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Effect of Polishing and Aging on Surface Properties of Permanent Restorative Materials Used in the Posterior Region

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Research Article

History

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ABSTRACT

Objectives: The aim of this *in vitro* study was to evaluate the effects of polishing and aging on the surface properties of different restorative materials used in the posterior region.
Materials and Methods: In this study, a total of 576 samples were prepared by using 6 different composite resin (Filtek Z250-Z250, Filtek One Bulk Fill-FOB, Sonic Fill 2-SFB, Zenit Nano Ceramic-ZNC, Gradia Plus Indirekt-GPI, Estelite Bulk Fill Flow-EBF), a giomer composite resin (Beautifil Flow Plus-BFP) a glass ionomer cement (Equia Forte HT Fil -EQF) and a hybrid ceramic (Vita Enamic-VE). Sixty-four cylindrical specimens (8 mm diameter and 2 mm thickness) were prepared for each restorative material. The specimens were divided into two groups according to whether or not polishing was applied and further solution subgroups (n= 8). Surface roughness of the samples were measured with a contact-type profilometer before and after immersed in different solutions and thermal aging, and average roughness values were recorded. Statistical analysis was performed using the three-way analysis of variance test ($p<0.05$).
Results: It was determined that the material type, polishing method and immersing solution had a significant effect on the roughness change ($p<0.05$). Among the restorative materials, the highest roughness change (ΔRa) was found in Equia Forte HT, the lowest ΔRa value was found in EBF, GPI and Z250 groups ($p<0.05$). The highest roughness change was caused by cola and the lowest roughness change was observed in distilled water groups ($p<0.05$).
Conclusions: It was determined that the type of restorative material, polishing and aging and immersion solution had a significant effect on the roughness change.

Keywords: Restorative material; polishing method; thermal cycles; acidic drinks; surface roughness.

Posterior Bölgede Kullanılan Daimî Dolgu Materyallerinin Yaşlandırma Sonrası Yüzey Özelliklerinin Karşılaştırılması

Araştırma Makalesi

Süreç

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ÖZET

Amaç: Bu çalışmanın amacı posterior bölgede kullanılan farklı restoratif materyallerin yüzey özelliklerine farklı polisaj sistemleri ve yaşlandırmanın etkisinin in vitro olarak değerlendirilmesidir.
Gereç ve Yöntemler: Bu çalışmada 6 farklı kompozit (Filtek Z250-Z250, Filtek One Bulk Fill-FOB, Sonic Fill 2-SFB, Zenit Nano Seramik-ZNC, Gradia Plus İndirekt-GPİ, Estelite Bulk Fill Flow-EBF), 2 farklı cam iyonomer siman (Equia Forte HT Fil -EQF, Beautifil Flow Plus-BFP), 1 hibrit seramik (Vita Enamic-VE) kullanılarak toplamda 576 adet örnek hazırlandı (n=8). Her bir restoratif materyalden 64 adet silindirik örnek elde edildi (çap: 8mm, kalınlık: 2mm). Örnekler 2 farklı polisaj yöntemi (Matris Bandı-MB, Kerr Occlubrush-KOB) ve sonrasında 4 farklı yaşlandırma solüsyonuna (distile su, kola, vişne suyu, soğuk çay) göre alt gruplara ayrıldı. Örneklerin yüzey pürüzlülüğü ölçümleri, farklı solüsyonlarda ve termalsiklusta bekletme öncesinde ve sonrasında profilometre cihazı ile yapıldı ve ortalama pürüzlülük değerleri kaydedildi. Çalışma sonucunda elde edilen verilerin istatistiksel analizi Dört Yönlü-ANOVA ile yapıldı.
Bulgular: Materyal türü, polisaj yöntemi ve bekleme solüsyonunun pürüzlülük değişiminde anlamlı etkisi olduğu belirlendi ($p<0,05$). Restoratif materyaller arasında en yüksek pürüzlülük değişimi (ΔRa) Equia Forte HT'de, en düşük ΔRa değeri ise Estelite Bulk Fill, Gradia Plus İndirect ve Filtek Z250 gruplarında görüldü ($p<0,05$). İçecek grupları değerlendirildiğinde ise pürüzlülük değişimine en fazla kola, en az ise distile suyun neden olduğu görüldü ($p<0,05$).
Sonuçlar: Bu çalışmanın sonucunda restoratif materyallerin yüzey pürüzlülüğünü; restoratif materyalin cinsi, kullanılan polisaj yöntemleri ve asitli içeceklerin etkileyebileceği belirlendi.

Anahtar Kelimeler: Restoratif materyal; polisaj yöntemi; termalsiklus; asitli içecekler; yüzey pürüzlülüğü

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Introduction

The main aim of dentistry is to restore the patient's lost tooth tissue functionally and aesthetically with successful restorations. Today, many materials have been developed that give doctors and patients the opportunity to choose restorative materials. The selection of restorative materials depends on factors such as duration of use in the mouth, wear resistance, solubility, volumetric stability, color stability, location of the mouth area where it is applied, size and localization of the cavity or preparation, chewing habits, dietary habits, oral hygiene, amount of saliva and systemic disorders.[1,2]

With the development of glass ionomer cements in 1972, these materials have become generally preferred restorative materials because they provide adhesion to dental tissue and are compatible with biological tissues. However, the low wear resistance, solubility and aesthetic properties of cements are not as good as composites, which has limited the clinical use of cements.[3,4] High viscosity glass ionomer has been developed to increase the wear resistance of glass ionomer cements and reduce their moisture sensitivity, allowing them to be used in areas where chewing stress is high.[5]

Although they were initially used in the restoration of anterior teeth, their micromechanical adhesion to dental tissues, superior aesthetic properties and higher wear resistance compared to other restorative materials have expanded the usage areas of composite resins. However, despite the positive properties of composite resins, they also have some disadvantages that affect the long-term clinical performance of the material. Placing composites with the incremental technique during the restoration of deep cavities causes loss of time for both the doctor and the patient. There is also a risk of air bubbles remaining between the layers and moisture contamination. To eliminate these disadvantages and reduce the processing cost, bulk fill composite resins that can be applied in a single layer up to 4-5 mm thick have been developed in recent years.[6]

In recent years, as a result of research conducted to combine the positive properties of composite resins and ceramics, CAD/CAM hybrid blocks have been introduced to the market. These hybrid blocks provide advantages such as easier processability, superior edge compatibility and high fracture resistance, thanks to their dual-phase structure that combines the positive properties of ceramic and composite resins.[7]

Finishing and polishing processes are the processes applied to restorative materials to harmonize the edges of the restoration and to obtain brighter and smoother surfaces by giving appropriate contours to the restoration.[8,9] When the finishing and polishing process is done properly, it is an important step that affects the aesthetics and permanence of the restorations.[10] It has been reported that the roughness of the restoration surfaces causes bacterial plaque to adhere, thus increasing the formation of periodontal diseases and secondary caries and causing patient dissatisfaction.[10-12] Evaluation of surface roughness is done with devices such as optical and mechanical profilometers, AFM and SEM.[13]

Restorative materials used in dentistry are intermittently exposed to chemical drinks frequently consumed in daily life.[14] It has been reported that carbonated drinks and drinks with acidic potential, which are frequently consumed today, cause morphological changes on restorative materials.[15,16]

The purpose of this study to compare the surface properties of permanent restorative materials with different properties used in the posterior region after cyclic aging. The null hypotheses of this study are;

1. There is no difference in surface roughness among the restorative materials.
2. There is no difference in surface roughness between the polishing methods applied to restorative materials.
3. There is no difference in the surface roughness change of the restorative materials between the soaking solutions.

Materials and Methods

Specimen Preparation

In this study, micro hybrid composite (Filtek Z250), nanohybrid composite (Zenit Nano-Ceramic), indirect composite (GC), bulk fill composite (Tokuyama Estelite Bulk, Filtek One Bulk fill, Sonic Fill), hybrid composite (Giomer), hybrid glass ionomer cement (Equia Fort) and hybrid ceramic (Vita Enamic) restorative materials were used. The restorative materials and polishing systems used in this study are shown in Table 1.

The G*Power (G*Power Ver. 3.0.10, Franz Faul, Üniversität Kiel, Germany) package program was used to determine the number of samples to be tested in the study. In order to determine the effect difference of F = 0.30 (moderate) with 80% power, at least 64 samples for each group were needed at the type I error level of α=0.05. For each of the eight restorative materials, 64 cylindrical specimens were prepared using a metal mold with a central hole of 8 mm in diameter and 2 mm in thickness. Composite resins were filled into a metal mold. Then, the surface of the materials was covered with mylar strip on the top and bottom and placed between two glasses. The glass surfaces were pressed with finger pressure to remove excess composite resin and eliminate pores. Composite resins were cured at a standard intensity of 1.000 mW/cm2 for 20 seconds from the bottom and top with LED polymerization light from a distance of 1 mm. Each composite resin group was randomly assigned to two subgroups for finishing and polishing procedures. Gradia Plus, an indirect composite resin, was polymerized for another 60 seconds using its own polymerization system (Labolight DUO, GC Corporation, Japan). The hybrid ceramic block was cut vertically with a diamond cutting disc (Microcut201, Metkon, Bursa, Turkey) with a thickness of 2 mm and a rectangular prism was obtained. After Equia Forte HT Fill hardened in the molds, Equia Forte Coat was applied to the sample surfaces and cured with light. Sixty-four specimens of each restorative materials were randomly assigned to one of the two finishing and polishing techniques.

***Table 1:** Compositions and manufacturer details of the tested materials*

Materials (Abbreviation)	Material Category	Composition	Manufacturer
Estelite Bulk-Fill Flow (EBF)	Bulk-Fill Composite	Organic matrix: Bis-GMA, TEGDMA, Bis-MPEPP, Mequinol, and Dibutyl hydroxyl toluene Filler: Spherical silica-zirconia filler(wt%/vol%: 70 / 56)	Tokuyama Dental, Tokyo, JAPAN
Filtek One Bulk Fill (FOB)	Bulk-Fill Composite	Organic matrix: AFM (dynamic stress-relieving monomer), AUDMA, UDMA, and 1,12-dodecane-DMA Fillers: 20-nm silica filler, 4- to 11-nm zirconia filler, an aggregated zirconia/silica cluster filler (comprised of 20-nm silica and 4- to 11-nm zirconia particles), and a ytterbium trifluoride filler consisting of agglomerate 100-nm particles. (wt%/vol%: 76.5 / 58.5)	3M ESPE, St. Paul, USA
Sonic Fill 2 (SFB)	Bulk-Fill Composite	Glass, oxide, chemicals (10–30%), 3-trimethoxysilylpropyl methacrylate (10–30%), silicon dioxide (5–10%), ethoxylated bisphenol A dimethacrylate (1–5%), bisphenol A bis(2-hydroxy-3-methacryloxypropyl) ether (1–5%), and triethylene glycol dimethacrylate (1–5%)	Kerr Orange CA, USA
Gradia Plus İndirect (GPİ)	Nanohibrit Composite	Organic matrix: : UDMA, dimethacry- late Fillers: SiO_2, fumed SiO_2, Sr and lanthanoid F, Al F silicate (prepolymer-ized) İnorganic fillers (wt%: 71)	GC Corporation, JAPAN
Zenith Nano Ceramic (ZNC)	Nanohibrit Composite	glass filler, pyrogenic silica, agglomerated nanoparticles, Diurethane dimethacrylate, butanediol dimethacrylate, isopropylide-bis [2(3)-hydroxy-3(2)-(4-phenoxy) propyl] bismethacrylate	President Dental, München, GERMANY
Filtek Z250 (Z250)	Micrahibrit Composite	Organic matrix: Trietyhlenglycol dimetacrylate (TEGDMA) < 1–5%; Bisphenol-A-glycidylmethacrylate (Bis-GMA) < 1–5%; Bisphenol-A polyethylenglycol dietherdimethacrylate (Bis-EMA) 5–10%; Urethane dimethacrylate (UDMA) 5–10% Filler: Zirconia/silica; 60 vol% inorganic fillers; Particle size 0.01 to 3.5 m	3M ESPE St., Paul, MN, USA
Equia Forte HT Fill (EQF)	High Viscosity Glass Ionomer	Powder: 95% strontium fluoroaluminosilicate glass (including highly reactive small particles) + 5% polyacrylic acid Liquid: 40% aqueous polyacrylic acid	GC, Tokyo, JAPAN
Beautifil-Bulk Restorative (BBF)	Giomer	Organic matrix: Bis-GMA, UDMA, Bis MPEPP, TEGDMA Fillers: S-PRG filler based on Fluoroboroaluminosilicate glass and nano filler (10- 20nm) (wt%/vol%: 87 / 74.5)	Shofu Inc., Kyoto, Japan
Vita Enamic (VE)	Hybrid Ceramic	Porous structure-sintered ceramic matrix infiltrated with polymer material. Inorganic ceramic 86 wt%: fine-structure feldspar ceramic enriched with aluminum oxide (silicon dioxide 58–63%, aluminum oxide 20–23%, sodium oxide 9–11%, potassium oxide 4–6%, boron trioxide 0.5–2%, zirconia < 1%, calcium oxide <1%). Organic polymer 14 wt% (urethane dimethacrylate, triethylene glycol dimethacrylate).	Vita Zahnfabrik, Bad Säckingen, GERMANY
Kerr Occlubrush (KOB)	4.0±0.5 mm thick	Silicon carbide particles impregnated in fiber bristles	Kerr Orange, CA, USA

Polishing procedures

All samples were divided into 2 subgroups, group 1 and group 2.

Group 1, unpolished (mylar strip): This group comprised the specimens that were left untreated, not submitted to finishing and polishing procedures.

Group 2, Kerr Occlubrush polishing system: The samples were treated with 600, 800 and 1000 grit silicon carbide paper to ensure standardization between samples before the application of the polishing systems. The samples were polished with KERR Occlubrush in dry conditions with light hand pressure at 10.000 rpm for 45 seconds in the order specified by the manufacturer. [17] After each polishing step, the samples were rinsed thoroughly with water for 10 seconds and air dried for 5 seconds until the next step and final polishing.

All samples were polished on a flat surface by the same operator. Specimens were then stored in distilled water at 37º C for 24 hours for rehydration and completion of the polymerisation.

Aging Procedure

Immersion of Specimens in Solutions

Each restorative material and polishing process was divided into four subgroups: cola (pH:2.53, The Coca-Cola Company, USA), ice tea (pH:3.71, Lipton Company, USA), cherry juice (pH:2.86, Dimes Company, TURKEY) and distilled water (pH:6.67) (n = 8). After the surface measurements, samples were kept in a water bath at 5±2 °C and 55±2 °C for 30 seconds and 10 seconds outside in a thermal cycle device (SD Mechatronik Thermocycler, SD Mechatronik GMBH, Westerham) in order to imitate the thermal changes in the oral environment for 2000 cycles.

The samples were kept in beverages such as distilled water, cola, cherry juice and iced tea for 3 days, 4 hours a day. This process corresponds to the exposure time of restorative materials to acidic drinks for 2 minutes per day for 1 year.[18,19]

During the study, samples were kept in sealed bottles and drinks were renewed daily. At the end of 3 days, the samples were subjected to thermal aging again 2000 times. This process was continued as a cycle until a total of 10,000 cycles were completed. Before surface roughness measurements, the samples were rinsed with deionized water for 60 seconds and dried with blotting paper.

Measurement of Surface Roughness

The surface roughness of specimens were measured before and after immersion in the solutions in three different areas using a surface profilometer (Surtronic 25, Taylor Hobson, Leicester, UK). The profilometer was calibrated according to the manufacturer's instructions before each measuring session. Surface roughness measurements were performed with a cut-off value of 0.25 mm, a transverse length of 1.25 mm, and a stylus speed of 0.1 mm/second near the center of each specimen. The average surface roughness value (Ra) and the surface roughness change (Δra) of each specimen were recorded separately.

Statistical Analysis

Statistical analyses were performed using SPSS software (SPSS 22.0 Chicago, IL, ABD). Descriptive analyzes were performed or the general characteristics of the data of the study groups. Data of continuous variables are given as mean ± standard deviation. The Shapiro-Wilk test was used to test normality of the variables. When the means of quantitative variables were compared between groups, two and three-way analysis of variance was used for repeated measurements ($p<0.05$).

Results

The results of three-way ANOVA test revealed significant differences among materials, solutions, polishing methods, materials*polishing methods, and solutions*polishing methods interactions ($p < 0.05$) ANOVA tables of the samples before and after aging are included in Tables 2 and 3.

Table 2: *Results of Two-Way Variance Analysis Between Groups in Terms of Roughness Values of Restorative Materials Before Aging*

Source	Type III SS	df	Mean square	F	p value
Intercept	47.639	1	47.639	20503.091	0.000
Material	32.169	8	4.021	1730.623	0.000
Polishing	0.521	1	0.521	224.108	0.000
Material * Polishing	0.369	8	0.046	19.876	0.000

Table 3: *Three-Way Variance Analysis Results Between Groups in Terms of Roughness Change Values of Restorative Materials After Aging*

Source	Type III SS	df	Mean square	F	p value
Intercept	1.127	1	1.127	264.302	0.000
Material	0.378	8	0.047	11.067	**0.000**
polishing	0.035	1	0.035	8.152	**0.004**
solution	0.075	3	0.025	5.888	**0.001**
Material * Polishing	0.229	8	0.029	6.720	**0.000**
Material * Solution	0.041	24	0.002	0.405	0.995
Polishing * Solution	0.001	3	0.000	0.055	0.983
Material * Polishing * Solution	0.039	24	0.002	0.381	0.997

Evaluation of Surface Roughness of Restorative Materials Before Aging

The average and standard deviations (µm) of the initial surface roughness values obtained as a result of the mylar strip and KOB polishing of the restorative materials in the study are shown in Table 4. Accordingly, the values of KOB were recorded significantly higher than the mylar strip ($p<0.05$).

It was observed that the average Ra values, except for EQF and VE, were below the threshold value (threshold value: 0.2 µm) in the groups prepared under the mylar strip. The lowest surface Ra value for all groups was obtained with the EBF group. There is a significant difference between EBF and all other restorative material groups ($p<0.05$). The highest surface Ra value was obtained with the VE group. At the same time, a significant difference was noted between VE and other groups ($p<0.05$). However, there was no significant difference between BFP and GPI, SFB and Z250 groups ($p>0.05$) (Table 4).

It was observed that the Ra values of the materials prepared with KOB, except for EQF, were below the threshold value (threshold value: 0.2 µm). It was noted that EBF group had the lowest surface roughness among all groups and there was a significant difference between EBF and all other restorative material groups ($p<0.05$). While the highest surface roughness was observed in the VE group, a significant difference was noted between the other groups ($p<0.05$) (Table 4).

Evaluation of Surface Roughness of Restorative Materials After Cyclic Aging

The average and standard deviations (µm) of the surface roughness values of the restorative materials after aging in the study are shown in Table 5. When the mylar strip groups were evaluated after aging, it was seen that the lowest Ra value was in the EBF group, and there was no significant difference between the EBF and GPI and Z250 groups (p>0.05). A significant difference was observed between the EQF and VE groups, whose roughness was above the threshold value, and the other restorative material groups (p<0.05) (Table 5).

When the KOB groups were evaluated after aging, a significant difference was noted between VE, whose roughness was above the threshold value (threshold value: 0.2 µm), and the other groups (p<0.05). It was observed that there was no significant difference between EQF, whose roughness was above the threshold value, and other BFP and SFB groups (p>0.05). It was observed that the lowest surface roughness was in the EBF group and there was no significant difference between the EBF and ZNC and Z250 groups (p>0.05) (Table 5).

Except for the EQF restorative material after aging, the roughness values of the KOB group were recorded higher than the values of the mylar strip group. Ra values of the mylar strip were obtained higher for the EQF restorative material than for the KOB group (p<0.05). For FOB restorative material, no difference was noted between polishing systems (Table 5).

The most significant roughness change between finished under mylar strip and groups cyclically aged in cola was found in EQF. A significant difference was observed between this group and other restorative materials (p<0.05). Among the materials polished with KOB and subjected to cyclic aging in cola, the highest roughness change was seen in the BFP group and there was no significant difference between it and the other groups (p>0.05). The lowest value was seen in the GPI group and this difference was not statistically significant (p>0.05) (Table 5).

Among the materials finished under mylar strip and subjected to cyclic aging in cherry juice, the highest roughness change was seen in the EQF group and there was no significant difference with the BFP group (p>0.05). The lowest change was seen in the EBF, GPI, Z250 groups and a significant difference was observed with EQF (p<0.05). Among the materials polished with KOB and subjected to cyclic aging in cherry juice, the highest roughness change was in the BFP group, and the lowest value was in the GPI and VE groups (p<0.05) (Table 5).

Among the materials finished with mylar strip and subjected to cyclic aging in cold tea, the highest roughness change was seen in the EQF group, and the lowest change was seen in the EBF, Z250 groups. Among the materials polished with KOB and subjected to cyclic aging in cold tea, the highest roughness change was in the BFP group, and the lowest change was in GPI, EBF, ZNC and VE groups (p>0.05) (Table 5).

Among the materials finished under mylar strip and subjected to cyclic aging in water, the highest roughness change was seen in the EQF group, and the lowest change was seen in the EBF, Z250 groups (p> 0.05). Among the materials polished with KOB and subjected to cyclic aging in water, the highest roughness change was in the BFP group and the lowest roughness change was in the GPI, EBF, Z250, ZNC and VE groups (p>0.05) (Table 5).

Table 4: *Comparison of initial surface roughness values between groups*

MATERIALS	INITIAL RA VALUES	
	Mylar Strip	**Kerr Occlubrush**
Equia Forte HT Fill (EQF)	0.209±0.01 (A)	0.235±0.02 (B)
Estelite Bulk-Fill Flow (EBF)	0.047±0.007 (A)	0.079±0.01 (B)
Filtek One Bulk Fill (FOB)	0.121±0.03 (A)	0.135±0.017 (B,b)
Beautifil-Bulk (BBF)	0.082±0.017 (A,a)	0.153±0.025 (B,c)
Gradia Plus İndirect (GPİ)	0.085±0.015 (A,a)	0.152±0.017 (B,c)
Vita Enamic (VE)	0.606±0.025 (A)	0.674±0.025 (B)
Sonic Fill 2 (SFB)	0.094±0.017 (A,a)	0.189±0.025 (B)
Filtek Z250 (Z250)	0.091±0.012 (A,a)	0.113±0.01 (B,d)
Zenith Nano Ceramic (ZNC)	0.066±0.007 (A)	0.124±0.01 (B,bd)

A,B: Indicates differences between lines in capital letters (p<0.05).
a,b,c,d: Differences in lowercase letter between columns (p<0.05).

Table 5: *Surface roughness values according to different beverages after cyclic aging*

		Ra Values in Groups After Cyclic Aging	
Restorative Materials	**Solution**	**Mylar Strip**	**Kerr Occlubrush**
	Cola	0.4±0.18 (A,a)	0.26±0.01 (B)
EQF	Cherry Juice	0.4±0.20 (A,a)	0.27±0.01 (B)
	Ice Tea	0.34±0.22 (A,ab)	0.27±0.02 (B)
	Distilled Water	0.3±0.11 (A,b)	0.26±0.02
	Cola	0.06±0.01	0.11±0.01
EBF	Cherry Juice	0.06±0	0.11±0.01
	Ice Tea	0.06±0.01	0.1±0.01
	Distilled Water	0.06±0.01	0.09±0.01
	Cola	0.16±0.02	0.18±0.04
FOB	Cherry Juice	0.17±0.03	0.17±0.02

	Ice Tea	0.17±0.02	0.17±0.01
	Distilled Water	0.17±0.03	0.17±0.03
	Cola	0.17±0.03 $^{(A)}$	0.26±0.02 $^{(B)}$
BFP	Cherry Juice	0.2±0.03 $^{(A)}$	0.28±0.02 $^{(B)}$
	Ice Tea	0.18±0.01 $^{(A)}$	0.24±0.02 $^{(B)}$
	Distilled Water	0.12±0.02 $^{(A)}$	0.21±0.01 $^{(B)}$
	Cola	0.14±0.01	0.18±0.02
GPİ	Cherry Juice	0.11±0.02	0.17±0.01
	Ice Tea	0.1±0.01 $^{(A)}$	0.18±0.02 $^{(B)}$
	Distilled Water	0.1±0.02	0.16±0.02
	Cola	0.65±0.05 $^{(A)}$	0.73±0.04 $^{(B)}$
VE	Cherry Juice	0.64±0.03	0.69±0.02
	Ice Tea	0.63±0.03	0.69±0.02
	Distilled Water	0.63±0.03	0.68±0.02
	Cola	0.15±0.03 $^{(A)}$	0.25±0.02 $^{(B)}$
SFB	Cherry Juice	0.14±0.02 $^{(A)}$	0.25±0.02 $^{(B)}$
	Ice Tea	0.15±0.03 $^{(A)}$	0.22±0.01 $^{(B)}$
	Distilled Water	0.13±0.02 $^{(A)}$	0.2±0.02 $^{(B)}$
	Cola	0.11±0.01	0.16±0.02
Z250	Cherry Juice	0.11±0.01	0.16±0.02
	Ice Tea	0.1±0.01	0.15±0.02
	Distilled Water	0.1±0.01	0.13±0.02
	Cola	0.12±0.02	0.17±0.01
ZNC	Cherry Juice	0.12±0.01	0.16±0.01
	Ice Tea	0.12±0.01	0.15±0.02
	Distilled Water	0.11±0.01	0.14±0.01

A,B: Indicates differences between lines in capital letters ($p<0.05$).
a,b,c,d: Differences in lowercase letter between columns ($p<0.05$).

Discussion

Surface roughness, which is one of the important factors affecting the clinical success of restorations, affects the aesthetic properties due to its tendency to discoloration, while it also affects the biological properties because it increases the retention of dental plaque.[20,22] At the same time, a well-done polishing process will increase patient comfort and satisfaction. For these reasons, the effectiveness of finishing and polishing processes is very important for the surface properties of restorative materials.

It has been shown that the smoothest surfaces in direct composite resins occur under the mylar strip.[17] However, the surfaces created under the mylar strip are rich in resin and need to be removed because they have poor mechanical properties.[23,24] In this study, the effect of a single-stage polishing brush (Occlubrush, KERR), which can be used in polishing both direct and indirect restorative materials, on the surface roughness of current restorative materials after waiting in acidic beverages was compared.

In terms of the findings of this study, null hypothesis 1 was rejected because there was a significant difference in initial surface roughness between the restorative materials evaluated. While the roughness was significantly lower in the EBF group than in all other restorative materials, the highest surface roughness was observed in the VE group. However, the fact that the roughness values in the VE group, which is an indirect restorative material, is higher than the other groups is thought to be due to the brush used as the polishing system being insufficient in terms of polishing the hybrid ceramic surfaces. Furthermore, the lower surface roughness observed in the EBF group is due to the high resin content and low filler rates of the flowable composites.

Although there is no consensus on the threshold value for the surface roughness of restorations, it is stated that restorations with a surface roughness of less than 0.2 µm are acceptable in terms of compatibility with oral tissues, and a surface roughness of more than 0.2 µm may cause plaque accumulation.[20] In addition, Jones *et al*. reported that the patient could detect roughness values above 0.5 µm with the tip of the tongue.[25] Considering the findings of this study, the second null hypothesis was also rejected. While a roughness value below 0.5 µm was observed in all groups of evaluated direct restorative materials finished under transparent tape and polished with a brush, roughness values below 0.2 µm were observed in all direct restorative materials except the high viscosity glass ionomer (EQF) group. Finishing and polishing processes of glass ionomer-containing restorative materials are more difficult due to their heterogeneous structure. During polishing, their softer matrix is easily eroded, leaving behind hard glass particles.[26,27]

Özarslan *et al*. Vita Enamic CAD/CAM blocks; They compared the roughness values of the groups that were not polished and those that were finished and polished with the Vita Enamic Polishing Set and reported that the groups finished with the Vita Enamic Polishing Set exhibited less roughness values.[28] However, as a result of this study, the highest roughness values were obtained in the VE group polished with KOB. KOB is an indicated polishing material for all restorative materials tested in the study; however, since the Vita Enamic polishing set is the material's own set, it is very likely to provide effective polishing.

The etching effect of acidic beverages on restorative materials has been evaluated in many studies, and it is known that beverages with low pH have a greater erosive effect on restorative materials.[29-31] In these studies, it was determined that the surface roughness of restorative materials varies depending on the type of aging solution and restorative material content.

In this study, a significant difference was observed between the restorative materials kept in cola, cherry juice, iced tea and water and the 3rd null hypothesis was also rejected. Sarı *et al.* reported that a significant increase in surface roughness values of restorative materials was observed after soaking in orange juice and cola.[32,33] While apple juice contains maleic acid, orange juice primarily contains citric acid. Fruit acids containing carboxylic acids such as these can chelate with calcium ions in the glass ionomer structure and form a structure that is soluble in water.[30] On the other hand, when the phosphoric acid in cola chelates with calcium, a water-insoluble structure is formed. The pH value of sour cherry juice used in this study is 2.86 and it contains citric acid in its structure. Among the restorative materials we subjected to cyclic aging in cherry juice, the highest roughness change was found in the BFP group and the lowest roughness change was found in the GPI group. It is thought that exposure of the BFP group to solutions causes a significant increase in roughness on the surface, as the size of the voids formed as a result of the removal of the S-PRG fillers in its structure from the surface is much larger.[34] We think that the lower roughness change in GPI is due to the fact that it has smaller filler particles.

This study evaluated the effects of different polishing procedures and solutions on surface roughness of permanent restorative materials used in the posterior region. The limitations of this study were the continuous immersion periods and lack of the cleaning effect of saliva and oral hygiene procedures. Although this study could not simulate intraoral conditions, the deleterious effects of commonly consumed drinks on restorative materials were confirmed.

Conclusions

Within the limitations of this study:

1. Although initially smoother surfaces were obtained in the groups finished under mylar strip, it was determined that the surface roughness after immersion in solutions was less in the groups polished with a single-stage brush.
2. Restorative materials showed varying rates of roughness change after aging and immersion in different solutions. It was determined that the type of restorative material, polishing and aging had a significant effect on the roughness change. Among the tested materials, high-viscosity glass ionomer exhibited the greatest increase in surface roughness after immersion in different solutions, whereas the flowable bulk-fill composite showed the least change.

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Conflicts of Interest Statement

There is no conflict of interest in this study.

References

1. ADA Council on Scientific Affairs. Direct and indirect restorative materials. J Am Dent Assoc. 2003;134: 463-472.
2. Cvar JF, Ryge G. Reprint of criteria for the clinical evaluation of dental restorative materials. Clin Oral Investig. 2005;9: 215-232.
3. Heintze SD, Loguercio AD, Hanzen TA, Reis A, Rousson V. Clinical efficacy of resin-based direct posterior restorations and glass-ionomer restorations–An updated meta-analysis of clinical outcome parameters. Dental Materials, 2022;38(5):e109-e135.
4. Çarıkçıoğlu B. "The effect of coating material on the color stability of glass-ionomer-based restorative materials: An in-vitro study." Cumhuriyet Dental Journal 2022; 24(4), 386-394.
5. Sidhu SK, Nicholson JW. A review of glass-ionomer cements for clinical dentistry. JFB. 2016; 7(3): 16.
6. Furness A, Tadros M, Looney S, Rueggeberg F. Effect of bulk/incremental fill on internal gap formation of bulk-fill composites. J Dent. 2014; 42(4): 439-449.
7. Spitznagel Frank A, Sebastian D, Horvath DMD, Petra C. Guess DDS, Markus B. Blatz DMD, Resin Bond to Indirect Composite and New Ceramic/Polymer Materials: A Review of the Literature. J Esthet Restor Dent. 2014; 26(6): 359-421.
8. Özgünaltay G, Yazici AR, Görücü J. Effect of finishing and polishing procedures on the surface roughness of new tooth-coloured restoratives. JORHB. 2003; 30(2): 218-224.
9. Turssi CP, Saad J, Duarte Jr S, Rodrigues Jr, A. Composite surfaces after finishing and polishing techniques. Am J Dent. 2000; 13(3): 136-138.
10. Jefferies SR. Abrasive finishing and polishing in restorative dentistry: a state-of-the-art review. Dental Clinics of North America, 2007; 51(2): 379-397.
11. Aykent F, Yondem I, Ozyesil AG, Gunal SK, Avunduk MC, Ozkan S. Effect of different finishing techniques for restorative materials on surface roughness and bacterial adhesion. J Prosthet Dent. 2010; 103(4): 221-227.
12. Türkün L, Türkün M. The Effect of One-Step Polishing System on the Surface Roughness of Three Esthetic Resin Composite Materials. Oper Dent. 2004; 29(2): 203-211.
13. Kakaboura A, Fragouli M, Rahiotis C, Silikas N. Evaluation of surface characteristics of dental composites using profilometry, scanning electron, atomic force microscopy and gloss-meter. J. Mater. Sci. Mater. Med. 2007; 18(1): 155-163.

14. Rios D, Honório HM, Francisconi LF, Magalhães AC, de Andrade Moreira Machado MA, Buzalaf MA. In situ effect of an erosive challenge on different restorative materials and on enamel adjacent to these materials. J Dent. 2008; 36(2): 152-157.
15. Grippo JO, Simring M, Schreiner S. Attrition, abrasion, corrosion and abfraction revisited: A new perspective on tooth surface lesions. J. Am. Dent. Assoc. 2004; 135(8): 1109-1118.
16. Wongkhantee S, Patanapiradej V, Maneenut C, Tantbirojn D. Effect of acidic food and drinks on surface hardness of enamel, dentine, and tooth-coloured filling materials. J Dent. 2006; 34(3):214-220.
17. Aytac F, Karaarslan ES, Agaccioglu M, Tastan E, Buldur M, Kuyucu E. Effects of novel finishing and polishing systems on surface roughness and morphology of nanocomposites. J Esthet Restor Dent. 2016; 28(4):247-261.
18. El-Badrawy W, McComb D, Wood R. Effect of home-use fluoride gels on glass ionomer and composite restorations. Dent Mater. 1993; 9(1): 63-67.
19. Yap A, Lye K, Sau C. Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems. Oper Dent. 1997; 22:260-265.
20. Hao Y, Huang X, Zhou X, Li M, Ren B, Peng X, Cheng L. Influence of dental prosthesis and restorative materials interface on oral biofilms. International Journal of Molecular Sciences. 2018; 19(10): 3157.
21. Borges MG, Soares CJ, Maia TS, Bicalho AA, Barbosa TP, Costa HL, Menezes MS. 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.
22. Gharechahi M, Moosavi H, Forghani M. Effect of surface roughness and materials composition. Journal of Biomaterials and Nanobiotechnology. 2018; 3(04):541.
23. Ergücü Z, Türkün LS, Aladag A. Color stability of nanocomposites polished with one-step systems. Oper Dent. 2008; 33(4):413-420.
24. Ryba TM, Dunn WJ, Murchison DF. Surface roughness of various packable composites. Oper Dent. 2002;27(3):243-247.
25. Jones CS, Billington RW, Pearson GJ. The in vivo perception of roughness of restorations. Br Dent J. 2004;196(1):42-45.
26. Pacifici E, Bossù M, Giovannetti A, La Torre G, Guerra F, Polimeni A. Surface roughness of glass ionomer cements indicated for uncooperative patients according to surface protection treatment. Ann Stomatol. 2013; 4(3-4): 250.
27. Wu SS, Yap A, Chelvan S, Tan E. Effect of prophylaxis regimens on surface roughness of glass ionomer cements. Oper Dent. 2005: 30(2):180-184.
28. Özarslan MM, Büyükkaplan UŞ, Barutcigil Ç, Arslan M, Türker N, Barutcigil K. Effects of different surface finishing procedures on the change in surface roughness and color of a polymer infiltrated ceramic network material. J Adv Prosthodont. 2016; 8(1):16.
29. Wongkhantee S, Patanapiradej V, Maneenut C, Tantbirojn D. Effect of acidic food and drinks on surface hardness of enamel, dentine, and tooth-coloured filling materials. J Dent. 2006; 34(3):214-220.
30. Yap AU, Low JS, Ong LF. Effect of food-simulating liquids on surface characteristics of composite and polyacid-modified composite restoratives. Oper Dent. 2000; 25(3):170-176.
31. Hamouda IM. Effects of various beverages on hardness, roughness, and solubility of esthetic restorative materials. Journal of Esthetic and Restorative Dentistry. 2011; 23(5): 315-322.
32. Mustain SMB., Alkadhim AH, Fatah FA, Jaafar A. Effect of tropical fruit juices on surface roughness of tooth coloured restorative materials. J Dent Sci Res Ther. 2017; 26-29.
33. Sari ME, Erturk AG, Koyuturk AE, Bekdemir Y. Evaluation of the effect of food and beverages on enamel and restorative materials by SEM and Fourier transform infrared spectroscopy. Microscopy Research and Technique. 2014; 77(1): 79-90.
34. Pimentel ES, França FMG, Turssi CP, Basting RT, Vieira-Junior WF. Effects of in vitro erosion on surface texture, microhardness, and color stability of resin composite with S-PRG fillers. Clinical Oral Investigations. 2023;27(7):3545-3556.