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SURFACE ROUGHNESS OF BIS-GMA FREE RESIN COMPOSITE IN COMPARISON WITH BIS-GMA CONTAINING RESIN COMPOSITE (IN-VITRO STUDY)

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ABSTRACT

Aim: To evaluate the Surface Roughness of Bis-GMA Free Resin Composite and Bis-GMA Containing Resin Composite.

Material and Methods: Two resin composites were assessed, Bis-GMA free composite (Admira Fusion) and Bis-GMA containing composite (Grandio). A total of 80 resin composite specimens were prepared in a Teflon mold (10 mm x 2 mm), categorized into two groups of (40 specimens) each was tested based on the type of resin composite, each group was categorized into 4 subgroups based on tested immersion solutions (n=10). Immersion solution used were artificial saliva, Coffee, Coca-Cola, and Tea. Readings of surface roughness (Ra) was obtained by profilometer after 24 hours, 2 weeks and one month of exposure to respective solutions.

Results: In terms of statistical significance, there was no difference between Bis-GMA Free Resin Composite and Bis-GMA Containing Resin Composite. Specimens immersed in cola showed the highest mean value of surface roughness among the different tested solutions.

Conclusion: Both tested types of resin composite have similar surface roughness behavior. All tested storage solutions caused surface roughness except artificial saliva. Cola caused marked surface roughness in both resin composites. Surface roughness was time-dependent, increasing with the passage of time.

KEYWORDS Surface Roughness, Admira Fusion, Grandio

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INTRODUCTION

Esthetics has a considerable part in the progress of dental research. The desire of having a natural look has paved the way for the progression of tooth colored restoratives that mimic teeth as closely as possible. Nowadays, resin-based composite materials are the most frequently used biomaterials in restorative dentistry especially due to the increased aesthetic demands. [1]

The most common monomer composites are those containing Bis-GMA, but it increases shrinkage stress, that results in fractures and leakage of several restorations. [2,3]

Recently, different strategies have been employed to change the monomeric matrix, including the usage of Ormocer, an organically modified ceramic that contains silicon dioxide as an inorganic base and polymerizable organic compounds. It has the properties of stiffness of the glass combined with the characteristics of the resin. This substance's goal is to improve the aesthetics and resistance to abrasion and corrosion, permitting caries protection and reduction in roughness of surface and polymerization shrinkage. It lacks Bis-GMA and other classic methacrylates; therefore, it cause no cytotoxicity, being considered non-active and improving the biocompatibility. [4]

Successful direct restoration is dependent on smoothness of the surface, which guarantees an easy and comfortable oral hygiene. Inadequate smoothness can lead to susceptibility of the restoration to marginal staining, plaque accumulation, secondary cavity, periodontal aggression, and precocious color change. Thus, smoothness has a potential role in lifespan restoration and improving the appearance. [5]

The purpose of this investigation was done in order to evaluate the surface roughness of resin composites manufactured with and without Bis-GMA. The initial null hypothesis for the present investigation was that the surface roughness of Bis-GMA-free and containing resin composites is the same. The effect of different storage solutions on the surface roughness of the investigated materials did not differ, according to the second null hypothesis. The third null hypothesis stated that the detected surface roughness wasn't affected by the various periods of storage.

MATERIALS AND METHODS:

Ethical regulation: This study was approved by the ethics committee of the faculty of dentistry, Minia University, meeting no. (73) & decision no. (434).

Specimens preparation:

For Eighty resin composite samples, 40 of each evaluated resin composite type were used. The specimens (10 mm in diameter and 2 mm in height) were made in a split Teflon mold. [3,6,7] A 1 mm glass

TABLE (1) Materials used, specification, composition, lot number and manufacturer.

Material	Specification	Composition	Lot Number	Manufacturer
Admira Fusion	Nano-hybrid ORMOCER*-Based resin composite restorative material (shade A2)	**Matrix:** Resin ORMOCER. **Filler:** glass ceramics, Silicon oxide Nano filler, Pigments. Filler content %: 84 (W/w).	**2043255**	Voco, Cuxhaven, Germany.
Grandio	Nano-hybrid Bis-GMA Based resin composite restorative material (shade A2)	**Matrix:** based on dimethacrylates, Contains Bis-GMA, TEGDMA. **Filler:** Inorganic filler (nano-sized silica). Filler content %: 87 (w/w).	**2049328**	service@voco.de

slide thickness was set over a glass slap and above it, the Teflon mold was set. A composite applicator made of gold was used for placing the material into the mold (Ukens Dental, Im Spiet 7, 26500 nordent, Germany) until it was overloaded. The composite was topped by a Mylar strip, and the remaining substance was gently compressed away from its position using a second glass slide. The material was cured using a light emitting diode (LED) curing unit of wave length (1000 mw/cm2, (Elipar, 3M ESPE, Germany), by putting the light guide tip in touch with the top surface of the glass slide. Each specimen was cured for 20 seconds according to the instructions given by the manufacturer. After curing, the specimens were released from the molds, extruded material was removed using Sof-Lex polishing discs ((3M ESPE, St. Paul, MN, USA)) in four series according to the instruction of manufacturer from coarse to superfine.[6, 7.8]

Grouping of specimens:

Based on the type of resin composite used, 80 resin composite samples were equipped and categorized into two groups of (40 samples each). Group (A1) Admira fusion resin composite (Bis-GMA free) and group (A2) Grandio resin composite (Bis-GMA containing). Each group was classified into 4 subgroups based on tested immersion solutions (n=10).

Immersion of the specimens into the tested solutions:

Group 1: Specimens from each group were submerged into artificial saliva (prepared in Faculty of Pharmacy, Cairo University, Egypt). Group 2: Specimens from each group were dipped into coffee` (Nescafe classic, Nestle, Egypt) 1.8g of prefabricated coffee` packet liquefied in 150 ml boiling water according to the manufacturer. Group 3: Specimens from each group were dipped into coca-cola (Coca cola Company, Egypt). Group 4: Samples from each group were immersed into tea (Lipton, yellow lable, Unilever brand, Egypt) prepared tea bag was submerged in 150 ml of boiling water for 2-3 minutes according to the manufacturer. Each subgroup immersed in 50 ml of immersion solutions at 37˚C in incubator (3M, advanced tech, Cairo, Egypt). Every day, the same amount of immersion solutions were replaced to maintain consistency and prevent microbial growth. To simulate a person's consumption of a beverage[12], the specimens were submerged in it for 15 minutes three times a day at a specific time. After that, the samples were rinsed in water and stored in artificial saliva for the study's duration in a 37°C incubator.[6,11,12] measurement of surface roughness was done after 24 hours (T1), 2 weeks (T2) and one month (T3).[6,9,10,11]

Assessment of Surface Roughness:

All discs were tested for surface roughness measurements using a USB digital surface profile (surface profilometer, Elcometer 224/2, Elcometer Instruments, Great Britain) and computer software (ElcoMaster 2, Elcometer Instruments) for data gauging and recording. The cut-off value for surface roughness was set at 0.8 mm, and the traversing distance of the stylus was 5.0 mm. The measurement force was 10 mN, and the tracing diamond tip radius was 2.5 m. To maintain reliability, the machine was constantly calibrated after each five specimens. The surface profile needle was vertically positioned over each test sample and three measurements were recorded from various points on the sample surface. The mean value of surface roughness was determined after three observations.

The surface roughness before immersion (T1) was estimated, then, the test was performed again after 2 weeks (T2) and after one month (T3). The readings for each sample were recorded and the mean reading in nanometers was determined. As a result, a high value would indicate that the surface is rough, whereas a low value would represent a smooth one.

Statistical analysis:

Independent t-test was performed to compare between tested materials, storage solutions and storage periods. A one-way ANOVA test was performed for each group to investigate the impact of variable interactions. When the test's findings were significant, Duncan's post hoc analysis was used to compare the group means. The significance level was set at 0.005. For the statistical evaluation, IBM® SPSS® Statistics Version 20 for Windows was used.

RESULTS

Table (2) and figure (1) revealed that the two examined resin composite restorative materials, Admira resin composite (A1) and Grandio resin composite (A2), were not different statistically significantly from each other.

Also the effects of the different storage solutions that had been examined on the mean surface roughness values. After (T1) and (T2), the highest mean value recorded in groups stored in cola storage solution (A1S3T3) and (A2S3T3). Between the (S1) and (S4) groups at the different testing periods, there was no statistically significant change. Also it showed that in Admira group stored in saliva, there was no significant variation between (T1, T2 and T3), in coffee group a remarkable difference was found between (T1) and both of (T2 and T3), in cola group there was a considerable difference between (T1, T2 and T3) with the highest mean value recorded in (T3), and in tea group a statistically difference found between (T1) and both of (T2 and T3) and the lowest mean value measured at (T1).

There was no statistically significant difference between (T1, T2, and T3) in the Grandio group stored in saliva, a significant difference was found between (T1, T2, and T3) in the coffee and cola groups, with the highest mean value recorded in (T3), and a statistically significant difference was found between (T1) and both of (T2 and T3) in the tea group, with the lowest mean value measured at (T1).

TABLE (2) Mean and standard deviation (SD) of surface roughness at the different tested groups.

Resin composite (A)	Storage solution (T)	Storage period (T)			P- value
		Baseline (T1)	15 days (T2)	1 month (T3)	
		Mean±SD	Mean±SD	Mean±SD	
Admira (A2)	Saliva (S1)	0.292±.002[a]	0.293±.001[a]	0.293±.007[a]	0.254 Ns
	Coffee (S2)	0.292±.002[b]	0.295±.001[a]	0.296±.004[a]	<0.001*
	Cola (S3)	0.292±.002[c]	0.295±.001[b]	0.298±.006[a]	<0.001*
	Tea (S4)	0.292±.002[c]	0.293±.001[b]	0.294±.015[a]	<0.001*
Grandio (A2)	Saliva (S1)	0.291±.001[a]	0.292±001[a]	0.293±.01[6]a	0.374 Ns
	Coffee (S2)	0.291±.001[c]	0.294±.001[b]	0.296±.001[a]	<0.001*
	Cola (S3)	0.291±.002[c]	0.295±.001[b]	0.299±.002[a]	<0.001*
	Tea (S4)	0.291±.001[b]	0.293±.008[a]	0.294±.016[a]	<0.001*

Significant difference is indicated by using various letters in the same row.

Significant (p<0.05) Ns; not-significant (p>0.05)

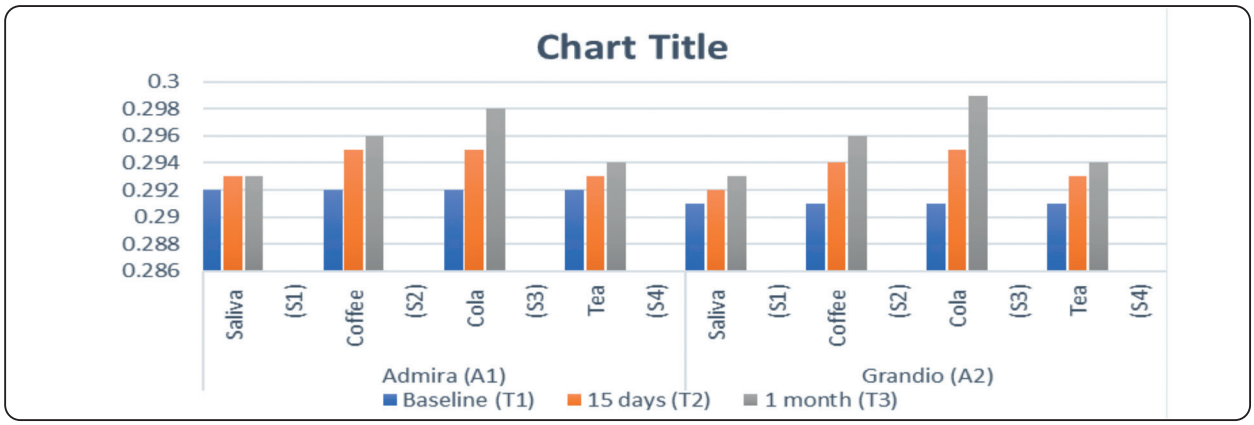

Fig. (1) Bar chart showed surface roughness of the different tested groups.

DISCUSSION

Esthetics showed an important role in the progression of dentistry. The demand for a natural appearance has accelerated the development of tooth-colored restorations that aim to match the tooth as closely as possible. Resin nanocomposites have various benefits such as improved optical and increased mechanical characteristics, diminished wear and better gloss retention.[9,14]

Ormocer is a recently developed resin composite material free of Bis-GMA that was produced for direct fillings. "Ormocer" is the abbreviation for "organically modified ceramic" and describes inorganic-organic co-polymers with inorganic silanated filler particles. When compared to conventional composites, it showed reduced shrinkage stress, volumetric shrinkage, intermediate strength, similar or lower wear resistance, elastic modulus, or fracture toughness. Admira Fusion-Ormocer, a nano-hybrid bulk fill Ormocer-based resin composite, is the only brand of the most recent generation of pure Ormocer-based composite resin.[15,16,17]

Admira Fusion (VOCO), in comparison to other resins that have dimethacrylate monomer matrix, has low shrinkage (1,25%) ceramic polysiloxane. This type of ormocer improves biocompatibility, aesthetics, caries protection, abrasion resistance, and decreases surface roughness as well as polymerization shrinkage, with absence of cytotoxicity found in classic monomers, such as TEGDMA and BisGMA. It was proven to be of a huge benefit compared to methacrylate-based resins.[3,11,18,13]

The specimens of each composite resin restorative material were made using both kinds of the material. The resin composite could shrink easily that's because the mold was made of Teflon material, which doesn't adhere to it.[16] The system of choice for polishing discs was the Sof-lex polishing discs. Because of its ability to make polished surfaces that are smooth, non-destructive, and less susceptible to chemical dissolution, aluminium oxide discs have been recommended as a standard approach.[11,14]

Plaque deposition, water absorption, and the restoration's aesthetic qualities are all dependent upon the surface roughness of resin composite restorations. Rough surfaces may lead to the accumulation of staining materials on the restoration surface, creating aesthetic issues. Common drinks like cola, coffee, and tea can leave behind colored residues that stain and cause roughness of the surface of the teeth and composite resin restorations.[14,20,21]

The surface roughness of materials is evaluated using a variety of methods as atomic force microscopy (AFM), profilometers and scanning

electron microscopy (SEM) analysis. A profilometer device is the most used parameter for assessing the surface roughness of composite resins. It has long been used as a reliable and practical way to assess the quality of composite surfaces.[10,13,14,22] Surface profilometer was the tool used in the current study to evaluate surface roughness.

The methodology chosen for the current study corresponded with earlier studies involving the use of a digital profilometer microscope capable of scanning a surface with a specific kind of laser and providing a 3D surface map without causing damage to the samples. This approach was suggested as a quick and simple evaluation technique. When surface texture exceeds the roughness limit, biofilm formation also increases (Ra = 0.2 m), while under the threshold value, no further decrease in bacterial adherence could be seen. The tip of the tongue can identify a change in surface roughness of 0.3 μm in diameter, which promotes patient comfort.[10,11,14]

The tested liquids were selected as the immersions since they are used frequently in daily life. As the specimens were immersed in their respective beverage for 15 minutes for 3 times at a fixed time daily, For individuals who drink coffee, the average daily consumption is 3.2 cups, and it takes around 15 minutes to drink one cup to imitate the oral environment during this time.[6,11]

The specimens were submerged for 24hs, 2 weeks and one month in tea, coffee, cola and artificial saliva as a control group.[6,9,10,11]

Since the shape of the surface affects its ability to color change, analyzing the texture of the surface is essential to investigate the effects of composite restoration. The acidity and pH of the surrounding environment were related to the surface degeneration of (Resin based composites) RBCs, which is similar to many previous findings that have indicated that RBCs' physical characteristics may change over time when exposed to acids. [10,11]

The findings of our study, both types of the resin composite restorative materials showed no statistical significant difference. No change in artificial saliva groups in both materials, slight change found in Tea, more change in coffee and the highest change was found in cola. [6,9,10,11,23]

The same material exhibited statistical differences between the baseline, coffee, tea, cola, and artificial saliva at the conclusion of the study, but there was no statistically significant variance between the two types of composites used. Our study found that submerging the specimens in the examined solutions caused an increase in surface roughness. Despite the fact that both coffee and coke had low pH levels, coke had a higher impact on the roughness of the tested composite resin. It might help to explain why since cola is a carbonate beverage with phosphoric and carbonic acids, which encourage dissolving and rapidly erode the materials. [6,9,11]

Additionally, our outcomes agreed with **(Ebaya M. et al., 2022)**[11] who demonstrated that Ormocer did not show notable differences compared to conventional composites regarding surface roughness due to the similar filler sizes and loads between them. The samples of distilled water and those that had been exposed to saliva did not significantly differ after staining. But both composites' surfaces became noticeably rougher following tea and cola. Due to the presence of malic, citric, and oxalic acids in tea and its acidic pH of 5.4, these results may be attributed to chemical erosion from the beverage. Cola's low pH (2.5) also affects the surface integrity of resin-based composites, increasing surface roughness. The significant difference between their composite values can be explained by the low pH of cola with respect to tea.

The current study's results confirmed with **(Sherif R et al., 2020), (Dündar A. et al., 2019)**[6,24] There were variances between tea, coffee, cola,

and distilled water with respect to the same material's baseline, but there were no difference between composite types. Coffee and cola both have low pH values, but in our study, cola had a greater effect on the resin's roughness. Cola is a carbonated beverage that contains phosphoric and carbonic acids, which accelerate degeneration and easily corroded materials, so this can happen.

Also in **(Chowdhury D. et al., 2020)**[10] study who found that, Surface roughness (Ra) values for samples exposed to Coca-Cola were the highest, followed by coffee and tea. Artificial saliva in the control group had the lowest surface roughness value. Coca-Cola had the lowest pH of all the beverages tested in that study. Due to the erosive wear that low pH acidic food and drink causes in materials. High levels of acidity may have a greater softening impact on the resin matrix, which would encourage the dislodging and leaching out of filler particles and therefore enhance the surface roughness of composite resin.

These results agreed with those of **(Chowdhury D. et al., 2020, Bansal et al., 2012)**[10,25] who found that, both surface roughness has revealed time dependence that increased in all time periods; The 7th day had the lowest values, followed by 2 weeks, and the month had the highest values.

Also **(Sarveshwar P. Et al., 2013, Ereifej et al., 2013 and Da Silva B. et al., 2016)**[9,26, 27] reported that there was no difference between the initial and one-month periods for any of the tested dental composites when they were immersed in artificial saliva, which was comparable with this study. In all composite resins, the Coke drink specimens exhibited increased surface roughness over time (24 hours, 2 weeks, and 1 month) compared to other subgroups. This was followed by the subgroups of coffee, tea and distilled water.[28,29]

In contrast to our study **(Tagtekin DA et al., 2004)**[30] which reported that, because the filler phase in ormocer had a positive surface that increased roughness on its surface because the filler particles were stronger than the matrix and caused preferential elimination via polishing and finishing. Ormocer, as a result, had a rougher surface than conventional hybrid RBC..

And also in **(Sadeghi M. et al., 2016)**[22,31,32] surface roughness of samples immersed in coffee (pH 5.41) was affected by staining solutions, and it was higher than that of cola (pH 2.47) and distilled water (pH 6.8) for both substances. In contrast to our research results, it is thought that the rise in the roughness of the surface in coffee may be correlated with the acidic pH, a relationship between quantity and type of load, as well as coffee's potential to dissolve at a high temperature.

The critical level (Ra 0.05) for surface roughness values after immersion in coffee solution was not reached, and these investigations found that coffee did not make the composite's surface rougher. These outcomes could be explained by the low resin content or low water sorption rate of these substances. In terms of the filler system, resin composites with small filler sizes and high filler loading are going to have desirable properties, be more resistant to changes in the nature of the surface and degradation, as well as having a reduced reaction to bleaching agents and staining solutions. Another clarification is that coffee did not replicate changes in surface roughness or resin degradation because coffee has a high pH and is not acidic compared to other staining solutions as red wine and cola.[33]

Because there was no apparent difference between the two tested composites, the first null hypothesis was accepted based on the data that were collected for the current study. Because there was a significant difference between the various tested solutions and between the various storage times, the second and third null hypothesis were rejected.

CONCLUSION

In respect to the limitations of this study, it is possible to make the following conclusions:

1. Both tested types of resin composite have similar surface roughness behavior.
2. All tested storage solutions increased the surface roughness except artificial saliva.
3. Cola caused marked surface roughness in both resin composites.
4. Surface roughness was time-dependent, increasing with the passage of time.

RECOMMENDATIONS

1. For aesthetics restorations of anterior and posterior cavities, resin composites free and containing bis-GMA may be recommended.
2. To support their clinical application, additional studies are needed to the characteristics of Bis-GMA free resin composites rather than surface roughness.

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