STOMATOLOGY EDU JOURNAL stomaedu

EFFECTS OF ACIDIC/ALCOHOLIC BEVERAGES ON THE SURFACE ROUGHNESS OF COMPOSITE RESINS LIGHT-CURED FOR TWO DIFFERENT PERIODS OF TIME

Günçe Ozan[1a], Meltem Mert Eren[2b], Sevda Ozel Yildiz[3a], Hande Şar Sancakli[1c*], Esra Yildiz[1d]

[1]Department of Restorative Dentistry Faculty of Dentistry, Istanbul University, TR-34390 Fatih / Istanbul, Turkey
[2]Department of Restorative Dentistry, Faculty of Dentistry, Altınbaş University, TR-34218 Bakirkoy / İstanbul, Turkey
[3]Department of Biostatistics, Faculty of Medicine, Istanbul University, TR-34093 Fatih / Istanbul, Turkey

[a]DDS, PhD, Research Assistant
[b]DDS, PhD, Assistant Professor
[c]DDS, PhD, Associate Professor
[d]DDS, PhD, Professor

ABSTRACT

DOI: https://doi.org/10.25241/stomaeduj.2019.6(4).art.1

Introduction: The purpose of this study was to evaluate the surface roughness values of various resin-based composites (RBC) regarding exposure time and immersion in alcoholic and acidic beverages.
Methodology: A total of 240 disc-shaped specimens (8 mm x 2 mm) were prepared from two microhybrid, one nanofilled and one nanohybrid RBC. Specimens were divided into two groups, according to the exposure time; 20 or 40 seconds and immersed for 10 min/day during one month in either non-alcoholic (Coca Cola), alcoholic (red wine) beverages, or distilled water (n=10). Surface roughness was measured after 24 hours, one week, and one month. Results were analyzed statistically using parametric and nonparametric test.
Results: The roughness values (Ra) measured at 1-month immersion were significantly higher than those measured at 24 hours. There was no statistically significant difference due to exposure time (20 or 40 seconds) ($p>0.05$). Structure of RBC and presence of alcohol and phosphoric acid in the immersion solutions caused a statistically significant difference among baseline and 1-month immersion intervals ($p<0.05$). Among all RBCs, lowest Ra was observed in the microhybrid RBC Charisma Classic group.
Conclusion: Immersion in both acidic and alcoholic beverages altered the surfaces of all RBCs and generated significant surface roughness changes. All analyzed RBCs showed unacceptable changes in surface roughness.
Keywords: Resin-based composites; Exposure time; Surface roughness; Aging.

Peer-Reviewed Article

Citation: Ozan G, Mert Eren M, Ozel Yildiz S, Şar Sancakli H, Yildiz E. Effect of acidic/alcoholic beverages on the surface roughness of composite resins light-cured in different times. Stoma Edu J. 2019;6(4):221-229

Received: October 11, 2019
Revised: November 04, 2019
Accepted: November 18, 2019
Published: December 10, 2019

***Corresponding author:**
Associate Professor Dr. Hande ŞAR SANCAKLI, Department of Restorative Dentistry Faculty of Dentistry Istanbul University
Millet St. 4th Floor TR-34093 Capa, Istanbul Turkey
Tel/Fax: +902124142020 / 30369
e-mail: handesar@hotmail.com

1. Introduction

Resin-based composits (RBC) are successfully used for the direct restoration of anterior and posterior teeth due to their simplified adhesive protocols, improved esthetic and adequate physical properties. Moreover, patients' priorities have shifted to highly esthetic restorations in both the anterior and posterior region. Considering that the posterior region has its own characteristics regarding the masticatory loads, chewing forces and possible parafunctional habits, RBCs challenge certain shortcuts when used in the posterior region. However, with the highlighted improvements in resin and filler technology, various types of RBCs have become available allowing for a clinically successful placement also in the posterior areas [1,2].

The mostly used RBC categories placed in the posterior areas include microhybrid [3], nanohybrid [4] and nano [5] RBCs [4]. To increase the esthetic aspect, progressively smaller particles have been incorporated in the monomer matrix leading to higher surface quality and superior polish retention [4,8], associated with low wear rates and increased wear resistance. Besides the filler, the degree of cure of the monomer matrix may also affect the polish ability of a RBC [9]. Under ideal polymerization conditions, less residual monomers are evidenced and consequently a lower monomer release.

On the contrary, monomers that were not involved in the polymerization reactions are able to alter the restorative material, due to a softening effect of the polymer matrix, thus making the RBC prone to wear and negatively affecting the surface qualities. Therefore, the curing units used for polymerization as well the exposure time and distance may have a direct effect on the properties of the RBCs and their surface. Apart from an improvement in the filler system, modifications in the chemical composition of the monomer system are identified as well in modern RBCs. Besides traditional monomers such

Table 1. Composition of the analyzed RBCs.

Name	Brand	Type	Shade	Lot/Ref. Number	Content
Aelite Aesthetic Enamel	Bisco	Nanohybrid	A2	H-852A2	Bis-EMA, TEGDMA, Bis-GMA, Glass filler, silica-glass filers (0.04 – 5.0µm) (73 wt%)
Filtek Ultimate Body	3M	Nanofilled	A2	N441522	Bis-GMA, UDMA, Bis-EMA, TEGMA, silica filler (20 nm), non-agglomerated/ non-aggragated zirconia filler (4-11 nm) and aggragated zirconia/silica cluster filler (0.6-10 µm) (78.5 wt%, 63.3 vol%)
G-aenial	GC	Microhybrid	A2	1405161	UDMA, prepolymerized fillers containing strontium and lanthan, prepolymerized fillers containing silica (16-17 µm), pyrogenic silica (< 100 nm) (81 wt%)
Charisma Classic	Kulzer	Microhybrid	A2	010718A	Bis-GMA, TEGMA, Ba-Al-B-F-Si-Glass fillers (0.7-2 µm), pyrogenic silica (0.01-0.07 µm) (78 wt%, 68 vol%)

Abbreviations: Bis-GMA = Bisphenol A glycidylmethacrylate ; UDMA = Urethane-dimethacrylate; TEGDMA = Triethylene glycol dimethacrylate ; Bis-EMA = Ethoxylated bisphenol A dimethacrylate.

Table 2. Properties of the beverages used in the study.

Brand	pH
Red wine Villa Doluca (14% alcohol)	3.72
Coca Cola Coca-Cola Company	2.5

as Bisphenol A glycidylmethacrylate (Bis-GMA), Urethane-dimethacrylate (UDMA), or Triethylene glycol dimethacrylate (TEGDMA), novel monomers such as modified aromatic (AUDMA = aromatic urethane dimethacrylate) and aliphatic (Bis-EMA = ethoxylated bisphenol A glycol dimethacrylate) methacrylates have been included in organic matrices [10,11] to reduce viscosity [11], water sorption, and solubility [10], thus preventing resin matrices from being softened and degraded [5]. Apart from the content of the resins, the surfaces of RBCs are expected to degrade according to the dynamics of the oral environment [12]. Excessive surface degradation by means of oral conditions may not only lower the physical properties of RBCs but also cause plaque accumulation, discoloration, and secondary caries [13]. Therefore, maintaining a smooth surface is important to the long-term success of restorations. Consuming certain types of beverages may change the surface texture of RBC restorations. The chemical properties of beverages, such as their acidity, may affect the surface properties leading to wear, softening, severe degradation, and staining [14]. Likewise, ethanol (present in alcoholic beverages) has the potential to plasticize the organic matrix of RBCs, thus lowering the physical and mechanical properties [15]. Thus, the effects of alcoholic and acidic beverages on the surface properties of RBCs need to be analyzed. The purpose of this study was to evaluate the surface roughness values of various RBCs as a function of the exposure time and the immersion in alcoholic and acidic beverages.

The null hypotheses were that (1) the exposure time would not affect the surface roughness of the various analyzed RBCs and (2) the analyzed RBCs would have similar surface properties after exposure to alcoholic and acidic beverages.

2. Materials and methods

240 disc-shaped samples (8 mm in diameter and 2 mm in thickness) from four RBCs were prepared with a custom made stainless steel mold: the microhybrid Charisma Classic (Kulzer, Wehrheim, Germany), the microhybrid G-eanial (GC, Tokyo, Japan), the nanohybrid Aelite Aesthetic Enamel (BISCO Dental Products, Schaumburg, IL, USA) and the nanofilled RBC Filtek Ultimate (3M, St. Paul, MN, USA). The composition of the materials is shown in Table 1.

2.1. Specimen Preparation

Specimens were prepared by inserting materials in one increment into a mold and placing a glass plate on the top and bottom of the mold, with a Mylar strip in between. A constant pressure (with 1 kg weight) was applied on the glass plate for 15 seconds to allow the excess material to escape, thus obtaining a flat specimen surface without bubbles. Sixty specimens were prepared for each of the four RBCs. After removal of the weight and the glass plate, the specimens were polymerized with a LED (Light Emitted Diode) LCU (Light curing unit, SmartLite Max, Dentsply, Pennsylvania, USA, 1600 mW/cm^2) for 20 seconds and 40 seconds. The LCU's tip was positioned perpendicularly to specimens' surfaces and the distance between the tip and specimen was standardized using a glass microscope slide (1 mm thickness).

All specimens were stored in distilled water at 37±1°C for 24 hours to allow for post-polymerization. The top surface of each specimen was polished with flexible aluminum oxide discs (Sof-Lex; 3M) under running water for 30 seconds. Polishing was performed by one operator to eliminate operator-dependent variability, and the discs were renewed after their 5th use.

2.2. Exposure to alcoholic and acidic beverages

Specimens from each group (n = 10) were stored for 10 min/day during one month in one of the following media: alcoholic (red wine-RW), acidic non-alcoholic (Coca Cola-CC), and distilled water (DW) as control (Table 2). All of the beverages were used at room temperature and were renewed during every period. The specimens were kept immersed in distilled water at 37±1°C between cycles.

2.3. Surface Roughness Measurements

The roughness values for each specimen were measured with three consecutive readings, and mean Ra values were calculated. Before the measurement, the top surface of each specimen was blotted dry using tissue paper, and the contact guide of a surface profilometer (Taylor Hobson Surtronic 3+, Taylor Hubson, Leicester, UK) was positioned at the center of the specimen surface. The profilometer, which was calibrated against a standard after each measurement, was set to a cutoff value of 0.8 mm, a transverse length of 0.8 mm and a stylus speed of 0.1 mm/s. Measurements were taken directly after polishing the specimens (baseline) as well as after one week and one month.

2.4. Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) for Windows 21.0. The normal distribution of the values was verified by Shapiro-Wilks tests. Acording to data distribution, both parametric (repeated measures) and non-parametric (Friedmann) tests were used for statistical analysis. A percentage roughness increase (%) after one month of immersion was calculated using following formula:

Percentage roughness increase =
(R - one month a – R-Baseline a)/ R-Baseline a

With a = exposure time (20 or 40 seconds);
R = Roughness,
p values less than 0.05 were considered statistically significant.

3. Results

The mean values of the surface roughness (Ra) of the RBCs cured for 20 or 40 seconds and immersed in varied beverages are shown in Table 3.

3.1. Comparisons of alterations in Ra values of RBCs by time and beverages.

Table 3 shows that the groups exhibit higher roughness values (Ra) after one week immersion compared to the baseline, except for the nanohybrid RBC (Aelite - 20 seconds polymerization) immersed in distilled water and the microhybrid RBC (Charisma Classic - 40 seconds polymerization) immersed in red wine. The mentioned specimens of the nanohybrid RBC show no surface roughness change during storage, and the microhybrid specimens showed smoother surfaces after one - week of immersion in red wine.

Regarding the one month results, except for the groups microhybrid (G-aenial - 20 seconds polymerization), microhybrid (Charisma Classic - 40 seconds polymerization) and nanohybrid (Aelite - 20 seconds polymerization) RBCs, all other groups exhibit highest roughness (Ra) values. Microhybrid (G-aenial) specimens immersed in distilled water showed no changes in surface roughness and microhybrid specimens had a slightly rougher surface after one month immersion in distilled water. Microhybrid specimens immersed in red wine had higher roughness values compared to the one week evaluation, but still showed better surfaces than the baseline. In addition, regarding the change of Ra values of the RBCs overall, there are no statistically significant differences between 20 or 40 seconds of

Original Articles

Table 3. Mean and standard deviations of Ra values of all RBCs polymerized with different curing times and immersed in various beverages*.

		20 seconds polymerization				40 seconds polymerization	
		Base	**1-week**	**1-month**	**Base**	**1-week**	**1-month**
Coca Cola (CC)	Bisco	0.28±0.05^{a}	0.34±0.05^{b}	0.38±0.06^{c}	0.38±0.13^{A}	0.48±0.09^{B}	0.62±0.14^{B}
	3M	0.42±0.11^{a}	0.48±0.13^{b}	0.64±0.14^{c}	0.41±0.20^{A}	0.57±0.16^{B}	0.72±0.19^{B}
	GC	0.53±0.20^{a}	0.61±0.17^{a}	0.73±0.26^{b}	0.43±0.07^{A}	0.50±0.08^{B}	0.57±0.08^{C}
	Kulzer	0.33±0.03^{a}	0.36±0.03^{b}	0.44±0.09^{c}	0.29±0.04^{A}	0.33±0.02^{A}	0.44±0.21^{B}
Red Wine (RW)	Bisco	0.44±0.11^{a}	0.52±0.12^{b}	0.68±0.21^{c}	0.38±0.07^{A}	0.47±0.13^{B}	0.58±0.18^{B}
	3M	0.43±0.09^{a}	0.50±0.08^{a}	0.58±0.06^{b}	0.26±0.09^{A}	0.35±0.09^{B}	0.45±0.11^{C}
	GC	0.54±0.12^{a}	0.64±0.09^{a}	0.87±0.23^{b}	0.51±0.13^{A}	0.63±0.10^{A}	0.73±0.15^{B}
	Kulzer	0.31±0.09^{a}	0.35±0.10^{a}	0.45±0.17^{b}	0.39±0.08^{A}	0.28±0.04^{B}	0.36±0.08^{A}
Distilled Water (DW)	Bisco	0.56±0.18^{a}	0.56±0.18^{a}	0.57±0.18	0.62±0.38^{A}	0.64±0.37^{B}	0.66±0.36^{C}
	3M	0.32±0.14^{a}	0.35±0.13^{a}	0.38±0.10^{b}	0.39±0.26^{A}	0.41±0.26^{A}	0.44±0.25^{B}
	GC	0.48±0.19^{a}	0.49±0.18^{b}	0.48±0.19^{c}	0.46±0.14^{A}	0.47±0.14^{B}	0.50±0.14^{C}
	Kulzer	0.37±0.07^{a}	0.38±0.07^{a}	0.40±0.08^{b}	0.35±0.08^{A}	0.37±0.08^{A}	0.38±0.08^{B}

**Different letters in the same line show statististically significant difference (p<0.05). Groups polymerized for 40* seconds *showed in capital letters and groups polymerized for 20* seconds *showed in lower cases.*

curing ($p>0.05$). Statistically significant differences between Ra values measured after one month immersion in different beverages are shown in Table 4 and Table 5. The tables indicated that the RBCs cured for 20 seconds and immersed in Coca Cola exhibit all statistical similar roughness. Likewise, specimens of the microhybrid RBC (Charisma Classic – 40 seconds polymerization) immersed in red wine had statistically significant lower roughness change than the nanofilled (Filtek Ultimate) and the nanohybrid RBCs (Aelite). After immesion in distilled water, specimens of microhybrid RBC (G-aenial) had hardly changed their surface roughness values. Therefore, specimens of microhybrid (Charisma Classic) and nanofilled (Filtek Ultimate) RBCs showed statistically higher roughness than the microhybrid RBC (G-aenial). All of the RBC were affected by immersion in distilled water but the specimens had statistically significant lower roughness changes compared to immersion in Coca Cola and red wine.

4. Discussion

The surface quality of the RBC materials is dependent on the physical characteristics of the materials as well as the techniques used for finishing and polishing them. The application of nanotechnology in dental materials enables the incorporation of smaller particles with increased filler loading and results in lower polymerization shrinkage and better physical and mechanical properties [4]. The polishability is also correlated, besides filler, to the polymerization quality [9]. The parameters affecting the quality of curing, such as the exposure time, the exposure distance or the curing characteristics of the used curing unit (radiant emittance, spectral distribution etc) may directly be related to the polishing ability. The effects of the polishing systems on the surface quality has already been analysed [7,18,19], however without involving the exposure time. Prolonged curing time may increase the degree of conversion, lower the residual monomers and improving thus the surface quality of RBCs [20]. In order to obtain sufficient curing, the type of the curing unit used, either LED or QTH (Quartz Tungsten Halogen), was proved to have no direct influence on the surface roughness of the RBCs [16]. This must also be the case for the curing conditions in the present study, since no significant difference in surface roughness was identified in any of the analysed materials when increasing the exposure time from 20 seconds to 40 seconds. Therefore, the first null hypothesis is accepted. Regardless of the curing time, the various types of RBCs analyzed in the present study reacted differently to storage in beverages with regard to their surface quality. This confirms the results of previous studies published for the same materials [16]. The RBCs tested in the present study were selected due to their specific filler properties. Regarding the differences in the filler content and size of the RBC that affect the physical characteristics, polymerization quality and surface roughness values were assumed to be different. Moreover, microfilled RBCs have adequate polishability, thus they could mimic the surface smoothess of enamel greatly. However, these types of RBCs had lower mechanical strength, so they are recommended for low-stress regions [3]. On the contrary, microhybrid RBCs had higher mechanical

Table 4. Roughness increase (%) and significance of RBCs cured for 20 seconds after one month immersion in different beverages*.

	Charisma Classic (Microhybrid)	Filtek Ultimate (Nanofilled)	G-aenial (Microhybrid)	Aelite (Nanohybrid)
	20 seconds of curing	20 seconds of curing	20 seconds of curing	20 seconds of curing
Coca Cola	33.3 A,a	52.4C,a	32.5D,a	35.7F,a
Red Wine	45.1A,b	34.9C,b	61.1D,b	54.4F,b
Distilled Water	8.1B,c	18.7C,c	0E,d	1.8G,c,d

**Different uppercase letters in each RBC column indicate a statistically significant difference between the roughness values caused by beverages. Different lowercase letters in the rows indicate a statistically significant difference between the RBCs (p<0.05).*

strength but lower polishability [19]. Apart for the above mentioned RBC categories, nano RBCs could be developed with not only excellent polishability but also with better mechanical and physical properties, including resistance to different media. This general remarks stay in contradiction to the results of the present study, since the analyzed microhybrid RBC, Charisma Classic, showed smoother, while the nanohybrid RBC rougher surfaces. Thus, the second hypothesis was rejected. The present study was intended to ensure standardization by selecting the ideal pair of materials and methods. For instance, the size of specimens was designated with a diameter of 8 mm to match the tip of the curing unit to use the light-curing unit only once and eliminate the tip location from being a polymerization variable. All of the RBCs were chosen in the same shade to avoid different curing time requirement. Varying particle sizes were also enrolled to evaluate the differet resistance and responses to acidic/alcoholic beverages effects in terms of surface roughness. Physical, thermal and chemical factors in the oral environment play fundamental roles in the degradation process of RBC surfaces. The influence of these processes reflects a change in the surface roughness values [21]. In the present study, lower Ra values were reached not only by aging specimens in acidic and alcoholic beverages but also in distilled water. According to the results, all of the groups and subgroups were similarly affected by distilled water. Exposure to water could result in the hydrolytic degradation of fillers' silane coating, loss of chemical bonding between fillers and plasticizing and swelling of resin matrices [22,23]. Consequently, fillers may be pulled out from the specimen's surface after the organic matrix absorbs water, which could increase the surface roughness [23]. In this context, RBCs containing TEGDMA, a hydrophilic monomer, are more susceptible to water degradation following water uptake [24]. In the present study, all of the RBCs except the microhybrid (G-aenial contain TEGDMA in their organic matrix. The RBC G-eanial is advertised as a microfilled RBC, but according to its particle sizes, it needs to be classified as a microhybrid RBC. In the present study it showed the significantly lowest surface changes among the analysed RBCs when cured for 20 seconds (Table 4). Evaluating the acidic (CC) and alcoholic (RW) beverages, the ethanol concentration of red wine and the phosphoric acid in Coca Cola may lead to surface degradation. Additionally, ethanol could penetrate the organic matrix, alter the polymeric structure [12], and eventually affect the mechanical and physical properties of the RBCs. The effects of ethanol are thought to be more significant than the prolonged exposure to water [25]. In the present study, there is no significant difference among RBCs cured for 20 seconds. However, after 40 seconds of curing, the nanofilled and nanohybrid RBCs showed significantly rougher surfaces than the microhybrid RBCs. This could be attributed to the higher amount (68 vol%) of smaller fillers (0.01-0.07 μm) in the microhybrid RBC. The present data confirmed thus the study of Tantanuch et al [23] which found out that nanofilled RBCs showed better surface properties than nanohybrid RBCs after being immersed in red wine.Furthermore, the acidity of the immersing solution may have a direct effect on softening resin matrices, allowing filler to be pull-out and creating thus voids over the surface, that may enhance roughness [23]. Red wine contains not only ethanol but may also act as an acidic solution. Both analysed beverages are characterized by a low pH; however, in the present study, regardless of the curing time, there were not statistically significant differences between the roughness values of RBCs after immersion in Coca Cola and red wine. On the other hand, Ra scores above 0.2 μm have been reported to increase the biofilm formation [26]. Ra values higher than 0.3 μm can be physically perceived by patients, which could lead to patient's dissatisfaction and an extra clinic sessions for polishing the restoration's surface [27]. Although all of the specimens were polished with discs (Sof-Lex), described as one of the best protocols to create low roughness scores in resin materials [28], even at the baseline results, all of the RBCs

Original Articles

Table 5. Roughness increase (%) and significance of 40 seconds cured RBCs after one month immersion in different beverages*.

	Charisma Classic (Microhybrid)	Filtek Ultimate (Nanofilled)	G-aenial (Microhybrid)	Aelite (Nanohybrid)
	40 seconds of curing	40 seconds of curing	40 seconds of curing	40 seconds of curing
Coca Cola	$51.2^{A,a}$	$75.6^{B,a}$	$37.8^{D,a}$	$63.1^{F,a}$
Red Wine	$-7.8^{A,b}$	$73.1^{B,c}$	$43.1^{D,b,c}$	$52{,}6^{F,c}$
Distilled Water	$8.6^{A,d}$	$12.8^{C,d}$	$8.7^{E,d}$	$6.4^{G,d}$

**Different uppercase letters in each RBC column indicate a statistically significant difference between the roughness values caused by beverages. Different lowercase letters in the rows indicate a statistically significant difference between the RBCs (p<0.05).*

showed surface roughness values higher as the mentioned thresholds. The possible reasons could be related to the inner characteristics, such as polishing responses of the materials. RBCs made of finer filler particles exhibit lower interspacing, less filler pullout and thus, smoother surfaces [29]. Research has shown that nanohybrid RBCs in particular create smaller voids after finishing and polishing procedures [23,29]. However, in the present study, the specimens cured for 40 seconds consisting of a nanofilled (Filtek Ultimate) and a nanohybrid (Aelite Aesthetic Enamel) RBC showed statistically significant rougher surfaces than the microhybrid RBC (Charisma Classic) after immersion in all beverages. Moreover, after 20 seconds curing and immersion in red wine, Charisma Classic showed smoother surfaces as compared to the nano-RBCs. These results could be attributed to the type, size, number and distribution of fillers, which all have a significant impact on the mechanical and physical characteristics of the RBCs [29]. There is clear evidence that the size and irregularity of fillers is directly proportional to the surface roughness of a RBC [30]. Smaller fillers were thought to be less prominent on the surface; thus, they were more resistant to wear because of their homogeneity in the resin matrices [22]. Small fillers could reduce the spacing that provides resistance and protects the resin matrix [13]. In the present study, the microhybrid RBC (G-aenial) and the nanofilled RBC (Filtek Ultimate) had the largest fillers (16-17 µm and 0.6-10 µm, respectively) among the tested RBCs. That could be one of the reasons for those RBCs having the highest roughness scores of almost all groups. Besides filler size, a low inorganic content compromises the surface smoothness [4]. The nanofilled RBC had the highest filler amount (63.3 vol%), which could be one of the reasons it has smoother surfaces than microhybrid (G-eanial) and nanohybrid RBCs, even having the largest filler particles overall. In general, the influence of the size and type of fillers on the surface quality has been thoroughly presented in the literature. Magdy et al [20] found that the RBCs with barium glass fillers showed higher surface roughness. In the present study, the microhybrid RBC was the only material containing Ba glass fillers, and results were not consistent with the above-mentioned study. It is reasonable to have conflicting results over fillers because the filler type may have an effect on surface roughness however, it is clearly not the only parameter. Besides size, amount and distribution of the fillers, their chemical composition may indirectly affect the roughness, since it determines the refractive index and thus may have an effect on the degree of conversion of the polymer matrix. At a lower refractive index mismatch between filler and matrix, less scattering occurs and the degree of conversion of the organic matrix may be increased. Marovic et al [31] showed that Ba fillers could increase the degree of conversion of the organic matrix, while silica fillers may decrease it. However, it must be considered that scattering is not only dependent on the refractive index mismatch between filler and matrix but essentially also on the filler size and its relation to the wavelength used for curing a RBC. In the present study, the tested RBCs contained differently formulated filler particles and sizes, so the effect of the chemical composition and size on the Ra values cannot be properly discussed. The nanofilled RBC contains zirconia/silica clusters, the microhybrid RBC pyrogenic made silica, the microhybrid (G-eanial) RBC contains besides pyrogenic silica also prepolymerized filler based on silica while the nanohybrid RBC contains silica –glass particles. One study [4] found that, even though nano particles create smaller gaps after polishing, nanoclustered particles are not pulled out from the resin matrices neither. Among the tested RBCs, only the nanofilled RBC (Filtek Ultimate) had nanoclustered particles, which could explain the superior Ra results of the nanofilled RBC. The monomer type is one of the main component of the RBCs affecting surface quality, and it was demonstrated that the chemical composition of monomers is related to preserve surface smoothness against the tough oral conditions over time [22]. Bis-GMA and UDMA are the most common monomers used in RBCs. Monomers, such as Bis-EMA, have been developed to improve viscosity, lower the polymerization shrinkage and toughening the resin matrix. Bis-EMA has fewer carbon-carbon double bonds that lead to a softer, less cross-linked organic matrix that could be affected by acidic or alcoholic beverages [4]. The nanofilled and nanohybrid RBCs analyzed in the present study contain Bis-EMA and tended to be rougher than microhybrid RBCs based on Bis-GMA and TEGDMA. Another monomer with a hydrophilic character, TEGDMA, tends to degrade more quickly [4]. In the analyzed RBCs (nanohybrid and nanofilled), both TEGDMA and Bis EMA were used, thus inferior results of those RBCs could also be attributed to the softer matrices which might be degraded by acidic intake or water uptake. On the other hand, the nanofilled (Filtek Ultimate) and microhybrid (G-aenial) RBCs containe UDMA in their resin matrices. UDMA has lower water sorption and solubility than TEGDMA, Bis-GMA and Bis-EMA [4]. The microhybrid (G-aenial) contains only UDMA in the resin matrix that may lower the water uptake and may be responsible for the less changes in roughness when immersed in distilled water after 20 seconds of curing.

5. Conclusion

Nanofilled and nanohybrid RBCs (Aelite, Filtek Ultimate) as well as one of the analyzed microhybrid RBC (Charisma Classic) showed similar surface roughness after curing for 20 seconds. Charisma Classic showed better surface quality than Aelite and Filtek Ultimate after 40 seconds of curing. Despite varying filler types and chemical composition of the monomer matrix, prolonged curing time had no significant effect on the surface roughness. Yet, immersion in both acidic and alcoholic beverages affected the surfaces of all RBCs and generated significant surface roughness changes. Thus, regardless of the curing time, all analyzed RBCs showed unacceptable changes in surface roughness.

Author Contributions

GO: had the idea of the hypothesis and MME designed the study. GO: collected the data and performed the experimental period with MME.
SOY: prepared the statistical analysis. HSS: revised the manuscript and corrected the language.
EY: editted the whole manuscript.

Acknowledgment

There is no conflict of interest.

References

1. Manhart J, Hickel R. Bulk-fill-composites. Modern application technique of direct composites for posterior teeth. *Swiss Dent J*. 2014;124(1):19-37.
[PubMed] Google Scholar Scopus
2. Gönülol N, Yilmaz F. The effects of finishing and polishing techniques on surface roughness and color stability of nanocomposites. *J Dent*. 2012;40(2):e64-e70.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
3. Lainović T, Vilotić M, Blažić L, et al. Determination of surface roughness and topography of dental resin-based nanocomposites using AFM analysis. *Bosn J Basic Med Sci*. 2013;13(1):34.
[Full text links] [Free PMC Article][CrossRef] [PubMed] Google Scholar Scopus
4. Yadav RD, Raisingani D, Jindal D, Mathur R. A comparative analysis of different finishing and polishing devices on nanofilled, microfilled, and hybrid composite: a scanning electron microscopy and profilometric study. *Int J Clin Pediatr Dent*. 2016;9(3):201-208.
[Full text links] [CrossRef] [PubMed] Google Scholar
5. de Alencar e Silva Leite ML, da Cunha Medeiros e Silva FD, Meireles SS, et al. The effect of drinks on color stability and surface roughness of nanocomposites. *Eur J Dent*. 2014;8(3):330-336.
[Full text links] [CrossRef] [PubMed] Google Scholar
6. Moda MD, Godas AGDL, Fernandes JC, et al. Comparison of different polishing methods on the surface roughness of microhybrid, microfill, and nanofill composite resins. *J Investig Clin Dent*. 2018;9(1):e12287.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
7. Erdemir U, Yildiz E, Eren MM, et al. Effects of polishing systems on the surface roughness of tooth-colored materials. *J Dent Sci*. 2013;8(2):160-169.
[CrossRef] Google Scholar Scopus
8. Attar N. The effect of finishing and polishing procedures on the surface roughness of composite resin materials. *J Contemp Dent Pract*. 2007;8(1):27-35.
[CrossRef] [PubMed] Google Scholar Scopus
9. Topcu FT, Erdemir U, Sahinkesen G, et al. Evaluation of microhardness, surface roughness, and wear behavior of different types of resin composites polymerized with two different light sources. *J Biomed Mater Res B Appl Biomater*. 2010;92(2):470-478.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
10. Kerby RE, Knobloch LA, Schricker S, Gregg B. Synthesis and evaluation of modified urethane dimethacrylate resins with reduced water sorption and solubility. *Dent Mater*. 2009;25(3):302-313.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
11. Moszner N, Fischer UK, Angermann J, Rheinberger V. A partially aromatic urethane dimethacrylate as a new substitute for Bis-GMA in restorative composites. *Dent Mater*. 2008;24(5):694-699.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
12. Erdemir U, Tiryaki M, Saygi G, et al. Effects of different kinds of beers on the surface roughness of glazed and polished methacrylate and Silorane-based composites: a 1-month study. *Ann Stomatol* (Roma). 2017;8(1):23-28.
[Full text links] [CrossRef] [PubMed] Google Scholar
13. Rajan VV, Ganapathy D, Sheeba PS, Kanniappan N. Effects of tooth brushing on wear, surface roughness, and color stability of composite resins-A review. *J Pharm Res*. 2018;12(1):95-102.
14. Bansal K, Acharya SR, Saraswathi V. Effect of alcoholic and non-alcoholic beverages on color stability and surface roughness of resin composites: An in vitro study. *J Conserv Dent*. 2012;15(3):283-288.
[Full text links] [Free PMC Article] [CrossRef] [PubMed] Google Scholar Scopus
15. Kumavat V, Raghvendra SS, Vyavahare N, et al. Effect of alcoholic and non-alcoholic beverages on color stability, surface roughness and fracture toughness of resin composites: an in vitro study. *IIOAB J*. 2016;7(6):48-54.
Google Scholar -
16. Eren MM, Saygi G, Yildirim Z, et al. Surface hardness change of composite resins immersed in beverages with/without alcohol (Abstract). *TDA 23th International Congress*; September 21-24, 2017; Izmir, Turkey.
17. Tabatabaei MH, Arami S, Farahat F. Effect of mechanical loads and surface roughness on wear of silorane and methacrylate-based posterior composites. *J Dent* (Tehran). 2016;13(6):407-414.
[Full text links] [PubMed] Google Scholar
18. Sadeghi M, Deljoo Z, Bagheri R. The influence of surface polish and beverages on the roughness of nanohybrid and microhybrid resin composite. *J Dent Biomater*. 2016;3(1):177-185.
Google Scholar
19. Kritzinger D, Brandt PD, De Wet FA. The effect of different polishing systems on the surface roughness of a nanocomposite and a microhybrid composite. *SADJ*. 2017;72(6):249-257.
[CrossRef] Google Scholar

20. Magdy NM, Kola MZ, Alqahtani HH, et al. Evaluation of surface roughness of different direct resin-based composites. *J Int Soc Prev Community Dent*. 2017;7(3):104-109.
[Full text links] [Free PMC Article] [PubMed] Google Scholar Scopus
21. Da Silva MA, Vitti RP, Sinhoreti MA, et al. Effect of alcoholic beverages on surface roughness and microhardness of dental composites. *Dent Mater J*. 2016;35(4):621-626.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
22. Dos Santos PH, Catelan A, Albuquerque Guedes AP, et al. Effect of thermocycling on roughness of nanofill, microfill and microhybrid composites. *Acta Odontol Scand*. 2015;73(3):176-181.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
23. Tantanuch S, Kukiattrakoon B, Peerasukprasert T, et al. Surface roughness and erosion of nanohybrid and nanofilled resin composites after immersion in red and white wine. *J Conserv Dent*. 2016;19(1):51-55.
[Full text links] [Free PMC Article] [CrossRef] [PubMed] Google Scholar Scopus
24. Gonçalves F, Kawano Y, Pfeifer C, et al. Influence of BisGMA, TEGDMA, and BisEMA contents on viscosity, conversion, and flexural strength of experimental resins and composites. *Eur J Oral Sci*. 2009;117(4):442-446.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
25. Benetti AR, Ribeiro de Jesus VC, Martinelli NL, et al. Colour stability, staining and roughness of silorane after prolonged chemical challenges. *J Dent*. 2013;41(12):1229-1235.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
26. Da Silva EM, De Sá Rodrigues CUF, Dias DA, et al. Effect of toothbrushing-mouthrinse-cycling on surface roughness and topography of nanofilled, microfilled, and microhybrid resin composites. *Oper Dent*. 2014;39(5):521-529.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
27. de Queiroz MMV, Nishitani Shibasaki PA, Pimenta Lima MJ, et al. Effect of erosion and methods for its control on the surface roughness of composite resin. *Rev Odonto Cienc*. 2017;32(2):88-93.
[CrossRef] Google Scholar Scopus
28. Karaman E, Tuncer D, Firat E, et al. Influence of different staining beverages on color stability, surface roughness and microhardness of silorane and methacrylate-based composite resins. *J Contemp Dent Pract*. 2014;15(3):319-325.
[PubMed] Google Scholar Scopus
29. Tavangar M, Bagheri R, Kwon TY, et al. Influence of beverages and surface roughness on the color change of resin composites. *J Investig Clin Dent*. 2018;9(3):e12333.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
30. Marghalani HY. Effect of finishing/polishing systems on the surface roughness of novel posterior composites. *J Esthet Restor Dent*. 2010;22(2):127-138.
[Full text links] [CrossRef] [PubMed] Google Scholar Scopus
31. Marović D, Šariri K, Demoli N, et al. Remineralizing amorphous calcium phosphate based composite resins: the influence of inert fillers on monomer conversion, polymerization shrinkage, and microhardness. *Croat Med J*. 2016;57(5):465-473.
[Full text links] [Free PMC Article] [CrossRef] [PubMed] Google Scholar Scopus
32. Ameri F, Abdotabrizi M, Ghasemi A, et al. Color stability of two bulk-fill composite resins. *J Dent Sch*. 2015;33(4):238-244.
[CrossRef] Google Scholar

Günçe OZAN
DDS, PhD, Research Assistant
Department of Restorative Dentistry
Faculty of Dentistry,
Istanbul University
Istanbul, Turkey

CV

Günçe Ozan received her DDS degree in 2011 from the Faculty of Dentistry at Istanbul University, Istanbul, Turkey. She immediately started her PhD at the Restorative Dentistry Department of the same university. After studying dental erosion and preventive dentistry, she had her PhD degree in 2017. She worked at the Young Dentists' Commission of the Turkish Dental Association for 2 years. She is now continuing her career at the Istanbul University as a Research Assistant.

Questions

1. Why are the novel monomers such as BIS-EMA, AUDMA developed? To reduce composites'…

❑a. Viscosity;
❑b. Water sorption;
❑c. Solubility;
❑d. All of the properties above.

2. Choose the most hydrophilic monomer above

❑a. UDMA;
❑b. AUDMA;
❑c. TEGDMA;
❑d. BIS-GMA.

3. Composites with smaller fillers show lower surface roughness values. Because…

❑a. They are less prominent when they are plugged out;
❑b. They have low modulus of elasticity;
❑c. They are highly soluble;
❑d. All of the statements above.

4. How could an acidic or alcoholic beverage affect composite resin? It could cause…

❑a. Organic matrix plasticizing;
❑b. Organic matrix softening;
❑c. Wear and degradation;
❑d. All of the statements above.