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The Effect of Acidic Beverages on Surface Characteristics of the Alkasite, Bulk-fill, and Universal Resin Composite Restorative Materials

Asidik İçeceklerin Alkasit, Bulk-fill ve Universal Rezin Kompozit Restoratif Materyallerin Yüzey Özellikleri Üzerine Etkisi

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ABSTRACT

Objectives: This study evaluated surface roughness, gloss, and color changes of an alkasite, bulk-fill, and a universal micro-hybrid resin composite after immersion in two different acidic beverages.
Materials and Methods: In this study, self-cured, and dual-cured alkasite (Cention N, Ivoclar Vivadent AG, Schaan, Liechtenstein), bulk-fill (SonicFill3, Kerr Corporation, USA), and a micro-hybrid resin composite (Palfique Estelite Paste, Tokuyama, Japan) materials were tested. Eighty-four disk-shaped samples were randomly divided into 3 experimental groups (n = 7). Distilled water (control group), coke (Coca-Cola Company, USA), and turnip juice (Doğanay Gıda, Turkey) were used as immersion mediums. The disks were individually immersed in their respective test substance at 37 ºC, for 6 days. Surface roughness, gloss, and color values were measured at baseline, 1 day, and 6 days.
Results: Data were analyzed by the Friedman test and the Kruskal-Wallis test ($p<0.05$). Following the 6-day duration, coke, and turnip juice solutions caused a statistically significant increase in the surface roughness and a decrease in the gloss values of all materials ($p<0.05$). In all samples except those kept in distilled water, color changes exceed the acceptable threshold value ($\Delta E00=1.8$).
Conclusions: In the study, in some materials, turnip juice caused more color change than coke, while SonicFill 3 had lesser surface alterations than other restorative materials.
Keywords: Resin composite, surface roughness, gloss, color stability, CIEDE 2000

ÖZ

Amaç: Bu çalışmada iki farklı asitli içeceğin alkasit, bulk-fill ve üniversal rezin kompozit materyalin yüzey pürüzlülüğü, parlaklık ve renk değerleri üzerine olan etkisi incelenmiştir.
Gereç ve Yöntemler: Bu çalışmada self-cure ve dual-cure alkasit (Cention N, Ivoclar Vivadent AG, Schaan, Liechtenstein), bulk-fill (SonicFill3, Kerr Corporation, USA), ve bir üniversal mikro-hibrit rezin kompozit (Palfique Estelite Paste, Tokuyama, Japan) materyali test edilmiştir. Çalışmada 84 disk şeklinde örnek 3 alt gruba ayrılmıştır (n=7). Distile su (kontrol groubu), kola (Coca-Cola Company, ABD) ve şalgam suyu (Doğanay Gıda, Türkiye) solüsyon olarak kullanılmıştır. Örnekler ayrı ayrı solüsyonlarda 37 ºC'de 6 gün bekletilmiştir. Yüzey pürüzlülüğü, parlaklık ve renk ölçümleri başlangıçta, 1. günün sonunda ve 6. günün sonunda ayrı ayrı ölçülmüştür.
Bulgular: Veriler Friedman ve Kruskal-Wallis testleri ile analiz edilmiştir ($p<0.05$). 6 günlük bekleme süresi sonunda kola ve şalgam suyu her materyalin yüzey pürüzlülüğü ve parlaklık değerlerinde istatistiksel olarak anlamlı derecede artışa yol açmıştır ($p<0.05$). Distile su haricindeki solüsyonlarda bekletilen her materyalde klinik olarak kabul edilebilen eşik değeri ($\Delta E00=1.8$) aşan miktarda renk değişimi gözlenmiştir.
Sonuç: Çalışmada elde edilen veriler ışığında gözlenmiştir ki, bazı materyallerde şalgam suyu koladan daha fazla renk değişimine yol açmıştır. SonicFill 3 materyalinde diğer materyallere göre daha az yüzey değişimi meydana gelmiştir.
Anahtar Kelimeler: Rezin kompozit, yüzey pürüzlülüğü, parlaklık, renk stabilitesi, CIEDE 2000

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INTRODUCTION

Resin composites have been widely used in dental restorations since they were first introduced in the mid-1960s. Their application area has expanded significantly, in line with developments in dental technology. From the past to the present, the progression in resin composites has been about compensating for the drawbacks or limitations of existing materials. The first dental composites were macrofills with filler particle sizes around 10–50 microns. Microfills were produced in order to eliminate problems such as poor wear resistance and poor polishing ability caused by large particle sizes, which lead to mechanical advantages but aesthetic disadvantages. Microfills with particles of 40–50 nm in size has proper polishing-ability but generally weak due to their relatively low filler content (Ferracane, 2011). Hybrid composites were created by combining macrofilled (10-50 μm) and microfilled (40nm) composites to provide desirable mechanical and optical qualities, as well as enhanced resistance to wear (Ferracane, 2011; Miletic, 2018). However, at that time, a composite material that had both aesthetic properties that could be used in the anterior region and mechanical properties that could be used in the posterior region, that is, a universal composite, had not yet been produced. Therefore, the micro-hybrids that are universal composites were invented containing 0.4–1 μm filler particles (glass, zirconia, or ceramic) in combination with smaller 40nm-sized amorphous silica particles (Miletic, 2018). Later, nanocomposites, which are the most common direct restorative materials today, have been developed. These materials consist of nanofillers that are incorporated and distributed in either dispersed or clusters. Nanofillers have small particle sizes that are generally invisible, so they have higher optical properties. Also, small sizes provide more inorganic filler rates, and lower polymerization shrinkage allows them to have better physical properties (Chen, 2010).

In restorative dentistry, the pursuit of scientists and manufacturers to develop novel products will persist until the discovery of the most optimal material, one that possesses identical characteristics and lifespan to natural enamel or dentine. Hence, various advanced restorative materials have been produced by making many modifications not only in filler particle size and ratio but also in other chemical features, which have bioactive properties (ion-releasing resin composites), time-shortening application methods (bulk-fills or self-adhering resin composites), or higher mechanical properties (low-shrinkage resin composites and fiber-reinforced resin composites) (Miletic, 2018). Among these materials, bulk-fill composites are much preferred by clinicians because they can be applied in 4-5 mm increments, provide time – savings, have less risk of voids and contamination between layers, and have similar clinical performance to conventional resin composites (Van Ende et al., 2017; Cidreira et al., 2019). Thanks to the presence of photoinitiators in their composition and enhanced translucency, bulk-fill composites can be applied in these thicknesses since they have deeper photopolymerization capabilities (Miletic, 2018). Bulk-fill composites can be divided into two groups according to their viscosities or clinical application strategies. Flowable bulk-fill composites have low viscosity and require an extra capping layer over the top surfaces due to their low wear resistance against oral environmental changes. Therefore, they are applied as a base bulk-fill layer beneath the conventional resin composites. Paste-like bulk-fill composites have high viscosity because of their high inorganic filler content which provides higher wear resistance. So they are named full-body bulk-fill composites and the entire restoration is created from this material, and there is no need for an extra cover layer (Van Ende et al., 2017; Miletic, 2018). Additionally, there are also numerous bulk-fill composite materials manufactured using various technologies by producers that are not fully included in either classification. SonicFill 3 (Kerr) bulk-fill material applied with the sonic activation technique is one of them. This product, which has a high rate of inorganic filler, utilizes sonic vibration to decrease viscosity during insertion in the cavity. The manufacturer claims that this application method provides in one product the mechanical strength of condensable composites and the good adaptation of flowable composites (Kerr Dental, 2024).

In recent years, bioactivity has been one of the most interesting and studied topics in the medical and dental fields. Bioactive materials refer to substances that can exert a biological effect or demonstrate biological activity. These materials are capable of forming a bond between tissues and the material itself (Vallittu et al., 2018). Considering that the most common cause of restoration loss, particularly in posterior resin composite restorations, is secondary caries. It is understood that there is a significant demand for restorative materials in restorative dentistry that have properties to prevent demineralization and provide remineralization through biological activity (Opdam et.al., 2007). There are a considerable number of permanent restorative materials in the dental market that are considered as bioactive due to their ion-releasing properties, which are produced for the purpose of remineralization and cariostatic effect (François et al., 2021). One of these products, Cention N (Ivoclar-Vivadent AG), which is a resin-based alkasite material, releases fluoride, calcium, and hydroxide ions due to the alkaline fillers it contains, such as Calcium Fluoro-Silicate Glass. This material has self-adhesive and self-curing properties and is also described as bulk-fill since it can be applied as a 4-5 mm layers (Van Ende et al.,2017; François et al., 2021).

The aim of this in vitro study was to assess and compare color stability, surface roughness, and gloss retention characteristics between alkasite, bulk-fill, and universal micro-hybrid resin composite restorative materials. The null hypothesis was that acidic beverages do not affect significantly the color stability, surface roughness, and gloss retention properties of restorative materials.

MATERIALS AND METHODS

Sample Preparation

In this study, alkasite (Cention N, Ivoclar Vivadent AG, Schaan, Liechtenstein), bulk-fill (SonicFill 3, Kerr Corporation, USA), and universal micro-hybrid (Palfique Estelite Paste, Tokuyama, Japan), materials were tested. Distilled water (control group), coke (Coca Cola Company, USA), and turnip juice (Doğanay Gıda, Turkey) solutions were used as immersion mediums. Details regarding restorative materials and solutions were presented in Table 1 and Table 2. The materials were divided into 4 main groups according to the polymerization methods. The Palfique Estelite Paste (PEP), SonicFill 3 (SF3), Cention N Dual-Cure (CNDC) were polymerized with LED light device, and Cention N Self-Cure (CNSC) was self-cured. A total of 84 disc-shaped samples (7 for each material) were prepared using Teflon molds with a diameter of 8 mm and a depth of 2 mm, according to the manufacturer's instructions.

Table 1. Restorative materials tested in the study

Materials	Type	Manufacturer	Components
Cention N	Alkasite	Ivoclar Vivadent AG, Liechtenstein	Liquid: UDMA, DCP, Aromatic aliphatic-UDMA, PEG-400 DMA, initiator. Powder: Barium aluminium silicate glass, Ytterbium trifluoride, Isofiller, Calcium barium aluminium fluorosilicate glass, Calciumfluoro silicate glass, Initiator, pigments. 78.4 wt%, 57.6 vol% Particle size: 0.1 – 35µm (Ilie, 2018)
Palfique Estelite Paste	Universal (Micro-hybrid)	Tokuyama, Japan	Bis-GMA, TEGDMA, Submicron Spherical Zirconia/ silica Particle size: 0,1 – 0,3 µm 82 wt%, 71 vol%
SonicFill 3	Bulk-fill (Nano-hybrid)	Kerr Corporation, USA	Bis-GMA Bis-EMA, TEG-DMA, EBPDMA, MPS; Barium glass, silicon dioxide 40 nm-10 µm 81 wt%, 65.9 vol%

UDMA: Urethane dimethacrylate, DCP: Tricyclodecan-dimethanol dimethacrylate, PEG-400 DMA: Polyethylene glycol 400 dimethacrylate, Bis-GMA: bisphenol A-glycidyl methacrylate, TEGDMA: Triethylene glycol dimethacrylate, Bis-EMA: ethoxylated bisphenol-A-glycidyl methacrylate, EBPDMA: ethoxylated bisphenol-A-dimethacrylate, MPS: 3-(trimethoxysilyl) propyl methacrylate

Table 2. Solutions used in the study

Solutions	Components	pH levels
Distilled Water	-	6.8
Coke (Coca Cola Company, USA)	Water, sugar, carbon dioxide, colorant (caramel), acidity regulator (phosphoric acid), natural flavorings, caffeine (max. 0.150 g/l)	2.50
Turnip Juice (Doğanay Gıda, Turkey)	Water, purple carrot, salt, wheat, turnip radish, preservative (sodium benzoate)	3.3-3.8

Each restorative material was inserted into the Teflon mold, with translucent matrix bands on either side. A glass slide, 1 mm thick, was placed on top of the sample. Excess material was then removed by applying consistent finger pressure. The light polymerization was conducted using a LED light device (Ultradent, South Jordan, UT, USA) with an intensity of 1000 mW/cm2 for 20 seconds. Before placing SF3 in the mold, it was activated with sonic energy by using a handpiece (SonicFill, Kavo/ Kerr, USA) to reduce the viscosity. Cention N powder and liquid were dispensed on a glass slab and manually mixed homogeneously with a spatula within 60 seconds, then transferred into the mold. CNDC samples were polymerized with LED light device, CNSC samples were self-cured after the 5 minute waiting period. All the samples were stored in distilled water at 37 °C in darkness for 24 hours. The finishing and polishing process for each sample was applied with aluminum oxide-coated discs (Sof-Lex™ XT Discs, 3M ESPE, Saint Paul, MN, USA) with coarse, medium, fine, and superfine grits respectively. New, unused disks were used for each sample with a low-speed handpiece at 10,000-30,000 rpm. Samples were divided into 3 subgroups according to the immersion mediums. For the simulation of approximately 6 months of the daily routine Ertas et al, 2006 of consumption of the beverages, samples were kept in distilled water, coke, and turnip juice for 6 days in the incubator. Solutions were refreshed every 12 hours to maintain acidity and prevent bacterial growth. Surface roughness, color, and gloss measurements were established before the immersion of the solutions, 1 day, and 6 days after immersion of the solutions. Before the measurements, samples were rinsed with 5 ml of distilled water and dried with high-pressure air.

Color Measurement

The color measurements of the samples were obtained with a spectrophotometer (Vita Easyshade V; Vita Zahnfabrik, Bad Säckingen, Germany) providing CIE L*, a*, and b* coordinates. The spectrophotometer was calibrated before each measurement, the color of each specimen was recorded as the average of three consecutive measurements, and the color changes were calculated using the CIEDE 2000 (ΔE00) formula (Ardu, 2019; Duc O, 2019).

Surface Roughness Measurements

A surface profilometer (Surtronic 3+, Taylor Hobson Ltd., Leicester, UK), with a cut-off of 0.25 mm and transverse length of 1.25 mm at a speed of 0.5 mm/s was used to measure surface roughness values of each sample. Three consecutive measurements were taken from the center of the samples and the average numerical value was accepted as the roughness value (Ra).

Gloss Measurements

Gloss was measured with a gloss meter (Novo-Curve, Rhopoint Instrumentation, East Sussex, UK) at a 60-degree angle (ISO 2813) which was calibrated with a reference value of 95.5 GU according to the manufacturer (Ereifej, 2012). To exclude ambient light, the measurement area was enclosed in a black box, and each sample underwent three consecutive measures, with the average result taken as the gloss value (GU).

Statistical Evaluation

The statistical analysis was conducted using the NCSS 2007 statistical software (NCSS, Utah, USA) with a significance level of 0.05. The data were analyzed by calculating the mean and standard deviation for each group, and the distribution of variables was examined with the Shapiro–Wilk normality test. For variables that did not show normal distribution, the Wilcoxon Test was used for two-measurement time comparisons, the Friedman Test was used for three-measurement time comparisons, and the Kruskal Wallis test was used for intergroup comparisons.

RESULTS

The mean values for the surface roughness, gloss, and color change values along with the corresponding standard deviation for each material group were displayed in Tables 3, 4, and 5.

When the changes in the roughness and color values of the material, it was seen that the surface alterations started at the end of 1 day in all materials that were kept in the coke and turnip juice solutions.

Table 3 demonstrates that following a 1-day immersion, coke, and turnip juice solutions resulted in a statistically significant increase in the surface roughness of all materials, except SF3. Following the 6-day duration, coke, and turnip juice solutions caused a statistically significant increase in the surface roughness of all materials ($p<0.05$).

Table 3. Mean and standard deviations of Ra values (μm) of restorative materials immersed in various storage solutions at different time periods

Materials	Solutions	Baseline	1 day	6 day
Cention N Dual-Cure	Distilled Water	0,50±0,13^{Aa}	0,51±0,18^{Aa}	0,58±0,10^{Ba}
	Coke	0,45±0,15^{Ab}	0,51±0,13^{Ba}	0,65±0,08^{Ca}
	Turnip Juice	0,54±0,10^{Aa}	0,58±0,18^{Bb}	0,72±0,17^{Cb}
Cention N Self-Cure	Distilled Water	0,52±0,19^{Aa}	0,53±0,19^{Aa}	0,57±0,14^{Ba}
	Coke	0,58±0,21^{Aa}	0,69±0,19^{Bb}	0,74±0,14^{Cb}
	Turnip Juice	0,50±0,10^{Aa}	0,62±0,13^{Bb}	0,74±0,10^{Cb}
Palfique Estelite Paste	Distilled Water	0,13±0,05^{Aa}	0,14±0,03^{Aa}	0,17±0,05^{Ba}
	Coke	0,12±0,02^{Aa}	0,17±0,04^{Bb}	0,24±0,07^{Cb}
	Turnip Juice	0,16±0,08^{Ab}	0,24±0,11^{Bc}	0,32±0,12^{Cc}
SonicFill 3	Distilled Water	0,19±0,03^{Aa}	0,20±0,05^{Aa}	0,22±0,06^{Aa}
	Coke	0,18±0,05^{Aa}	0,22±0,05^{Ba}	0,25±0,06^{Ca}
	Turnip Juice	0,16±0,02^{Aa}	0,19±0,03^{Ba}	0,22±0,03^{Ca}

* In each column, groups with different uppercase superscripts are significantly different ($p<0.05$).

** In each row, groups with different lowercase superscripts are significantly different ($p<0.05$).

Following the 6-day immersion, distilled water resulted a statistically significant surface roughness increase in all materials ($p<0.05$), except SF3.

Following the all immersion periods, CNDC and CNSC materials have the higher roughness values among the other restoration materials.

At the end of the 6 days, the lowest roughness values were observed for PEP in distilled water (0.17 μm), SF3 in distilled water (0.22 μm), and SF3 in turnip juice (0.22 μm), respectively.

Gloss values of the tested materials were presented in Table 4.

Table 4. Mean and standard deviations of Gloss Units (GU) of restorative materials immersed in various storage solutions at different time periods

Materials	Solutions	Baseline	1 day	6 day
Cention N Dual-Cure	Distilled Water	24,59±7,69^{Aa}	23,95±6,14^{Aa}	20,88±6,60^{Ba}
	Coke	26,76±6,30^{Aa}	23,42±5,71^{Ba}	20,28±4,88^{Ca}
	Turnip Juice	29,53±3,96^{Aa}	26,7±5,73^{Ba}	23,16±4,25^{Ca}
Cention N Self-Cure	Distilled Water	12,62±4,16^{Aa}	12,06±3,87^{Aa}	09,45±3,78^{Ba}
	Coke	19,70±7,32^{Aa}	16,80±5,64^{Ba}	15,30±4,77^{Ba}
	Turnip Juice	16,94±4,32^{Aa}	13,45±4,00^{Ba}	10,43±3,15C^{Ca}
Palfique Estelite Paste	Distilled Water	65,24±11,77^{Aa}	58,11±13,87^{Ba}	48,98±18,24^{Ca}
	Coke	71,80±13,38^{Aa}	58,84±18,82^{Ba}	52,97±18,67^{Ca}
	Turnip Juice	58,22±8,29^{Aa}	57,97±14,05^{Aa}	47,02±11,07^{Ba}
SonicFill 3	Distilled Water	44,74±9,03^{Aa}	43,53±12,05^{Aa}	40,90±12,11^{Aa}
	Coke	34,78±10,91^{Aa}	32,90±7,14^{Aa}	28,93±9,58^{Ba}
	Turnip Juice	37,89±12,18^{Aa}	31,5±10,83^{Ba}	28,84±11,12^{Ca}

* In each column, groups with different uppercase superscripts are significantly different (p<0.05).
** In each row, groups with different lowercase superscripts are significantly different (p<0.05).

The results showed that at the end of the 6-day period, cola and turnip solutions caused a statistically significant decrease in the gloss values of all materials (p<0.05). Distilled water resulted in a statistically significant gloss decrease in all materials (p<0.0001), except SF3.

After 1-day and 6-days immersion period, in CNDC samples, coke and turnip solutions caused statistically similar gloss values (p>0.05). SF3 samples immersed in coke and turnip solutions also showed similar gloss values (p>0.05). PEP material had the highest, CNSC had the lowest gloss values before and after immersion of the solutions among the other materials.

The gloss values of CNDC samples were statistically higher than the CNSC samples after all immersion periods in all solutions (p<0.05).

The gloss values of all materials in the groups that were kept separately for each solution were statistically different from each other at the beginning and at the end of the 6-day waiting period (p<0.05).

As shown in Table 5, the highest color change was obtained in the CNSC samples that were immersed in turnip juice, and the lowest color change was obtained in the SonicFill3 samples that were immersed in distilled water for all periods (p<0.05).

Table 5. The mean and standard deviations of ΔE00 values of restorative materials immersed in various storage solutions at different time periods

Materials	Solutions	ΔE_{001}	ΔE_{002}
Cention N Dual-Cure	Distilled Water	1,24±0,70^{Aa}	1,41±0,72 ^{Aa}
	Coke	1,28±0,87 ^{Aa}	1,84±0,89^{Ba}
	Turnip Juice	3,45±1,19^{Ab}	4,26±1,27 ^{Bb}
Cention N Self-Cure	Distilled Water	1,34±0,56^{Aa}	1,56±1,08^{Aa}
	Coke	4,30±0,62^{Ab}	4,57±1,23^{Ab}
	Turnip Juice	10,07±3,98^{Ac}	11,82±3,41^{Ac}
Palfique Estelite Paste	Distilled Water	1,09±0,98^{Aa}	1,74±0,74^{Ba}
	Coke	2,77±0,71^{Aa}	3,46±0,43^{Bb}
	Turnip Juice	3,07±1,96^{Aa}	3,47±0,85^{Bb}
SonicFill 3	Distilled Water	1,20±0,81^{Aa}	1,71±0,62^{Ba}
	Coke	1,71±0,28^{Ab}	1,87±0,36^{Ab}
	Turnip Juice	1,51±0,68^{Ab}	2,03±1,10^{Bb}

* ΔE001: average color change of samples following 1 day of immersion,
ΔE002: average color change of samples following 6 day of immersion,
** In each column, groups with different uppercase superscripts are significantly different (p<0.05).
*** In each row, groups with different lowercase superscripts are significantly different (p<0.05).

The color change values of all materials immersed in coke and turnip juice were significantly higher than the color change values of those immersed in distilled water (p=0.0001).

After both of the immersion periods, in SF3 samples, coke and turnip solutions caused statistically similar color change values (p>0.05). PEP samples immersed in coke and turnip solutions also showed similar color change values (p>0.05). After 6-days immersion period, rate of color change in PEP samples immersed in these solutions is statistically higher than that in SF3 material (Coke: p= 0.002; Turnip juice: p= 0.018).

After both of the immersion periods, statistically similar color changes were observed in CNDC and CNSC materials stored in distilled water (1-day period: p=0.565; 6-day period: p=0.949). Statistically, more color change was observed in CNSC material kept in coke and turnip compared to CNDC (p<0.05). At the end of the 6-day period, turnip solution caused statistically more discoloration than coke for both dual-cure (p=0.003) and self-cure (p=0.002) Cention N materials.

DISCUSSION

Regardless of the material utilized in dentistry, restorations have a finite lifespan. Once the initial restoration is performed on a tooth, a death spiral commences, because of the need for larger cavities in repeated restorations. This cycle progresses from endodontic treatments and ultimately ends with tooth extraction (Schwendicke et al., 2018). Therefore, it can be asserted that the life span of a tooth is essentially determined by the clinical longevity of the restoration. The main reasons for failure and replacement of composite restorations are secondary caries and discolorations which are the outcomes of increased surface roughness due to chemical, physical and mechanical dynamics in the oral environment (Alshehri et al., 2022). Each material exhibits a unique response to these parameters.

In this study, the acidic beverages, coke (pH: 2.5) and turnip juice (pH: 3.3-3.8), increased the surface roughness and decreased gloss of all tested materials, which was statistically significant (p<0.05). It was observed that all materials kept in both two solutions had discolorations. According to the Paravina et al, (2015), after aging and staining procedures, color stability should be assessed based on a 50:50% acceptability threshold, which was ΔE00=1.8. After 6-day, in all samples except those kept in distilled water, color changes exceed the acceptable threshold value (ΔE00=1.8). The null hypothesis asserting that various beverages do not influence the color stability, surface roughness, and gloss retention of restorative materials was rejected.

Acidic beverages with a low pH can produce erosive wear by softening the restorative material surface (Isabel et al., 2016). According to Borges et al, (2019), high acidity causes degradation in the organic matrix, which leads to the deterioration of the bond between the filler and the silane, thus the leaching of inorganic particles. In this case, the roughness on the softened and worn surface increases. It was stated that there may be a relationship between surface roughness parameter and gloss values or color stability (Dietschi et al, 1994;

Nasim et al., 2010; Hasoya et al., 2011; Ghinea et al., 2011). Increased surface roughness increases plaque and stain retention, and also increases the degree of diffuse reflection of light which causes gloss decrease (Hasoya et al., 2011; Bitencourt et al., 2020; Papathanasiou et al., 2022). Previous studies conducted with resin-based materials, it was observed that gloss values decreased and discoloration occurred in materials with increased surface roughness, similar to our findings (Lu et al., 2005; Reddy et al., 2013; Tavangar et al., 2018; Papathanasiou et al., 2022, Rohym et al., 2023). On the other hand, although the pH value of turnip juice is higher than coke, the staining it caused in Cention N materials was more than the coke solution. The color of the turnip juice comes from its purple carrot content which is rich in red anthocyanin pigment, like red wine (Toktaş, 2016). Manojlovic et al, (2015) conducted a study examining the relationship between the reflection spectra and the color change in the composite when it was immersed in various solutions with different absorption spectra. As a result of the study, the significant difference between the diffuse reflection spectra of the stained and baseline samples was observed for the anthocyanin containing red wine solution, but no significant changes in the reflection spectra with coke or distilled water. In parallel with this, the color change was significant in the composites immersed in red wine, and it was negligible in the sulfite ammonia caramel-containing coke group. The variations in color changes produced by the solutions in our research may be attributed to the diffuse reflection spectra generated in the materials, as indicated in the previous study.

According to results in this study, the highest roughness and lowest gloss values were obtained in dual-cure and self-cure Cention N samples before and after immersion in solutions. Surface roughness properties of resin-based restorative materials are dependent on size, geometry, distribution and amount of filler particles (Marghalani et al., 2010; Lepri et al., 2012). Marghalani et al, (2010) stated that inorganic fillers with spherical shapes and small particle sizes provide a smoother surface in the composite than those with irregular shapes and large sizes. In a previous study (Daabash et al., 2023), similar to our study, the roughness values of Cention N materials were higher than other resin composite material. This may be associated with the fact that Cention N contains larger-sized (0.1 – 35µm) inorganic particles than other materials (Ilie, 2018). On the other hand, in the previous study, the Cention N material was prepared by hand-mixing the powder and liquid as in our study. The authors stated the bubbles generated by this process may potentially contribute to the higher roughness values (Daabash et al., 2023).

In our study, the self-cure and dual-cure Cention N materials exhibited comparable roughness values; however, the most significant color change was observed in the self-cure Cention N samples. According to Dietschi et al., (1994), the susceptibility to stain in a resin-based material is influenced by monomer conversion rate, chemical properties, and water sorption rate. In our study, the less color change in dual-cure Cention N than in self-cure Cention N may be related to the high degree of monomer conversion with the light curing, thus providing less water absorption.

Bollen et al., (1997) stated that surface roughness above 0.2 µm increase the bacteria accumulation on the composite surfaces. The baseline roughness levels of Palfique Estelite and SonicFill 3 were below 0.2 µm, whereas the baseline roughness values of Cention N exceed this threshold. In addition, when the baseline roughness values were examined, it was seen that Palfique Estelite has the smoothest surface. This might be associated with the fact that although it has larger particle sizes (0.1-0.3 µm) than SonicFill 3 (40 nm-10 µm), the spherical form of the particles provides better polishability. However, after 6 days of immersion in the solutions, the greatest increase in roughness occurred in Palfique Estelite, and the color change was significantly greater than that in SonicFill 3. The organic resin matrix significantly influences the surface degradation characteristics and staining properties of materials due to its propensity for water sorption (Ertaş et al., 2006; Lepri et al., 2012). The organic matrix content of resin composites mainly consists of monomers such as bisphenol A glycidyl dimethacrylate (Bis-GMA), triethylene glycol dimethacrylate (TEGDMA), and urethane dimethacrylate (UDMA) (Wang et al., 2018). Among these, TEGDMA has the highest tendency to water uptake, while UDMA has the lowest (Sideridou et al., 2003). Additionally, many different monomers with different water sorption or polymerization kinetics are available in more recent restorative materials. Such as ethoxylated bisphenol-A-glycidyl methacrylate (Bis-EMA), ethoxylated bisphenol-A dimethacrylate (EBPDMA) which are more hydrophobic monomers than Bis-GMA (Sideridou et al., 2003; Ling et al, 2009). The lesser degree of roughness and color alterations in SonicFill 3, composed of organic components Bis-GMA, Bis-EMA, TEG-DMA, and EBPDMA, compared to Palfique Estelite, which contains Bis-GMA and TEGDMA, may be attributed to the disparity in water absorption among these monomers.

CONCLUSION

SonicFill3 demonstrated superior performance in surface roughness, gloss, and color stability among various restoration materials stored in different solutions. Differences in organic and inorganic compositions in materials may lead to different clinical results.

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Conflict of Interest

The authors affirm that they have no conflicts of interest relevant to this article.

REFERENCES

1. Alshehri A, Alhalabi F, Mustafa M, Awad MM, Alqhtani M, Almutairi M, Alshabib A. Effects of accelerated aging on color stability and surface roughness of a biomimetic composite: an in vitro study. Biomimetics. 2022;7(4):158.
2. Ardu S, R I. Resin composite thickness' influence on L* a* b* coordinates and translucency. Clin. Oral. Investig. 2019;23:1583-1586.
3. Bitencourt SB, Catanoze IA, da Silva EVF, Dos Santos PH, Dos Santos DM, Turcio KHL, Guiotti AM. Effect of acidic beverages on surface roughness and color stability of artificial teeth and acrylic resin. J. Adv. Prosthodont. 2020;12(2):55.
4. Bollen CM, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dent. Mater. 1997;13(4):258-269.
5. Borges MG, Soares CJ, Maia TS, et al. Effect of acidic drinks on shade matching, surface topography, and mechanical properties of conventional and bulk-fill composite resins. J. Prosthet. Dent. 2019;121(5):868. e1.
6. Chen MH. Update on dental nanocomposites. J. Dent. Res. 2010;89(6):549-560.
7. Cidreira Boaro LC, Pereira Lopes D, de Souza ASC, Lie Nakano E, Ayala Perez MD, Pfeifer CS, Gonçalves F. Clinical performance and chemical-physical properties of bulk fill composites resin—A systematic review and meta-analysis. Dent. Mater. 2019;35
8. Daabash R, Alqahtani MQ, Price RB, Alshabib A, Niazy A, Alshaafi MM. Surface properties and Streptococcus mutans biofilm adhesion of ion-releasing resin-based composite materials. J. Dent. 2023;134:104549.
9. Dietschi D, Campanile G, Holz J, Meyer JM. Comparison of the color stability of ten new-generation composites: an in vitro study. Dent. Mater. 1994;10:353-362.
10. Duc O, Di Bella E. Staining susceptibility of resin composite materials. Am. J. Dent. 2019;32:39-42.
11. Elfakhri F, Alkahtani R, Li C, Khaliq J. Influence of filler characteristics on the performance of dental composites: a comprehensive review. Ceram. Int. 2022;48(19):27280-27294.
12. Ereifej NS. The effect of polishing technique on 3-D surface roughness and gloss of dental restorative resin composites. Oper. Dent. 2012;38(1)
13. Ertas E, Gueler AU, Yuecel AC, Koepruelue H, Gueler E. Color stability of resin composites after immersion in different drinks. Dent Mater J. 2006;25(2):371-376.
14. Ferracane JL. Resin composite—State of the art. Dent. Mater. 2011;27(1):29-38.
15. François P, Remadi A, Le Goff S, Abdel-Gawad S, Attal JP, Dursun E. Flexural properties and dentin adhesion in recently developed self-adhesive bulk-fill materials. J. Oral Sci. 2021;63(2):139-144.
16. Ghinea R, Ugarte-Alvan L, Yebra A, Pecho OE, Paravina RD, Perez MDM. Influence of surface roughness on the color of dental-resin composites. J. Zhejiang Univ. Sci. B. 2011;12:552-562.
17. Hosoya Y, Shiraishi T, Odatsu T, et al. Effects of polishing on surface roughness, gloss, and color of resin composites. J. Oral Sci. 2011;53(3):283-291.
18. Ilie N. Comparative effect of self-or dual-curing on polymerization kinetics and mechanical properties in a novel, dental-resin-based composite with alkaline filler. Materials. 2018;11(1):108.
19. Isabel CAC, Dominguette AAS, Santos SGD, Ribeiro JCR, MoysÉs MR. Surface roughness of a resin composite. RGO Rev. Gaucha. Odontol. 2016;64(1):50-55.
20. Kerr Dental. SonicFill 3 Singlefill Composite System. Kerr Dental. Accessed October 16, 2024. https://www.kerrdental.com/kerr-estoratives/sonicfill-3-singlefill-composite-system.
21. Lepri CP, Palma-Dibb RG. Surface roughness and color change of a composite: influence of beverages and brushing. Dent. Mater. J. 2012;31(4):689-696.
22. Ling L, Xu X, Choi GY, Billodeaux D, Guo G, Diwan RM. Novel F-releasing composite with improved mechanical properties. J. Dent. Res. 2009;88(1):83-88.
23. Lu H, Roeder LB, Lei LEI, Powers JM. Effect of surface roughness on stain resistance of dental resin composites. J. Esthet. Restor. Dent. 2005;17(2):102-108.
24. Manojlovic D, Lenhardt L, Milićević B, Antonov M, Miletic V, Dramićanin MD. Evaluation of staining-dependent colour changes in resin composites using principal component analysis. Sci. Rep. 2015;5(1):14638.
25. Marghalani HY. Effect of filler particles on surface roughness of experimental composite series. J. Appl. Oral Sci. 2010;18:59-67.
26. Miletic V, ed. Dental Composite Materials for Direct Restorations. Cham, Switzerland: Springer International Publishing; 2018.
27. Nasim I, Neelakantan P, Sujeer R, Subbarao CV. Color stability of microfilled, microhybrid and nanocomposite resins—an in vitro study. J. Dent. 2010;38
28. Opdam NJ, Bronkhorst EM, Roeters JM, Loomans BA. A retrospective clinical study on longevity of posterior composite and amalgam restorations. Dent. Mater. 2007;23:2-8.
29. Papathanasiou I, Papavasiliou G, Kamposiora P, Zoidis P. Effect of staining solutions on color stability, gloss and surface roughness of removable partial dental prosthetic polymers. J. Prosthodont. 2022;31(1):65-71.
30. Paravina RD, Ghinea R, Herrera LJ, et al. Color difference thresholds in dentistry. J. Esthet. Restor. Dent. 2015;27(Suppl 1)
31. Reddy PS, Tejaswi KS, Shetty S, et al. Effects of commonly consumed beverages on surface roughness and color stability of the nano, microhybrid and hybrid composite resins: an in vitro study. J. Contemp. Dent. Pract. 2013;14(4):718.
32. Rohym S, Tawfeek HEM, Kamh R. Effect of coffee on color stability and surface roughness of newly introduced single shade resin composite materials. BMC Oral Health. 2023;23(1):236.
33. Schwendicke F, Lamont T, Innes N. Removing or controlling? How caries management impacts on the lifetime of teeth. In: Caries Excavation: Evolution of Treating Cavitated Carious Lesions. Vol 27. Karger Publishers; 2018:32-41.

34. Sideridou I, Tserki V, Papanastasiou G. Study of water sorption, solubility and modulus of elasticity of light-cured dimethacrylate-based dental resins. Biomaterials. 2003;24(4):655-665. doi:10.1016/s0142-9612(02)00380-0.
35. Tavangar M, Bagheri R, Kwon TY, Mese A, Manton DJ. Influence of beverages and surface roughness on the color change of resin composites. J. Investig. Clin. Dent. 2018;9(3)
36. Toktaş B. Şalgam suyu fermentasyonunun fenolik madde ve antosiyanin içeriği, antioksidan kapasitesi ve in vitro biyoyararlılık üzerine ekisi [doctoral dissertation]. Fen Bilimleri Enstitüsü; 2016.
37. Vallittu PK, Boccaccini AR, Hupa L, Watts DC. Bioactive dental materials: do they exist and what does bioactivity mean? Dent. Mater. 2018;34(5):693-694.
38. Van Ende A, De Munck J, Lise DP, Van Meerbeek B. Bulk-fill composites: a review of the current literature. J. Adhes. Dent. 2017;19(2):95-109.
39. Wang X, Huyang G, Palagummi SV, et al. High performance dental resin composites with hydrolytically stable monomers. Dent. Mater. 2018;34(2):228-237