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Research Article / Araştırma Makalesi

The Effect of an Energy Drink And 35% Hydrogen Peroxide on Discoloration and Microhardness of Current Restorative Materials

Havalandırılmış Enerji İçeceği ve %35'lik Hidrojen Peroksitin Güncel Restorasyon Materyallerinin Renk Değişimi ve Mikrosertliği Üzerindeki Etkisi

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ABSTRACT

Aim: This study aimed to evaluate the effect of 35% hydrogen peroxide and aerated energy drink on microhardness and discoloration of CAD/CAM hybrid blocks and contemporary composite resins.

Materials and Methods: A total of sixty specimens, 15 specimens in disc shape (4x10 mm) from each test material, were produced (Tetric-N-Ceram=TNC, Estelite Sigma Quick=ESQ, Shofu HC=SH, and Vita Enamic=VE). Each group was divided into three subgroups, and the separated samples were subjected to 3 different treatments. One of the groups was kept in an aerated energy drink, while the other was kept in distilled water at 37°C. The other group was exposed to 35% hydrogen peroxide bleaching gel. Color changes and microhardness of the samples were measured before and after application. Data were analyzed with Mann-Whitney-U, Wilcoxon rank-sum test, one-way ANOVA, and post hoc test ($p>0.05$).

Results: No change in the microhardness of the test material groups ($p>0.05$). The higher discoloration was found in the hydrogen peroxide-exposed subgroup of the ESQ group (4.75±0.88), while the lowest discoloration was found in the VE hydrogen peroxide group (0.37±0.22).

Conclusion: Within the limits of this study, there was no change in the microhardness of the hybrid blocks and nanocomposites when the energy drink, hydrogen peroxide, and distilled water-treated samples were compared. However, energy drinks or hydrogen peroxide can cause discoloration of current restoration materials.

Keywords: Microhardness, Computer-aided design, Energy drinks, Hydrogen peroxide (H_2O_2), Composite Resins

ÖZ

Amaç: Bu çalışma, %35 hidrojen peroksit ve havalandırılmış enerji içeceğinin CAD/CAM hibrit blokların ve güncel kompozit reçinelerin mikrosertlikleri ve renk bozulmaları üzerine etkisini değerlendirmeyi amaçlamıştır.

Gereç ve Yöntemler: Her bir test materyalinden disk şeklinde (4x10 mm) 15 örnek olmak üzere toplam 60 örnek üretildi (Tetric-N-Ceram=TNC, Estelite Sigma Quick=ESQ, Shofu HC=SH ve Vita Enamic=VE). Her grup üç alt gruba ayrıldı ve ayrılan örnekler, 3 farklı işleme maruz bırakıldı. Gruplardan biri havalandırılmış enerji içeceği içinde bekletilirken diğeri 37 °C'de damıtılmış su içinde bekletildi. Diğer grup %35'lik hidrojen peroksit ağartma jeline maruz bırakıldı. Örneklerin renk değişimleri ve mikrosertlikleri, uygulama öncesi ve sonrası ölçüldü. Veriler Mann-Whitney-U, Wilcoxon sıralama toplamı testi, tek yönlü ANOVA ve post hoc testi ile analiz edildi ($p>0,05$).

Sonuçlar: Test materyal gruplarının mikrosertlik derecelerinde istatiksel anlamlı değişiklik görülmedi ($p>0.05$). ESQ grubunun hidrojen peroksite maruz bırakılan alt grubunda daha yüksek renk değişimi (4,75±0,88) bulunurken, en düşük renk değişimi VE hidrojen peroksit grubunda (0,37±0,22) bulundu.

Sonuç: Bu çalışmanın sınırları dâhilinde, enerji içeceği, hidrojen peroksit ve distile su ile muamele edilmiş numuneler karşılaştırıldığında, hibrid blokların ve nanokompozitlerin mikrosertliğinde değişiklik meydana gelmedi. Fakat enerji içeceği veya hidrojen peroksit güncel restorasyon materyallerine renk değişimine sebep olabilmektedir.

Anahtar Kelimeler: Mikrosertlik, Bilgisayar destekli tasarım, Enerji içecekleri, Hidrojen peroksit (H_2O_2), Kompozit Reçineler

INTRODUCTION

Many restorative materials have been used in dentistry to provide the increasing aesthetic demand.[1] Over the past decade, CAD/CAM technology and materials have gained importance in indirect restorations.[2] Composite resin block materials have been produced and developed for CAD/CAM systems since the 2000s. These block materials have higher micro-mechanical properties as they are fabricated industrially under high temperatures and pressure.[3] CAD/CAM hybrid blocks have an aluminum oxide reinforced polymer infiltrated feldspathic network structure. In addition to micro-mechanical properties, color compatibility, and color stability are also crucial for the long-term clinical success of the restoration.[4]

Composite resin materials undergo multiple physical and frequent changes in the mouth. These changes may be related to the color change of restorative materials. Previous studies have shown that the factors affecting color change are internal and external. Intrinsic coloration depends on the relationship between the matrix structure of the material and the filling materials. These factors directly affect coloration. The external discoloration is due to factors such as food, drink, and cigarettes responsible for external contact.[5] Due to their industrially optimized polymerized structures, CAD/CAM blocks are expected to have high coloration resistance.

Sports and energy drinks have increased to increase performance and endurance in recent years.[6] The low pH of acidic foods and beverages causes wear on restoration materials.[7] Restorations are subject to intermittent or continuous exposure to chemicals, foods, and drinks. These chemicals can soften the resin matrix of composite resins and seep into the filler components.[8] Hardness is called the resistance of a material to sink. Hardness is related to the strength of a material, its proportional limit, and its ability to oppose or corrode tooth structures/materials.[9] Any chemical softening from foods, beverages, and bleaching agents affects the clinical durability of restorations.[10] Without saliva, acidic foods, and drinks, bleaching procedures can cause softening and increased surface roughness in resin composites. This study was carried out to determine the microhardness and color changes of existing CAD/CAM hybrid blocks and composite resins when exposed to 35% hydrogen peroxide and energy drinks (Red Bull).

Material and Methods

This study used two restorative hybrid CAD/CAM blocks and two resin composite materials (**Table 1**).

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Table 1. Used materials

Material	Type	Manufacturer	Monomer	Filler	Mass%, (Vol%)
Shofu HC	Hybrid ceramic block	Shofu Inc., Kyoto, Japan	UDMA, TEGDMA	Silica powder, micro fumed silica, zirconium silicate	61.0
Vita Enamic (VE)	Hybrid ceramic block	Vita Zahnfabrik H. Rauter GmbH, Bad Sackingen, Germany	UDMA, TEGDMA	Feldspar ceramic enriched with aluminum oxide	86.0 (75.0)
Tetric N-Ceram Bulk-Fill (TNC)	Nano-hybrid Bulk-Fill composite	Ivoclar Vivadent, AG, Lichtenstein	Bis-GMA, Bis-EMA, UDMA	Barium glass, silicate glass,	81.0 (61.0)
Estelite Sigma Quick (ESQ)	Conventional restorative composite resin	Tokuyama Dental Corporation, Tokyo, Japan	Bis-GMA, TEGDMA	Silica-zirconia filler, composite filler	82.0 (71.0)

Samples of two hybrid ceramic block materials (15 samples per material) were prepared by cutting ceramic CAD/CAM blocks using a water-cooled precision low-speed saw (IsoMet 1000, Buehler; Illinois, ITW, USA). Thirty samples were obtained by cutting the ceramic blocks into rectangular slices of approximately 4 mm thickness (**Figure 1**).

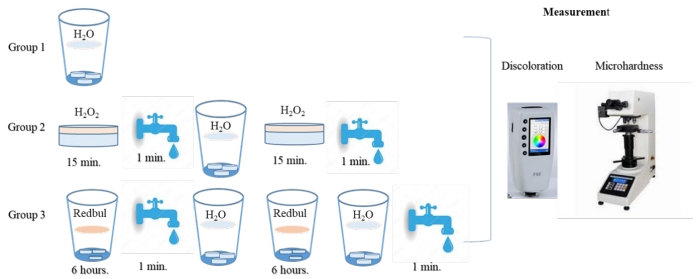

Figure 1. Experimental groups and processes

Thirty hybrid discs with a diameter of 10 mm were produced from the obtained block sections with the help of a trephine bur (Hu-Friedy Mfg. Co., LLC, USA). For composite resin samples, resin materials were placed in a 4 mm thick and 10 mm diameter hollow Teflon mold, and polymerization was performed according to the manufacturer's recommendations. Isolation gel was used to prevent the resin from sticking to the inner surfaces. Surfaces of resin composite samples were polished with a special kit (Super-Snap Mini-Kit, Shofu INC, California, USA) for 10 s. VE materials were polished with a set clinical diamond polishing system (Vita Enamic, Vita Zahnfabrik, Germany), and SH materials were polished with Shofu Cadmaster HP Kit (Shofu Dental GmbH, Germany) according to the manufacturer's recommendations. Samples were cleaned with distilled water for one minute and air-dried for 10 seconds. A single operator performed all finishing and polishing procedures. A total of sixty test samples were obtained, fifteen disc samples from each test material. The samples (n=15) prepared for each material were randomly divided into three groups (n=5) according to the application method. After numbering the samples, initial hardness and color values were measured. A thickness of 2 mm was determined to minimize the effect of background color and transparency on the calculated color. A recent study has shown that a ceramic thickness of at least 2 mm is required to mask the color of most backgrounds.[11]

*Experimental groups (**Fig. 1**)*

Group 1: Samples were immersed in distilled water at 37°C for 42 hours.

Group 2: 35% hydrogen peroxide gel (Venus White Pro 35% Whitening Gel, Kulzer, Germany) was applied at 2 mm thickness for 15 minutes, according to the manufacturer's instructions. After the first application, The specimens were rinsed with distilled water for one minute and dried, followed by the second application. This procedure was repeated after 42 hours. Between the first and second applications, the samples were kept in distilled water at 37°C.

Group 3: Samples were soaked in an energy drink (Red Bull) at 37°C for 6 hours a day and then in distilled water at 37°C for the remainder of the day and continued in the same procedure for seven days.

Measurement of roughness

Surface roughness was measured with a profilometer device (Marsurf PS 10, Mahr, Germany). Three roughness measurements were taken from the polished surface for each sample, and their arithmetic mean was recorded (**Table 2**).

Table 2. Mean roughness of groups

	N	Mean*	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
SHC	15	0.50^{a}	0.15	0.04	0.42	0.58	0.31	0.73
VE	15	0.47^{b}	0.12	0.03	0.40	0.54	0.22	0.69
TNC	15	0.21^{a,b}	0.09	0.02	0.16	0.25	0.11	0.38
ESQ	15	0.31^{b}	0.19	0.05	0.21	0.42	0.11	0.76

**The same superscript letter indicates mean difference is significant at the 0.05 level between groups.*

Measurement of discoloration

Color values (L*, a*,b*) were measured from the center of the polished surface before and after treatment using a spectrophotometer (3nh NR10QC, Shenzhen 3nh Technology Co., Ltd, Shenzhen, China) on a white background. A white calibration standard was used before measurement for each sample. The color value was measured three times from each sample, and the average value was calculated. The formula $\Delta E=[(L_2^*-L_1^*)^2+ (a_2^*-a_1^*)^2+(b_2^*-b_1^*)^2]^{1/2}$ was used for the calculated and recorded data. Clinically acceptable color difference values have been reported as $\Delta E \leq 2.0$, $\Delta E \leq 3.3$, and $\Delta E \leq 3.7$.[12] Color change between $1<\Delta E<3.3$ is clinically acceptable.[5] Values in this study were evaluated according to these clinically important values for CIELAB discoloration (ΔE) (**Table 3**).

Table 3. Variables values of discoloration

Groups	Storage	N	Mean*	Std. Deviation
Shofu	Hydrogen peroxide	5	3.10	2.28
Hc	Water	5	1.62^{d}	0.57
(SHC)	Redbull	5	1.38^{d}	0.64
Vita	Hydrogen peroxide	5	0.37^{c}	0.22
Enamic	Water	5	0.64^{c,d}	0.13
(VE)	Redbull	5	0.89^{c,d}	0.42
Tetric-N-Ceram (TNC)	Hydrogen peroxide	5	4.21^{b,c}	2.46
	Water	5	2.91^{a,b,d}	1.39
	Redbull	5	4.19^{b}	1.77
Estelite Sigma Quick (ESQ)	Hydrogen peroxide	5	4.75^{b}	0.88
	Water	5	2.91^{a}	0.79
	Redbull	5	2.83	1.28

**The same superscript letter indicates that the mean difference is significant at the 0.05 level between groups.*

Vicker's Microhardness Test

Before the experimental procedures, the surface microhardness of the samples was measured using a Vickers hardness tester (Duroline M, Metkon, Bursa, Turkey). A 1000 g load was used to create a micro-recess with a 10-second dwell time. After the test protocols, the second measurement was made near the previously measured positions under the same measurement conditions as the previous one. After loading, a plus sign (+) indentation was formed on the surface of the samples. The vertical and horizontal dimensions of the crosshair were measured to calculate the average hardness number according to the Vickers table (**Fig. 2**). These measurements were repeated 3 times for each sample. The mean hardness values of the measurements were reported as the Vickers hardness number of each sample.[13]

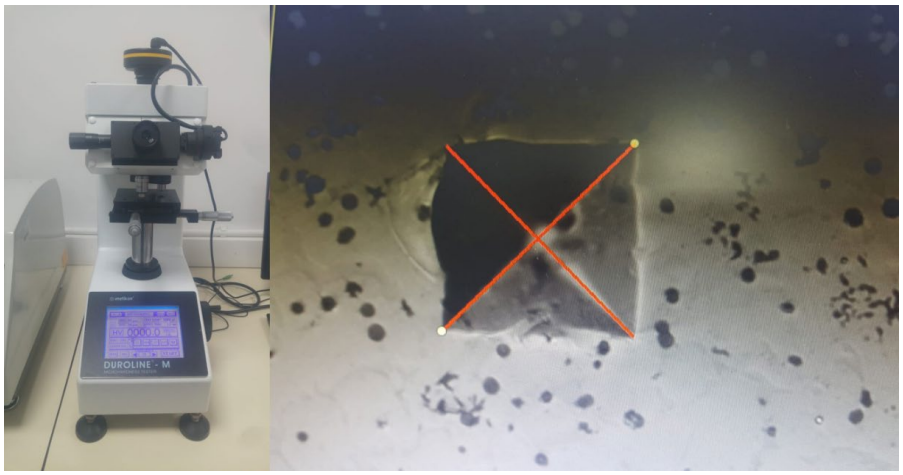

Figure 2. Measurement of microhardness

Statistical Analysis

Data were statistically analyzed using the SPSS V.22 program (SPSS Inc, Chicago, USA). The Mann-Whitney-U, Wilcoxon rank-sum test, One-way analysis of variance (ANOVA), and post hoc test (Bonferroni) were used to find the statistical significance between the groups. Evaluations were made according to the p=0.05 significance level.

Results

The initial hardness values of the groups were measured (**Table 4**). One-way ANOVA statistical analysis revealed a difference between the microhardness values of the four groups ($p<0.05$). However, the Estelite group and bulk-fill group values were similar. The change in the surface hardness values of the materials after 42 hours of storage was statistically insignificant compared to the base surface hardness values. While the groups did not change color before and after the procedure, there were differences in the multiple comparisons. The highest color change was found in the ESQ hydrogen peroxide group (**Table 3**). The coloration was found above the accepted value ($\Delta E \leq 3.7$) in the composite samples (TNC and ESQ) stored in hydrogen peroxide and Red Bull and in bulk fill composite stored in Red Bull.

Table 4. Microhardness of groups

Groups	Storage	M	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
							Lower Bound	Upper Bound		
Shofu Hc (SHC)	Redbull	I	5	70.1	3.95	1.77	65.19	75.01	65.8	76.5
		S	5	71.42	2.22	0.99	68.66	74.18	69	73.5
	Water	I	5	69.78	1.04	0.46	68.49	71.07	68.7	71.2
		S	5	69.48	4.81	2.15	63.51	75.45	62.7	74.5
	Hydrogen peroxide	I	5	72.22	2.51	1.12	69.11	75.33	68.8	75.8
		S	5	67.94	3.44	1.54	63.67	72.21	63.1	72
Vita Enamic (VE)	Redbull	I	5	228.98	16.06	7.18	209.04	248.92	214.3	251.9
		S	5	215.66	14.38	6.43	197.81	233.51	201.5	239.5
	Water	I	5	218.78	9.49	4.25	206.99	230.57	207.2	232.2
		S	5	213.64	12.96	5.79	197.55	229.73	203.4	236.1
	Hydrogen peroxide	I	5	207.48	13.59	6.08	190.61	224.35	192.3	222.7
		S	5	199.98	6.96	3.11	191.33	208.63	189.5	209
Tetric-N-Ceram (TNC)	Redbull	I	5	53.98	5.64	2.52	46.97	60.99	45	59
		S	5	53.22	16.63	7.44	32.57	73.87	42.4	82.6
	Water	I	5	43.7	6.29	2.81	35.88	51.52	34.5	51.3
		S	5	59.94	3.17	1.42	56.01	63.87	55.6	63.8
	Hydrogen	I	5	56.1	2.7	1.21	52.75	59.45	53.3	59.6
		S	5	48.7	4.51	2.02	43.1	54.3	45.5	55
Estelite Sigma Quick (ESQ)	Redbull	I	5	49.84	2.21	0.99	47.1	52.58	48.3	53.7
		S	5	53.3	2.95	1.32	49.64	56.96	49.8	57.7
	Water	I	5	51.78	4.38	1.96	46.35	57.21	47.4	57.8
		S	5	54.54	5.35	2.39	47.9	61.18	47.7	61.9
	Hydrogen	I	5	61.48	6.56	2.93	53.33	69.63	54.9	72.2
		S	5	48.44	6.1	2.73	40.87	56.01	39.8	53.3

Discussion

Many factors cause the discoloration of resin composites. The resin's structure and patients' external behavior affect the color change.[14] Internal or external factors can cause the discoloration of resin composites.[15] External discoloration depends on the coloring of the superficial layer of the composite-containing restoration material, smoking and eating habits, plaque accumulation, pigmentation of the colorants, the exposure time of the material to the stain, and the surface roughness of the material. The internal color change of composite-containing resin materials depends on dehydration, water absorption, oxidation of unreacted carbon double bonds, matrix structure, filler, matrix-filler interface, and degree of polymerization. The polymeric matrix, filler size, filler shape, and silanization are effective in creating polished surfaces. Inorganic matrix tears are common when the filler particles are much harder than the surrounding resin matrix.[16] Although composite resin samples have less roughness than block samples, because of this reason can be more color changes were detected in this study

External discoloration results from the resin matrix's adsorption and absorption of water-soluble substances. Internal color changes are permanent and can be caused by the structure of the resin material. The matrix structure of the resin, the interface between the matrix and fillers, the type and amount of fillers, and the polymer quality significantly affect the color change.[17] Studies have shown that soaking is negligible in internal discoloration when fully polymerized composites.[18] Colorants, chemical dyes caused significant color changes in poorly polymerized composites.[19] Because of the hydrophobic/hydrophilic properties of the resin matrix, the color sensitivity of composites varies.[20] Water-soluble pigments such as tea, coffee, and soft drinks cause discoloration in composites where the resin matrix is more likely to absorb water.[21] Conversely, composites with low water absorption are more sensitive to discoloration with hydrophobic solutions.[22] Besides, it has become clear that resins containing bisphenol A glycidyl methacrylate have a lower susceptibility to discoloration due to hydrophilic hydroxide groups than urethane dimethacrylate (UDMA) resins with less hydrophilic aliphatic chains. The properties of fillers have an essential role in discoloration.

It is known that various resin matrices in composite structures have significant effects on coloring. The water absorption potential of BisGMA monomers is higher than that of UDMA, TEGDMA, and BisEMA monomers. When comparing BisGMA and UDMA monomers, it was found that the UDMA monomer has a higher resistance to coloration due to its lower water absorption and water-solubility properties. UDMA monomer has a more hydrophobic structure than BisGMA monomer. The coloration of the BisGMA monomer more than other monomers was attributed to the hydroxyl groups present in the monomer being more susceptible to water absorption. Liena et al. reported that the resin materials were more colorful because the BisGMA-based organic matrix was more hydrophilic. ESQ and TC composite resins varied more discoloration than CAD/CAM block materials in this study. The organic resin matrix makes up 21% of the weight of the TNC material, and the monomers in this organic resin matrix are BisGMA, BisEMA, and UDMA. When Barutçigil et al. examined the color stability of different bulk-fill composite resins, they found that bulk-fill composite resins containing BisGMA and TEGDMA monomers had more discoloration. They explained that this is because the BisGMA and TEGDMA monomers combine to cause higher water absorption.[16] These findings are similar to the results of this study.

Some studies have shown that increased filler content improves color stability. Micro hybrid composites with a high organic filler content have been shown to have greater color stability than nano-filled and nanohybrid composites after immersion for two weeks in the three different solutıons. The results are associated with the fill size and morphology of the micro-hybrid composite.[22] Poor matrix filler linked also resulted in a color change.[21]

Assuming that with each sip, the restoration is exposed to about 30 ml of energy drink for about 6 seconds, one can of energy drink equals 60 seconds of exposure. Thus, holding 6-hour samples in energy drinks corresponds to daily exposure of teeth or restorations to an energy drink for one year. Forty-two hours of storage is equivalent to seven years of frequent energy drink use.[13]

This study revealed that there wasn't a decrease in microhardness of all three groups regardless of the solution. The average micro-hardness value of composite samples increased 42 hours after immersion in distilled water. This result isn't similar to the results found by Yanıkoğlu et al.[23] This reduction in hardness may be due to the incomplete polymerization reaction of the composite resin. Mottaghi et al. reported that this decrease in hardness was due to the initial polymerization reaction of the composite resin. In this study, the hardness of all composites decreased after 6 hours of immersion in distilled water, but their hardness increased after immersion in distilled water for 42 hours. This can be attributed to higher crosslinking reactions and the completion of polymerization of the resin matrix.[13] These results were like the results of this study. TNC and ESQ groups kept in the water had higher values than initial hardness values.

Erdemir et al. stated that during consumption, food and beverages touch the teeth or restoration surfaces for a short time before being washed with saliva. This study was conducted because of the acidity and corrosive potential of the energy drink and hydrogen peroxide. Composite discs were stored in distilled water to simulate the washing effect of saliva.[6] Distilled water was chosen instead of artificial saliva.

When the composites are immersed in distilled water, the resin matrix swells and reduces the friction forces between the polymer chains. The whole hydrolytic degradation mechanism is a process that depends on the polymer type, the amount of filling, and filling type. The diffusion rate is affected by the surface treatment of the particles. Besides, tensile stresses are produced at the resin-filler interfaces by stretching the bonds in the matrix and increasing the frictional forces between the filler and the resin matrix, making it easier to pull the fillers out. Water absorption reduces circle stresses around the fillers, facilitating particle separation.[24]

Samples immersed in hydrogen peroxide showed a greater decrease in surface hardness than samples stored in distilled water. Nicholson et al. have reported that all composite materials tend to corrode under acidic conditions, and the acid penetrates the resin matrix, promoting the release of unreacted monomers. This results in lower surface hardness.[25]

Energy drink (Red Bull) contains sucrose, glucose, citric acid, taurine, sodium bicarbonate, magnesium carbonate, caffeine, niacinamide, calcium pantothenate, pyridoxine HCL, and Vitamin B12. The pH value of the energy drink is 2.80. The pH of the drinks can adversely affect the properties of aesthetic restorative materials. Valinoti et al. stated that the solubility of the resin material immersed in low-pH beverages is high, which causes surface erosion and dissolution, the matrix structure's softening, and the loss of structural ions. This affects wear, hardness, and surface integrity.[26] In addition to the more corrosive effect of water uptake and acidic conditions on restorative materials, the interaction between solutions and resins causes a decrease in surface hardness values in this study.[6]

Nano-filled composite resin Estelite has a combination of nano-silica fillers and zirconia-silica nanoclusters. Beun et al.[27] reported that this composite type has mechanical properties similar to those of medium-fill composites. However, due to the presence of silica particles, the high surface/volume ratio can increase water absorption and the polymer matrix-filler interface, which causes a possible decrease in some mechanical properties. The mentioned mechanism and the effect of the bleaching agent on the filler-matrix interface are probably responsible for reducing the microhardness in these materials in this study.[7]

The mean microhardness values of the restorative materials tested after various applications did not differ significantly ($p<0.05$). The surface hardness values of the composite materials after 42 hours of waiting were not much different from the fundamental surface hardness values. There was no significant difference between the energy drink (Red Bull) and 35% hydrogen peroxide groups compared to the initial microhardness values 42 hours after the intervention. The mean surface hardness of the materials in distilled water was different from that measured for the energy drink and 35% hydrogen peroxide. However, it was not statistically significant. The microhardness of the composite resin increased 42 hours after

immersion in water and energy drinks ($p>0.05$). However, there was no significant difference between the energy drink (Red Bull) and 35% hydrogen peroxide groups ($p>0.05$). Various studies have shown that the acids found in airted energy drinks reduce the hardness of the restorative material.

Conclusions:

While energy drinks (Red Bull) and 35% hydrogen peroxide do not change the hardness properties of CAD/CAM blocks and new-generation composite materials, they may cause discoloration.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

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It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

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Çıkar Çatışması / Conflict of interest

Çıkar çatışması beyan edilmemiştir.

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