, Chondrus Crispus (Irish Moss) Powder, Xylitol, Sorbitol, Mentha Piperita (Organic Peppermint) Oil, Vaccinium Macrocarpon (Cranberry) Seed Oil, Aloe Barbadensis Leaf Juice, Chamomile Flower Extract, Cocamidopropyl Betaine, Lemon Extract	Cali White LLC, USA
i-White Instant Teeth Whitening	Over-the-Counter Whitening Product	Aqua, Hydrated Silica, Glycerin, Sorbitol, Phthalimido Peroxy Capronacid (PAP), Chondrus Crispus (Irish Moss), Aroma Powder/Hydrated Silica, PEG-40, Xylitol, Hydrogenated Castor Oil, Citric Acid, Acrylates/ Arcylamide Copolymer and Mineral Oil and Polysorbate 85, Methyl Paraben, Calcium-Lactate-Gluconate, Potassium Acesulfame	Sylphar, Belgium

Each composite group was divided into 5 subgroups, as 4 experimental groups and 1 control group, according to the whitening products to be tested (n=10). The material properties and manufacturers of the whitening products used in the study are given in Table 2.

Sub-group 1: Control group; No treatment was applied and kept in distilled water throughout the experimental phases.

Sub-group 2: i-White Whitening Material; i-White Whitening Product whitening set consists of 10 pieces of soft bendable transparent plaques, each of which is already applied and made in accordance with the curve of the mouth. The same procedure was repeated for a total of 5 days with 20 minutes of application per day. Each 20-minute application was kept at 37°C in an oven to mimic the mouth temperature.

Sub-group 3: *Cali White Lighted Whitening Kit*; Cali White Light Whitening Kit whitening set includes a 5 ml tube containing 2 whitening gels and a transparent plaque suitable for the curve of the mouth that emits blue light that activates the whitening agent. The same procedure was repeated for a total of 10 days with 30 minutes of application per day. Each 30-minute application was kept at 37°C in an oven to mimic the mouth temperature.

Sub-group 4: *Opalescence Home Whitening Gel*; Opalescence Home Whitening Gel was kept in an oven at 37°C for 4-6 hours a day to mimic oral temperature. This procedure was repeated for a total of 14 days.

Sub-group 5: Mr. Blanc Lighted Whitening Kit; Mr. Blanc Light Whitening Kit whitening set includes 3 tubes of 5 ml each containing whitening gel and a transparent plaque, called universal, suitable for the curve of the mouth, which emits blue light that activates the whitening agent. The same procedure was repeated for a total of 15 days with 30 minutes of application per day. Each 30-minute application was kept at 37°C in an oven to mimic the mouth temperature.

Measurement of Surface Roughness

A profilometer (Mitutoyo Surftest/SJ-301, Tokyo, Japan) was used for surface roughness measurements. Each sample was placed on the table of the profilometer with a 90 degree contact angle with the reader tip. The surface scan length on the surface profilometer was set to

4 mm and the surface cut length value was set to 0.25 mm. The profilometer was recalibrated before and after the measurements in each group. Measurements were taken from three different areas of each sample and the average surface roughness (Ra) value was calculated by taking the arithmetic mean of the data obtained.

Measurement of Microhardness Values

Qness Q10A/A+ Fully Automatic Microhardness Tester was used for the microhardness test. The microhardness measurement process involved applying 200 gr weight to 3 separate areas of the sample for 20 seconds for a total of 1 minute, with an application speed of 5 seconds. The 3 separate points were selected as follows; The start point was selected as 0.10 mm, the distance x was selected as 2.00 mm and the maximum path length was set as 4.20 mm. For each sample, the numerical value of the 3 separate regions was recorded and then the arithmetic mean of these values was taken.

SEM Analysis

The surfaces of the restorative materials were examined using an SEM device (TESCAN MIRA3, Czech Republic). Before SEM analysis, 1 sample of each restorative material was coated with gold-palladium at a thickness of 90 A° using a coating device (Quorum Q150R ES, UK) in an airless environment and then examined under magnifications of 2-5-10-20-50 thousand respectively.

Statistical Analysis

The data obtained from our study were evaluated with SPSS (Statistical Package for the Social Sciences) 22.0 program. Normality of the data was checked by Kolmogorov-Smirnov Test. In our study, two-way Analysis of Variance (ANOVA) was used to evaluate the data obtained from microhardness and surface roughness tests since parametric test assumptions were fulfilled, and Tukey test was used to determine which group was different from the others. The error level was taken as 0.05.

Tablo 3. Mean values, standard deviation values and statistical comparison of surface roughness tests of composite materials used in the study.

Whitening Materials	Tokuyama Estelite Asteria *Mean (SD)*	Filtek Universal Restorative *Mean (SD)*	Brilliant Ever Glow *Mean (SD)*	Ceram.x SphereTEC one *Mean (SD)*
Subgroup 1 Control	0.27 (0.06)$^{A.a}$	0.51 (0.10)$^{A.B}$	0.40 (0.12)	0.30 (0.11)$^{B.c}$
Subgroup 2 i-White	0.22 (0.05)$^{C.D.b}$	0.56 (0.11)$^{C.E}$	0.26 (0.07)^{E}	0.40 (0.09)^{D}
Subgroup 3 Cali White	0.33 (0.04)^{F}	0.52 (0.12)$^{F.G.H}$	0.35 (0.18)^{G}	0.35 (0.09)^{H}
Subgroup 4 Opalescence	0.47 (0.11)$^{a.b}$	0.45 (0.08)	0.35 (0.14)	0.46 (0.09)^{c}
Subgroup 5 Mr. Blanc	0.31 (0.05)	0.44 (0.09)	0.39 (0.09)	0.41 (0.07)

F=8.736, P=0.000 (p<0.05)

^{A,B,C,D,E,F,G,H} In the same row; the same upper index symbolizes the groups where there is a difference between the composite groups indicated by capital letters.

^{a,b,c} In the same column; the same upper index symbolizes the groups where there is a difference between the whitening groups indicated by lower case letters.

Tablo 4. Mean values, standard deviation values and statistical comparison of the composite resin materials used in the study for the microhardness test.

Whitening Materials	Tokuyama Estelite Asteria *Mean (SD)*	Filtek Universal Restorative *Mean (SD)*	Brilliant Ever Glow *Mean (SD)*	Ceram.x SphereTEC one *Mean (SD)*
Subgroup 1 Control	80.78 (3.21)^{a}	68.15 (3.84)^{A}	58.68 (4.27)^{B}	62.13 (5.02)$^{A.B}$
Subgroup 2 i-White	81.99 (3.029)^{b}	73.36 (5.41)	56.30 (5.14)	63.69 (2.73)
Subgroup 3 Cali White	79.65 (2.98)^{c}	73.66 (3.11)	59.42 (4.89)^{C}	64.62 (3.56)^{C}
Subgroup 4 Opalescence	70.98 (2.16)$^{D.E.a.b.c.d}$	71.39 (3.89)$^{D.F}$	57.23 (2.55)	66.86 (1.57)$^{E.F}$
Subgroup 5 Mr. Blanc	77.60 (2.68)^{d}	70.78 (2.81)	58.63 (2.08)^{G}	63.16 (4.13)^{G}

F=51.018 P=0.000 (p<0.05)

^{A,B,C,D,E,F,G} In the same row; the same upper index symbolizes the groups with no difference between the composite groups indicated by capital letters.

^{a,b,c,d} In the same column; the same upper index symbolizes the groups with differences between the whitening groups indicated by lower case letters.

Results

Table 3 displays the mean values, standard deviation (SD) values, and statistical differences in the surface roughness test between the bleaching groups and the four different composite materials that were bleached as a result of the statistical evaluations.

When the average surface roughness values of all groups were analyzed, the i-White subgroup of the Filtek Universal Restorative composite group showed the

highest average surface roughness value, while the I-White subgroup of the Tokuyama Estelite Asteria group showed the lowest average surface roughness value.

Table 4 displays the mean values, standard deviation (SD) values, and statistical differences between the bleaching groups and the four distinct composite materials that underwent the Vickers microhardness test as a consequence of the statistical evaluations.

When the average microhardness values of all groups are analyzed, the i-White subgroup of the Tokuyama Estelite Asteria composite group showed the highest average microhardness value, while the i-White subgroup of the Brilliant Ever Glow composite group showed the lowest average microhardness value.

SEM Analysis

SEM Images of Tokuyama Estelite Asteria Composite Groups (Figure 1)

In the Cali White group, zirconium particles were observed, while in the Mr.Blanc group, the whitening agent caused the composite particles to break off from the surface in places, resulting in the appearance of irregular pits. In the Opalascence group, zirconium particles appeared on almost the entire surface, while the melting of the surrounding inorganic matrix led to the appearance of a rough surface.

SEM Images of Filtek Universal Restorative Groups (Figure 2)

Crater-shaped pits in the i-White group, abundant zirconium particles on the surface in the Cali-White group, numerous indentations and protrusions with the dissolution of the inorganic matrix on the surface in the Opalescence group, and larger pits in the Mr.Blanc group were observed.

SEM Images of Brilliant Ever Glow Groups (Figure 3)

Deep regular cracks in i-White group, irregular cracks in Cali-White group were observed. In the Opalescence group, dense silica glass particles were found only on the surface, while deep and irregular pits were observed on the surface when Mr.Blanc whitening was applied.

SEM Images of Ceram.x SphereTEC.one Groups (Figure 4)

In the i-White group, irregular cavities in the form of deep caves were observed, in the Cali-White group, a rough surface with more ceramic particles on the surface compared to the control group was observed, in the Opalescence group, many irregular large and small pits were observed and in the Mr.Blanc group, small pits were observed due to the rupture of spherical nanoceramics in places compared to the control group.

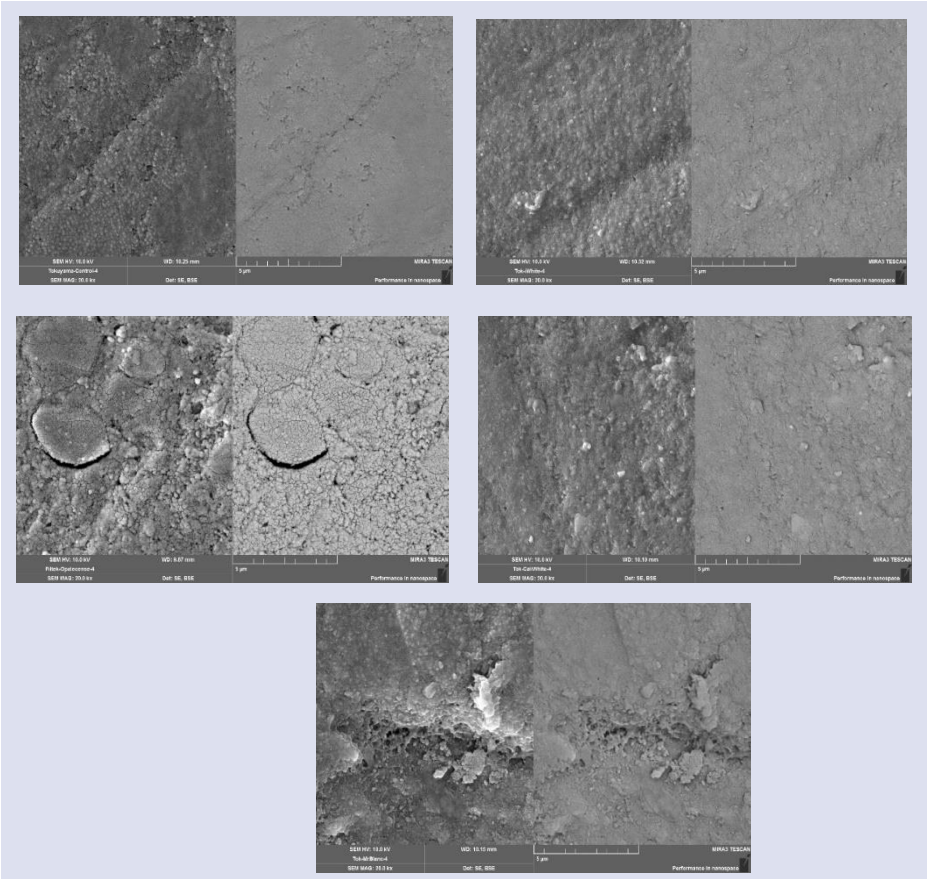

Figure 1. SEM Images of Tokuyama Estelite Asteria Composite Groups a) Control, b) i-white, c) Cali White, d) Opalescence, e) Mr.Blanc

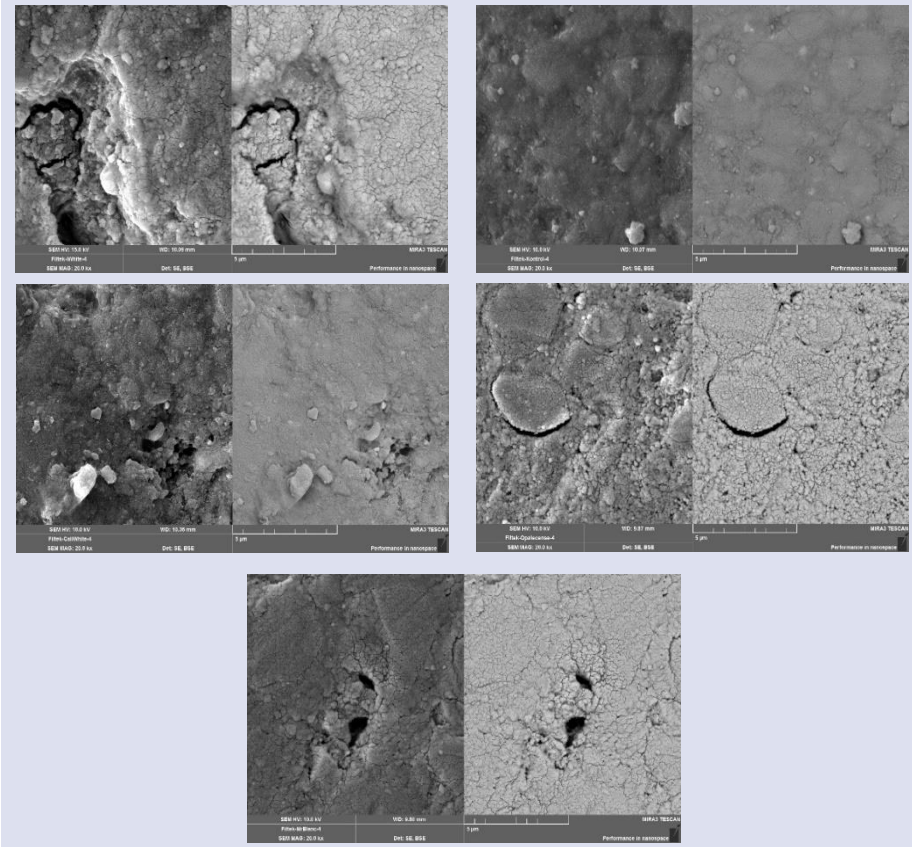

Figure 2. SEM images of Filtek Universal Restorative Groups a) Control, b) i-white, c) Cali White, d) Opalescence, e) Mr.Blanc

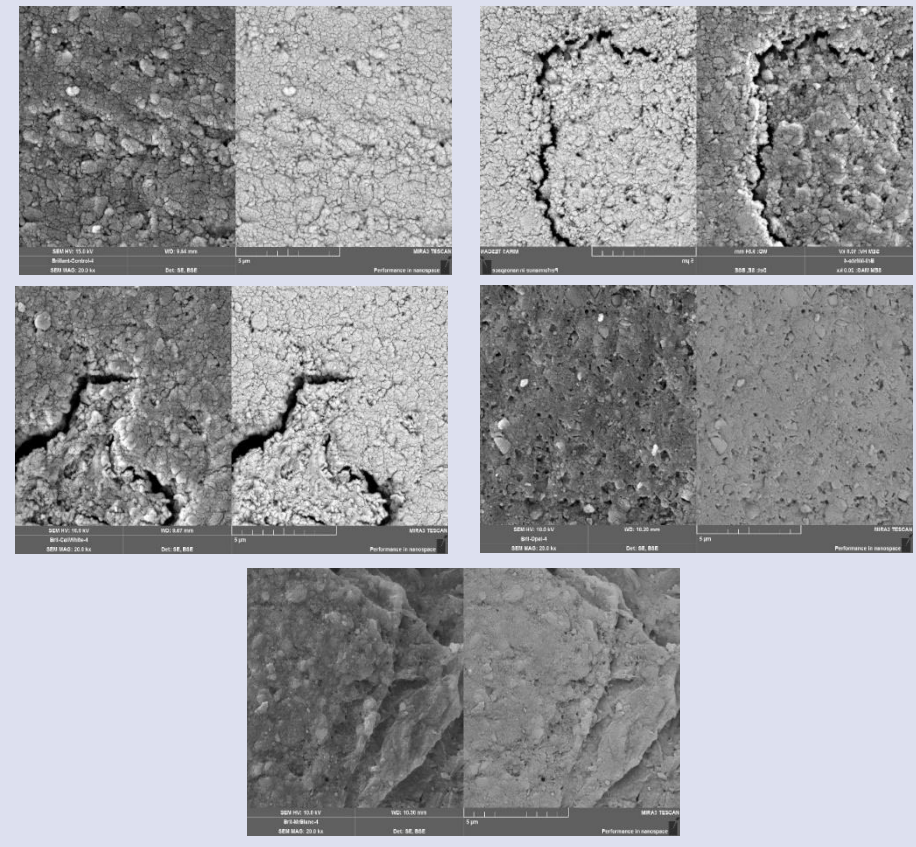

Figure 3. SEM Images of Brilliant Ever Glow Groups a) Control, b) i-white, c) Cali White, d) Opalescence, e) Mr.Blanc

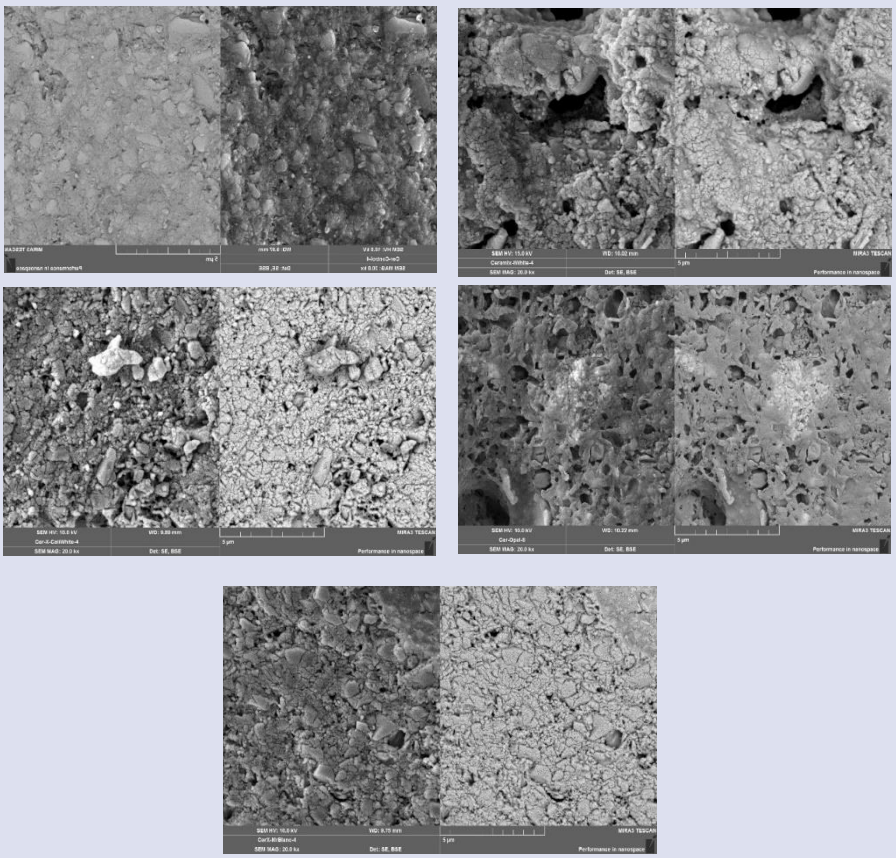

Figure 4. SEM Images of Ceram.x SphereTEC.one Groups a) Control, b) i-white, c) Cali White, d) Opalescence, e) Mr.Blanc

Discussion

Nanofiller composites are differentiated from microfiller composites by the fact that nanotechnology allows for a higher level of control than conventional microfiller technology, resulting in the polishability of a microfiller composite and the strength and wear resistance of a hybrid composite. The difference between nanofiller composites and nanohybrid composites is that nanofiller composites use nanometer-sized particles throughout the resin matrix, while nanohybrid composites take the approach of combining nanometer-sized particles with more traditional filler technology.[12] In this study, we used composites with different particle size fillers (supra-nano, submicron hybrid, nanofilament, nanoceramic) with high aesthetic properties thanks to nanotechnology.

Due to the decreasing incidence and severity of caries in aesthetic dentistry, clinicians have turned their attention to conservative and non-invasive treatments such as tooth whitening.[13] Home teeth whitening with special trays under the supervision of a dentist is the most common whitening procedure performed by dentists on patients. In this treatment method, a customized mouth tray is made and a whitening gel, usually containing 10% carbamide peroxide, is applied to the patient at night for 2 weeks.[14] Auschill et al.[15] compared an over-the-counter bleaching system, a home bleaching system containing 10% carbamide peroxide, and a system containing 38% hydrogen peroxide and applied by physicians in the office in an in vivo study and found that the home bleaching system was more effective. In another study, they reported that the most effective and safe whitening technique was home bleaching because it reduced the possibility of side effects.[16]

Many studies have shown that the use of whitening agents containing carbamide peroxide is safe and effective when performed in accordance with dentist recommendations and under dentist control.[17] We preferred to use Opalescence home whitening gel containing 16% carbamide peroxide in our study because home whitening is preferred more frequently and the side effects related to self-administration are similar to the side effects related to self-administration in OTC (over-the-counter) products.

Most whitening products use hydrogen peroxide as the active ingredient. However, whitening treatments with peroxide can cause local side effects such as oral mucosal irritation, pulp sensitivity, pulpitis or changes in the enamel surface.[18] On the other hand, whitening is a relatively safe procedure that causes serious side effects on hard tissue, soft tissue and restorative materials predominantly only at high concentrations of hydrogen peroxide.[14] The efficacy of products containing hydrogen peroxide is usually based on cumulative and repeated treatments. There are not enough in vitro and clinical studies on non-peroxide whitening products. One study examined a non-peroxide home whitening product based on sodium chloride in vitro and reported adverse effects on tooth enamel.[19]

In the light of this information, in our study, we investigated the efficacy of 3 different OTC whitening products, which are new to the market and promise to be safe and effective whitening because they do not contain peroxide, on 4 different composites in vitro.

The surface roughness and hardness of composite restorations are affected by the structural properties of the material such as monomer type, filler type and percentage.[20] Carbamide peroxide is unstable and breaks down immediately upon contact with tissue and saliva, decomposing first to hydrogen peroxide and urea and then to oxygen, water and carbon dioxide.[21,22] The apparent mechanism of action of whitening agents on tooth structures is the oxidation of dentin molecules, which causes discoloration. This oxidation reaction can disrupt the structural integrity of restorative materials.[23] Some studies have shown that exposure of hard dental tissue and restorative materials to whitening agents can cause changes in their surfaces and reduce their microhardness.[24,21,22,25,26] Other studies have shown only minor or no changes in restorative materials and tooth tissues.[21,27-29] The results of these studies suggest that the effect of whitening gels may depend on the composite material.[21,30]

AlQahtani [31] compared the micro-hybrid (Filtek Z250), nanofiller (Filtek Z350), fluid (Filtek P90) and hybrid (Valux Plus) composites with different contents after 14 days of whitening with 10% KP (Opalescence PF). He reported a significant decrease in microhardness in composites with nanofillers (Filtek Z350), fluid (Filtek P90) and hybrid (Valux Plus). The researcher stated that this result may be related to the higher amount of TEGDMA in the nanofilament (Z350) and hybrid (Valux Plus) composite and the absence of TEGDMA in Z250. The inclusion of diluent monomers of TEGDMA in the resin matrix may make the resin matrix less resistant to whitening agents and increase the softening of the resin composite material. He also reported that the decrease in the microhardness of the nanofiller composite (Z350) was higher than that of the hybrid composite (ValuxPlus) due to the higher molecular weight and lower filler content of the resin matrix in the nanofiller (Z350). Among the composites we used in our study, only Filtek Universal Restorative does not contain TEGDMA. After Opalescence home whitening with 16% KP content, Filtek Universal Restorative showed the highest value in microhardness values among all composites. The study showed that the absence of TEGDMA in the matrix of Filtek Universal Restorative composite showed resistance to the whitening agent.

Malkondu et al.[32] compared the microhardness values of two nanocomposites (Filtek Supreme XT and Premise), leucite-reinforced glass ceramic (Empress Esthetic), glass ceramic (Empress 2 layering) and feldspathic porcelain (Matchmaker MC) on esthetic dental materials using a home whitening agent (Opalescence PF) containing 20% KP and an OTC whitening product (Treswhite Supreme) containing 10% HP. They reported that Opalescence with 20% KP content increased the microhardness of Filtek Supreme XT composite and significantly decreased the microhardness of all other materials, while OTC Treswhite Supreme with 10% HP content significantly decreased the microhardness of Premise nanocomposite. They said that the organic matrix of Filtek Supreme XT consists of UDMA, Bis-EMA, and a small amount of TEGDMA. UDMA and Bis-EMA resins have a higher molecular weight and therefore fewer double bonds per weight unit. They stated that the higher molecular weight of the resin results in less shrinkage, less aging and a slightly less soft resin matrix. The increase in the microhardness values of the Ceram.x SphereTEC one composite, which we used in our study, after all whitening applications, is due to the fact that both Bis-EMA and UDMA resin are present in its content together, we think that it reacts less with whitening products and the microhardness of the composite samples increases as time passes. We believe that these results are similar to the study of Malkondu et al.

Cohen et al.[11] examined the microhardness values of 10% KP whitening agent (PolaNight) and 5 different OTC whitening materials (Brilliant 5 minute kit, Smile Science Harley Street professional teeth whitening kit, i-White instant teeth whitening, Mr Blanc Teeth, Janina Ultra White) on human enamel. They also investigated the effectiveness of samples colored in green tea with 6 different whitening agents. They stated that the greatest decrease in microhardness values was in Brilliant 5 minute kit and i-White groups, while there was an increase in microhardness values in negative control (distilled water), Smile Science Harley Street professional teeth whitening kit groups. They stated that i-White and Smile Professional had less whitening effect than the negative control group. They also stated that Brilliant 5 minute kit and i-White were the whitening products that showed the most changes in the enamel in SEM analysis, and although the active ingredient of both products was different, citric acid in the content of both products could cause surface changes. The i-White OTC whitening product we used in our study increased the microhardness values of all composites (except Brilliant Ever Glow). In addition, SEM analysis showed that i-White and Mr.Blanc Teeth were the OTC whitening products that caused the most deformation in composites. The reason for this is due to the citric acid content of both OTC whitening products.

Cengiz et al.[33] evaluated the surface roughness after application of 10% HP (Opalescence Treswhite) and KP (Opalescence PF) whitening agents on 5 different composites including nano hybrid, micro hybrid and orcomer based nano hybrid (Reflexions XLS, Grandio, Gradia Direct, Clearfil Majesty Esthetic, Ceram-X Mono). They applied KP for 8 hours a day for 14 days and HP for 60 minutes a day for 14 days. They reported that the roughness values of all bleached composite groups were higher than the control group (distilled water). They stated that there was no significant difference in roughness values after 10% KP and HP application. After whitening, they reported that the orcomer-based nano-hybrid showed the lowest surface roughness values, while the nano-hybrid (Reflexions XLS) composite showed the highest roughness values. Reflexions XLS and Clearfil Majesty Esthetic showed higher Ra values than other composites after KP application. The researchers stated that both composites were based solely on Bis-GMA as the organic matrix, and that water uptake

for this hydrophilic monomer may be higher than for TEGDMA and UDMA, which may cause disruption of the resin matrix and particle/matrix interface. In our study, after 16% carbamide peroxide treatment, the surface roughness of supra-nano (Tokuyama Estelite Asteria) and nano-ceramic (Ceram.x SphereTEC one) composites decreased.

Bizhang et al.[9] evaluated the whitening efficacy of a peroxide-free OTC product (i-White Instant) and a placebo product without a whitening product in-vivo. They measured color before, after and 24 hours after treatment. They reported that the OTC whitening product was significantly more effective in whitening than the placebo group. The researchers also evaluated tooth sensitivity and gingival irritation. During the whitening application; although there were patients in the test group who experienced gingival irritation, they stated that none of the patients experienced tooth sensitivity. In the placebo group, they reported both gum irritation and tooth sensitivity. After the treatment, they reported that although gingival edema, tooth sensitivity and gingival irritation occurred in the test group, there were no complaints in the placebo group. The researchers believe that the ready-to-use mouth trays in the i-White Instant whitening kit may cause uncontrolled whitening and gingival irritation.

Although the OTC whitening products we used in our study did not create a statistically significant difference in the surface roughness and microhardness values of the composites, SEM analysis shows that especially i-white and Mr.Blanc whitening products caused cracks and defects on the composite surfaces.

Conclusion

Although OTC whitening products did not significantly change the surface roughness and microhardness values of composites, SEM analysis showed that all OTC whitening products caused more splits, cracks and defect-like changes on composite surfaces than Opalescence home type whitening agent. Since peroxide-free OTC whitening products cause surface changes on composite surfaces similar to or more than carbamide peroxide, the use of peroxide-free OTC products without a physician's control may cause greater irreversible damage. Therefore more in-vitro and clinical studies with newly released OTC products are needed.

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Conflict of Interest Statement

None.

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