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Serin-Kalay, Tugba; Zaim, Beyza

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How a 16% Carbamide Peroxide Home Bleaching Agent Affects the Surface Properties of Chairside CAD/CAM Materials?

¿Cómo afecta un agente blanqueador casero de peróxido de carbamida al 16% a las propiedades de la superficie de los materiales CAD/CAM de consultorio?

Tugba Serin-Kalay DDS, PhD¹; Beyza Zaim DDS²

1. Assistant Professor, Department of Restorative Dentistry, Faculty of Dentistry, Karadeniz Technical University, Trabzon, Turkey. <https://orcid.org/0000-0003-1197-4858>

2. Research Assistant, Department of Restorative Dentistry, Faculty of Dentistry, Karadeniz Technical University, Trabzon, Turkey. <https://orcid.org/0000-0002-0962-7833>

Correspondence to: Dr. Tugba Serin Kalay - tugbaserinkalay@hotmail.com

ABSTRACT: Surface changes of restorative materials after bleaching have clinical importance in terms of the durability and survival of restorations. This study aimed to evaluate the effect of home bleaching on the surface roughness, microhardness, and surface analysis of four different types of chairside computer-aided design and computer-aided manufacturing (CAD/CAM) materials. Specimens were prepared from composite resin (Brilliant Crios: BC), resin nanoceramic (Lava Ultimate: LU), polymer-infiltrated ceramic-network (Vita Enamic: VE), and zirconia-reinforced lithium silicate glass-ceramic (Vita Suprinity: VS) CAD/CAM materials. Specimens were polished using 800, 1000, 1200, and 2000 grit SiC papers. Each restorative material was randomly divided into two groups; control and bleaching (n=10). The 16% carbamide peroxide bleaching agent (Whiteness Perfect 16%, FGM) was applied to the specimens for 4 h/day for 14 days. Surface roughness values (Ra) were obtained using a profilometer, and microhardness values (VHN) were obtained using a Vickers microhardness test. Surface analysis of specimens was evaluated by scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX). Data were analyzed Two-way ANOVA and Fisher's Least Significant Difference (LSD) test ($p < 0.05$). After bleaching, the surface roughness of BC ($p < 0.001$) and VE ($p < 0.032$) significantly increased. Bleaching did not significantly affect the microhardness of CAD/CAM materials. SEM

evaluation showed material-dependent surface damages after bleaching procedures. The effect of 16% carbamide peroxide home bleaching agent on surface roughness and microhardness of chairside CAD/CAM materials is material-dependent. Before bleaching, restorative materials should be protected by applying a protective barrier and contact with the bleaching agent should be minimized. Also, after bleaching, the restoration surface should be carefully inspected, and re-polishing might be beneficial.

KEYWORDS: CAD/CAM; Bleaching; Surface roughness; Microhardness.

RESUMEN: Los cambios en la superficie de los materiales de restauración tras el blanqueamiento tienen importancia clínica en cuanto a la durabilidad y supervivencia de las restauraciones. Este estudio tenía como objetivo evaluar el efecto del blanqueamiento en casa sobre la rugosidad de la superficie, la microdureza y el análisis de la superficie de cuatro tipos diferentes de materiales de diseño asistido por computadora y fabricación asistida por computadora (CAD/CAM). Se prepararon especímenes de materiales CAD/CAM de resina compuesta (Brilliant Crios: BC), de nanocerámica de resina (Lava Ultimate: LU), de cerámica en red infiltrada por polímeros (Vita Enamic: VE) y de cerámica de vidrio de silicato de litio reforzada con circonio (Vita Suprinity: VS). Las muestras se pulieron con papeles de SiC de grano 800, 1000, 1200 y 2000. Cada material de restauración se dividió aleatoriamente en dos grupos: control y blanqueo (n=10). El agente blanqueador de peróxido de carbamida al 16% (Whiteness Perfect 16%, FGM) se aplicó a las muestras durante 4 h/día durante 14 días. Los valores de rugosidad de la superficie (Ra) se obtuvieron utilizando un perfilómetro, y los valores de microdureza (VHN) se obtuvieron utilizando una prueba de microdureza Vickers. El análisis de la superficie de las muestras se evaluó mediante microscopía electrónica de barrido (SEM) y espectroscopia de rayos X de energía dispersiva (EDX). Los datos se analizaron mediante ANOVA de dos vías y la prueba de diferencia mínima significativa (LSD) de Fisher ($p < 0,05$). Tras el blanqueamiento, la rugosidad de la superficie del CB ($p < 0,001$) y del VE ($p < 0,032$) aumentó significativamente. El blanqueamiento no afectó significativamente a la microdureza de los materiales CAD/CAM. La evaluación SEM mostró daños superficiales dependientes del material después de los procedimientos de blanqueo. El efecto del agente blanqueador casero de peróxido de carbamida al 16% sobre la rugosidad de la superficie y la microdureza de los materiales CAD/CAM en el sillón depende del material. Antes del blanqueamiento, los materiales de restauración deben protegerse aplicando una barrera protectora y debe minimizarse el contacto con el agente blanqueador. Además, después del blanqueamiento, la superficie de la restauración debe inspeccionarse cuidadosamente y puede ser beneficioso volver a pulirla.

PALABRAS CLAVE: CAD/CAM; Blanqueamiento; Rugosidad superficial; Microdureza.

INTRODUCTION

The smile is affected by many factors, including the shape, size, location and color of the teeth (1). With rising aesthetic expectations, there has been an accelerated development in dental materials and approaches. Among these approaches, bleaching is a more conservative approach to treating discolored teeth than prosthetic and restorative procedures (1,2). Bleaching can be performed by a clinician in the office (office-bleaching) with a high concentration of 30-35% hydrogen peroxide or carbamide peroxide agents, as well as by using a lower concentration of 10-20% carbamide peroxide by the patient under the control of the clinician (home-bleaching) or by using 3-7% hydrogen peroxide cosmetic products (over-the-counter/OTC) purchased by the patient (3). There are also different regulations for OTC products: different concentrations or 'non-hydrogen peroxide' products may be commercially available. Recently, the proper use of bleaching products containing 0.1 to 6 % hydrogen peroxide has been considered safe after consultation and approval with the dentist (4,5).

Most home bleaching agents contain carbamide peroxide. The carbamide peroxide breaks down into hydrogen peroxide (3%) and urea (7%) (6). The active part in bleaching is hydrogen peroxide. When hydrogen peroxide interacts with dental materials and teeth, it transforms into reactive oxygen molecules and free hydroxyl radicals, removing discoloration through oxidation (7). During home bleaching, not only tooth surfaces but also restorations contact with the bleaching agent. It has been previously reported that bleaching agents affect the surface properties of restorative materials (8-10). This can be explained by the absorption of chemical products by restorative materials (11).

Ceramics and composite resins are generally used in the esthetic restoration of teeth. The

popularity of computer-aided design and computer-aided manufacturing (CAD/CAM) systems continues to increase. CAD/CAM systems make chairside restoration production possible from prefabricated CAD/CAM materials with reduced laboratory working times (12). These systems offer prefabricated block alternatives with various material contents to be used in chairside restoration construction. Composite resin, resin nanoceramic, polymer-infiltrated ceramic-network, lithium disilicate glass-ceramic, zirconia, and zirconia-reinforced lithium silicate glass-ceramic are alternative materials for chairside CAD/CAM materials.

Previously, the effect of surface treatments and acidic environments on surface properties of CAD/CAM materials has been reported (13-15). There is a lack of studies investigating the effect of home bleaching agent on surface properties of currently available chairside CAD/CAM materials.

This study aims to evaluate the effect of 16% carbamide peroxide home bleaching agent (Whiteness Perfect %16, FGM, Joinville, Brazil) on the surface roughness, microhardness, and SEM/EDX analysis of the four different types of chairside CAD/CAM restorative materials. The null hypothesis tested was that the bleaching agent does not affect the surface roughness, microhardness and morphological properties of CAD/CAM restorative materials.

MATERIALS AND METHODS

In this study, four chairside CAD/CAM materials with different components were selected based on the manufacturer's instructions. The products' Lot number and composition were taken from the manufacturer's datasheet and presented in Table 1. Materials: composite resin (Brilliant Crios: BC), resin nanoceramic (Lava Ultimate: LU), polymer-infiltrated ceramic-network (Vita Enamic: VE), zirconia-reinforced lithium silicate glass-ceramic (Vita Supriniy: VS), and home bleaching

agent with 16% carbamide peroxide (Whiteness Perfect: WP) (Table 1).

The sample size was calculated by using GPower 3.1.9.4. It was calculated according to the data of previous study (16). After consi-

dering the alpha error=0.05, beta error=0.05 (Power=95%) and the effect size as 1.8, the sample size was calculated as 9 for per group. However, while considering the potential data losses, final sample size was determined as 10 for each group.

Table 1. Compositions, manufacturers and specifications of the materials used in this study.

Material	Composition	Manufacturer	Lot.
Brilliant Crios (BC)	%70.7 Amorphous silica (<20nm), barium glass (<1 µm) %29.3 Cross-linked methacrylate matrix (Bis-GMA, Bis-EMA, TEGDMA)	Coltène/Whaledent AG Switzerland	60019987
Lava Ultimate (LU)	%80 SiO ₂ (20 nm), ZrO ₂ (4-11 nm) %20 Highly cross-linked resin matrix (Bis-GMA, UDMA, Bis-EMA, TEGDMA)	3M ESPE, Bad Seefeld, Germany	N894216
Vita Enamic (VE)	%86 Feldspathic porcelain,, SiO ₂ (%58-63), Al ₂ O ₃ (%20-23), Na ₂ O (%6-11), K ₂ O (%4-6) %14 Polymer (UDMA, TEGDMA)	Vita Zahnfabrik Bad Sackingen Germany	78440
Vita Suprinity (VS)	%56-64 SiO ₂ , %1-4 Al ₂ O ₃ , %15-21 Li ₂ O, %8-12 ZrO ₂ , %1-4 K ₂ O	Vita Zahnfabrik Bad Sackingen, Germany	79911
Whiteness Perfect 16% (WP)	%16 carbamide peroxide, %20 water, %3 Potassium nitrate, %0,2 sodium fluoride, glycol	FGM Joinville Brazil	250719

SPECIMEN PREPARATION

The specimens were prepared from CAD/CAM materials (BC, LU, VE, and VS) as 14×14×2mm plates. Specimens were cut under water cooling using a low-speed precision cutter (Micracut 150; Metkon Instruments, Bursa, Turkey). The crystallization of VS specimens were made according to the manufacturer's instructions (Programat EP 3000, Ivoclar Vivadent AG, Schaan, Liechtenstein). Each specimen was mounted in autopolymerizing acrylic resin. Specimens were polished under water cooling with SiC paper (800,1000, 1200, 2000 grit) in a polishing machine (Beta Grinder-Polisher, Buehler, Illinois, USA). 20 specimens were prepared from each material, and each group of 20, was

subdivided into 2 groups to be treated accordingly (control and bleaching) (n=10). The one specimen for each group was prepared for scanning electron microscopy (SEM).

BLEACHING PROCEDURE

The WP 16% carbamide peroxide was applied on the surface of the bleaching group's specimens and left at 37°C for 4 h/day for 14 days, according to the manufacturer's instructions. After each bleaching application, the samples were rinsed for 1 min with distilled water and then kept in distilled water at 37°C until the next application. The distilled water used in storage was changed every day.

SURFACE ROUGHNESS AND MICROHARDNESS

The specimens' surface roughness was measured to on one half and microhardness on the other half. Surface roughness values (Ra) were calculated in micrometers (μm) with a profilometer (MarSurf PS 10, Mahr, Göttingen, Germany) before and after the bleaching procedures. Three measurements per specimen were determined over a transverse length of $L_t=4.8\text{mm}$, with a cut-off value of 0.8mm and a stylus speed of 0.1mm/s . Surface roughness values were recorded, and mean roughness values were determined.

The microhardness of the specimens before and after bleaching was determined using a microhardness tester (Duramin Microhardness Tester, Struers, Cleveland, USA) under a load of 200g and dwell time of 15s (14). Three measurements were taken on each specimen, and the Vickers hardness number (VHN) was recorded. The mean VHN values were calculated to determine the hardness values.

SCANNING ELECTRON MICROSCOPY (SEM) AND ENERGY-DISPERSIVE X-RAY SPECTROSCOPY (EDX)

Eight specimens (one from each group) were evaluated with SEM for surface analysis. The specimens were gold-sputter coated (SPI-Module Sputter Coater, Structure Probe Inc., PA, USA), and scanning electron microscopy (EVO LS10, Zeiss, Oberkochen, Germany) images were taken for analysis of materials surface topography. Surfaces were examined using secondary electron (SE) mode and SEM images ($3000\times$ magnifications) were obtained at 15 kV acceleration voltage with a working distance of around 10mm .

Elemental analysis was performed by an energy-dispersive X-ray spectroscopy system (EDAX, AMETEK Inc., NJ, USA). EDX measurements for elemental distribution were recorded from

three different locations in each specimen, selected at random and the average weight percentages (wt%) were calculated.

STATISTICAL ANALYSIS

A computerized statistical software program (SPSS 17.0 for Windows, SPSS Inc., Chicago, USA) was used for statistical analysis. Normality of the data distribution was checked with the Shapiro-Wilks test. The test showed normal distribution of the variables. Two-way analysis of variance (ANOVA) tests were used to analyze the effects of the CAD/CAM material and bleaching agent on surface roughness and microhardness. The Fisher's LSD test was used to identify which groups significantly differ. The data were presented as the mean \pm standard deviation (SD) values, and $p<0.05$ was accepted as statistically significant.

RESULTS

The analysis of variance; CAD/CAM materials, bleaching agent and the interaction between these two factors are shown in Table 2. Two-way ANOVA showed that the factors, bleaching ($p<0.001$) and CAD/CAM materials ($p<0.001$) significantly affected the surface roughness. The microhardness was significantly influenced only by materials ($p<0.001$). while the interaction was not significant ($p=0.260$). No statistically significant interaction was found between material and bleaching agent for surface roughness ($p=0.260$) and microhardness ($p=0.084$).

Mean surface roughness values, mean microhardness values and standard deviations of each restorative material group are given in Table 3. Surface roughness values of control group showed significant difference between CAD/CAM materials ($p<0.05$) except BC and LU ($p<0.22$). WP did not significantly affect the surface roughness of the LU

($p=0.510$) and VS ($p=0.175$); but it significantly increased the roughness of the BC ($p=0.001$) and VE ($p=0.032$).

Microhardness values of control group showed significant difference between CAD/CAM materials ($p<0.05$) except BC and LU ($p<0.105$). The microhardness values of CAD/CAM materials were decreased after the bleaching procedure. However, this decrease in the microhardness value of the materials was not statistically significant.

The SEM images of the CAD/CAM materials at 3000 \times magnification are shown in Figure 1. A-H. The specimens of the VE, LU, and BC groups that applied 16% carbamide peroxide bleaching agent

showed more irregular microholes and microporosities. These irregularities and micropores were less evident in VS groups (Figure 1. H).

Elemental analysis with EDX of surface composition (wt%) of the CAD/CAM materials is presented in Table 4. The findings of the EDX analysis for CAD/CAM materials were in accordance with the manufacturer's description of the materials (Table 1). The high content of Barium for BC, Zirconia for LU and VS and Aluminium for VE can be explained by the components of the materials. Trace amounts of F, K, and Ca were found on the specimens, but their quantities were very low; however, a trace of P was only observed on VS specimens.

Table 2. The two-way analysis of variance for surface roughness and microhardness.

Source	Surface roughness					Microhardness				
	Type III sum of squares	df	Mean square	F	p	Type III sum of squares	df	Mean square	F	p
Bleaching	,011	1	,011	14,460	,000	734,473	1	734,473	,815	,370
CAD/CAM materials	,218	3	0,73	94,787	,000	2727544,897	3	909181,632	1008,908	,000
Bleaching* CAD/CAM materials	,003	3	,001	1,365	,260	141,307	3	47,102	,052	,984

$p<0.05$ represents significant difference.

Table 3. Mean surface roughness (Ra) and microhardness (VHN) values, \pm standard deviations and statistical analysis .

	BC	LU	VE	VS	p(BC-LU)	p(BC-VE)	p(BC-VS)	p(LU-VE)	p(LU-VS)	p(VE-VS)
Surface Roughness (μm)										
Control	0.11 \pm 0.04	0.08 \pm 0.01	0.18 \pm 0.02	0.04 \pm 0.02	0.22	<0.001	<0.001	<0.001	0.006	<0.001
WP	0.15 \pm 0.06	0.09 \pm 0.01	0.21 \pm 0.02	0.06 \pm 0.01	<0.001	<0.001	<0.001	<0.001	0.44	<0.001
p	0.001	0.510	0.032	0.175						
Microhardness (VHN)										
Control	74.09 \pm 2.56	96.12 \pm 4.01	153.80 \pm 11.45	540.46 \pm 61.56	0.105	<0.001	<0.001	<0.001	<0.001	<0.001
WP	70.29 \pm 1.96	89.34 \pm 5.81	150.21 \pm 16.33	530.22 \pm 56.75	0.160	<0.001	<0.001	<0.001	<0.001	<0.001
p	0.778	0.615	0.790	0.460						

$p<0.05$ represents significant difference. BC: Brilliant Crios, LU: Lava Ultimate, VE: Vita Enamic, VS: Vita Suprinity, WP: Whiteness Perfect.

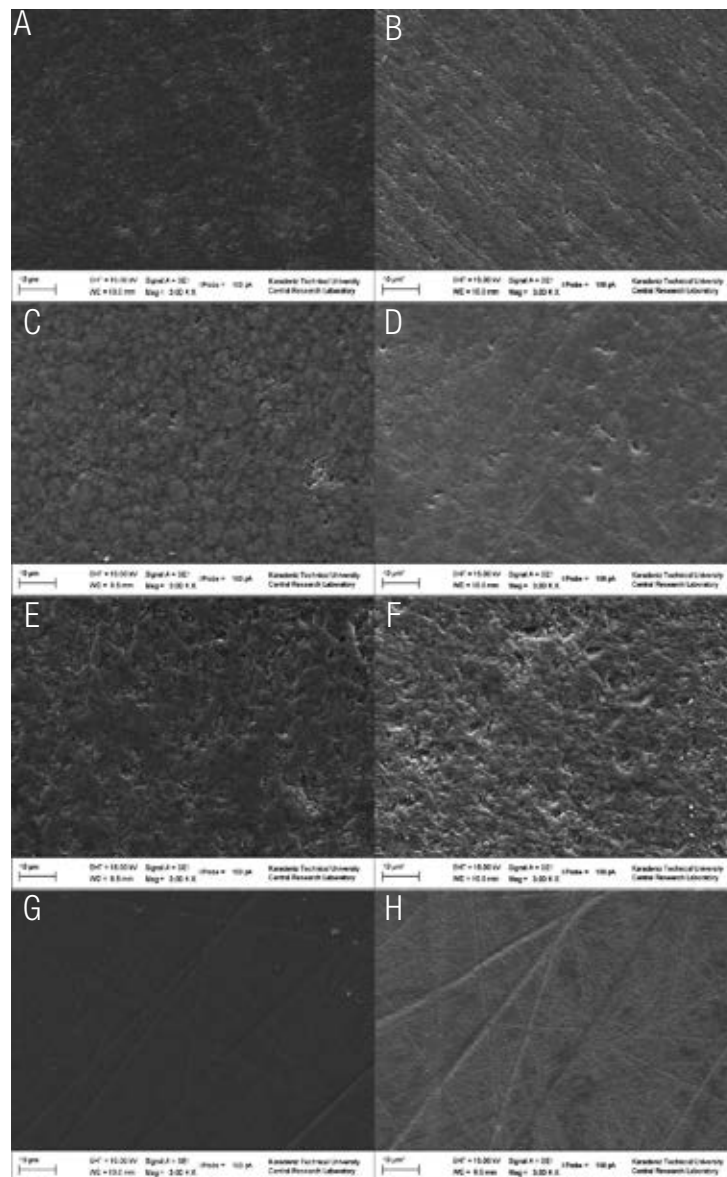


Figure 1. SEM Micrograph of CAD/CAM materials at magnification of $\times 3000$ (A) BC control, (B) BC after bleaching ; (C) LU control, (D) LU after bleaching; (E) VE control, (F) VE after bleaching; (G)VS control, (H)VS after bleaching.

Table 4. EDX analysis of element surface composition (wt%)± standard deviations of CAD/CAM materials with control group and WP group.

	BC		LU		VE		VS	
	Control	WP	Control	WP	Control	WP	Control	WP
C	10.30±2.3	9.55±1.3	0.01	0.01	1.43±0.4	1.47±0.1	0.01	0.01
O	30.78±3.4	29.71±4.6	38.09±2.2	37.51±3.5	37.50±4.3	35.88±3.7	45.02±3.6	43.54±2.8
Si	27.47±1.1	25.35±2.3	34.62±3.4	32.88±2.6	28.31	28.33±2.1	31.70±1.1	31.19±2.3
Na	0.82±0.1	0.88±0.1	0.65	1.01±0.1	7.21±3.1	7.03±4.2	0.68±0.3	1.11±0.1
Mg	0.56±0.1	0.47	0.52±0.2	0.58±0.1	0.32±0.2	0.35	0.51	0.39±0.1
Al	4.90±2.4	5.01±1.1	0.71±0.1	0.71±0.1	11.66±1.6	11.72±1.2	1.59±0.4	1.52±0.3
P	0	0	0	0	0	0	1.10±0.1	0.11
Zr	2.24±1.1	3.87±0.2	20.50±5.6	22.17±1.6	2.34±0.3	3.20±0.2	12.82±2.1	15.22±1.3
K	0.26±0.1	0.38±0.1	0.31	0.67±0.1	5.84±1.3	6.07±1.1	2.28±0.1	2.29±0.6
F	0.03	0.14	0.34±0.1	0.21	0.31	0.43	0.49±0.1	0.72±0.1
Ca	0.36±0.1	0.35±0.1	0.21	0.25	0.46±0.1	0.52±0.1	0.29	0.23±0.1
Ba	18.49±1.5	19.83±1.3	0.71±0.1	0.99±0.2	0.70	0.85	0.67±0.3	0.79±0.2
Li	3.90±1.2	4.35±1.6	3.08±1.2	3.26±1.1	3.92±2.4	4.15±1.1	2.85±1.1	2.88±1.1

BC: Brilliant Crios, LU: Lava Ultimate, VE: Vita Enamic, VS: Vita Suprinity, WP: Whiteness Perfect, C: Carbon, O: Oxygen, Si: Silicon, Na: Sodium, Mg: Magnesium, Al: Aluminium, P: Phosphorus, Zr: Zirconium, K: Potassium, F: Fluorine, Ca: Calcium, Ba: Barium, Li: Lithium.

DISCUSSION

The findings of this study revealed that the surface roughness and morphological properties of the tested CAD/CAM materials was affected by bleaching agent; but the microhardness of CAD/CAM materials was not affected. Based on the present findings, the null hypothesis was partially accepted.

Today, in line with aesthetic expectations, most bleaching treatments can be performed uncontrolled without the supervision of a professional. It might be possible to purchase an over-the-counter commercial product and for the patient to self-administer the product. The sale of bleaching agents without the need for a prescription and guidance of a professional increase the risk of adverse outcomes. When bleaching is applied in-office, esthetic restorations will have adequate protection. However, if the bleaching is

done at home, the bleaching agent might contact the restorations, and the restorations might be damaged (17). Little is known about the influence of bleaching agents on new chairside CAD/CAM materials. The bleaching agent might change the microstructural, esthetic, or mechanical properties of the restorative material. These changes can be caused by chemical reactions between the bleaching agent and dental materials (18). A reduction in microhardness due to organic matrix erosion might affect the surface properties (e.g., surface energy, roughness and gloss) of materials and influence the durability of restorations (2,17). The increase in surface roughness of material surfaces can cause discoloration, biofilm accumulation, and increased wear (1,19).

The bleaching agent used in this study was a 16% carbamide peroxide solution. Carbamide peroxide (10-16%) is generally used at application intervals of 4 to 8 h per day (20). The carbamide

peroxide breaks down into hydrogen peroxide and urea. Hydrogen peroxide causes oxidation by generating free radicals and might induce the breaking of polymer chains (21). Furthermore, free radicals can affect the resin-filler interface and cause filler-matrix debonding (22,23). This might cause changes in the structure and mechanical properties of the material (24). The high surface/volume ratio increases degradation and leads to a ravage of the filler-matrix interface (23,25).

The effect of 10-16% carbamide peroxide gels on the surface microhardness of restorative materials has been investigated, but the results are controversial. Some studies have reported that home bleaching agents decreased the microhardness of composite resins (26,27). Other studies reported an increase in microhardness (28) or no significant change (29-31). Demir *et al.* (19) found that the microhardness of the ceramic was not affected by the %16 carbamide peroxide bleaching agent. The differences between the studies can be explained by the differences in the application periods, bleaching agents and restorative materials. Surface hardness is one of the most important physical properties affecting the long-term durability of restorative materials (32). Composite resins are less resistant to chemical change than inert metal or ceramic restorations due to their organic matrix (22). However, in this study, the decrease in microhardness values of LU and BC was not statistically significant. LU and BC might be less affected by oxidation reactions during bleaching due to their nano-sized filler and highly cross-linked matrix structures (Table 1) (18). The microhardness values of VE and VS decreased but were not statistically significant; this can be explained by the lower organic matrix ratio and higher content of the filler particles of VE and VS.

The surface roughness of all materials used in this study was increased, but the increase in BC and VE was statistically significant. A large particle size can increase the microporosity in the structure

(21,32). The increase in the surface roughness of BC can be explained by its larger particle sizes ($<1\mu\text{m}$) (Table 1). Diffusion of chemical agents to micro-cracks on the restorative material, which may result in faster degradation (34). VE is called "polymer-infiltrated ceramic-network (PICN)" and is a hybrid material. VE contains porous feldspathic ceramic matrix and infiltrates of polymer (35). The relatively higher surface roughness of VE after bleaching (compared to other CAD/CAM material groups) can be attributed to its porous structure of the material.

The bleaching agent did not significantly affect the surface roughness of the resin nanoceramic LU and zirconia-reinforced lithium silicate glass-ceramic VS. The relationship between the matrix and filler particles makes an important contribution to the impact of bleaching agents (16). Resin nanoceramics typically contain nanoceramic particles embedded in a highly cross-linked resin matrix. Tinaštepe *et al.* (16) reported that the treatment of ceramics with a silane coupling agent and the heat treatment of a resin matrix contributed to the structural integrity of Lava Ultimate, and therefore, the surface roughness of Lava Ultimate was less affected than hybrid ceramics.

Among control and bleaching groups, VS showed the lowest surface roughness values and highest microhardness values. VS has a smoother surface due to its fine microstructure (36). VS may be less affected simply because is denser and harder material than all others, because it is the only reinforced glass-ceramics among tested materials. All other material have polymers in their composition, reason why it is logical that they would be more affected by the bleaching than the VS.

Similar to this study, Tinaštepe *et al.* reported that 15% carbamide peroxide increased the surface roughness of VE and when comparing SEM images, the alteration in surface morphology in VE samples were more evident compared to LU

(16). Moraes *et al.* reported that 10% carbamide peroxide increased the surface roughness of feldspathic porcelain when applied for 3 h/day for 21 days (37). In an *in vitro* study, it was reported that home bleaching applications (10-16% CP) do not affect the surface roughness of VE and LU (11); this result might indicate that the application time of the bleaching agent (2-3 h/day for 14 days) was shorter than that of this study. The dissolving effect of the bleaching agent on the material depends on the degree of penetration into the restorative material (2). If the restorative material is tightly cross-linked by high-molecular-weight polymer molecules, more time may be required for the bleaching agent to penetrate (38).

SEM evaluation showed material-dependent surface damages after bleaching procedures due to detachment of filler particles or superficial deterioration of material fragments. Differences between ceramic materials can be attributed to the crystalline phase or additional particles. Zirconia-reinforced lithium silicate glass-ceramic showed a different morphology, and the bleaching procedure did not cause evident alteration in SEM and also no significant changes detected in terms of microhardness or surface roughness. Noticeable alterations in SEM and a significant increase in surface roughness of VE specimens after the bleaching procedure can be attributed to the revealed polymer network after the superficial dissolution of the ceramic component (13). Si content difference in BC and LU can be attributed to the ingredient amorphous silica of BC and SiO₂ of LU and possible reduction of the silica-based component after the bleaching procedure. Also, the reduction in surface microhardness might be due to inorganic filler loss on the surface of BC and LU.

The limitation of this study was that it was performed under *in vitro* conditions; therefore, oral and clinical conditions, including saliva, food slurry, and thermal and chewing cycles, could not be provided in this study design. Furthermore,

different agents, concentrations, and application times will affect the material's surface properties. Future studies simulating oral conditions and using different bleaching procedures are needed.

CONCLUSION

The effect of 16% carbamide peroxide home bleaching agent on surface roughness and microhardness of chairside CAD/CAM materials is material-dependent. Before bleaching, restorative materials should be protected by applying a protective barrier and contact with the bleaching agent should be minimized. Also, after bleaching, the restoration surface should be carefully inspected, and re-polishing might be beneficial.

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The study was self-funded.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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