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The Effect of Pepsi Cola Beverage on Surface Roughness of Two Composite Resins (In Vitro study)

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Abstract

An acidic environment causes surface changes of resin composites. Filler particle size and filler distribution also have a direct effect on these surface changes. This in vitro study evaluated the influence of Pepsi Cola drink on the surface roughness of Composan LCM and Composan Ceram over time. Sixteen disc shaped specimens (10mm diameter, 2mm thickness) of each resin composite were fabricated, thereby forming two groups (n= 8). Surface roughness (Ra) was analyzed after 24 hrs before exposure to beverage. The specimens were submitted to a five minutes immersion in Pepsi Cola three times daily interrupted by immersion in deionized distilled water (37 C˚). Surface roughness measurements were done at 10, 30, and 60 days intervals. Data were submitted to paired t-test. There was a statistically highly significant ($p < 0.001$) increase in surface roughness values of the tested composites after 30 days and 60 days immersion in Cola drink. Composan LCM exhibited a significantly ($p < 0.05$) higher surface roughness values than Composan Ceram.

The surface roughness of the composite materials are significantly affected by exposure to acidic drink over time, highly filled micro hybrid composites with small filler particle size are significantly more resistant to acid erosion.

Key words: Composan LCM, Composan Ceram, surface roughness, Pepsi Cola drinks

Introduction

Although the physical and mechanical properties of composite resins are indicators that predict the behavior of composite restorations, other aspects such as material biodegradation, must be taken into account in the clinical performance of this type of restorative procedure. The critical oral environmental conditions, i.e., PH changes and humidity, may increase resin disintegration over time. This process may deteriorate the mechanical properties of the material, and reduce the clinical life of the composite resin restorations [1, 2]. In addition, the surface disintegration of the resin composites is related to the fillers content, particle size, hardness, and distribution, as well as composition of the resin matrix, and the effect of silane surface treatment on the fillers[3]. Almost all important properties of resin composites are improved by using higher filler levels. Highly filled compositions with smaller size filler particles results in a relatively smooth finished surface [4]. In addition to inorganic fillers it is

possible to add crystalline polymer fillers, which is not nearly as strong as inorganic fillers, but it is stronger than simply amorphous polymer matrix. Microfilled and hybrid dental composite utilize microfiller of silica glass that can be produced in variety of ways and designed with different names [5]. The actual properties of each form are slightly different but the differences have not yet been shown to produce different clinical properties of dental composites [5]. Surface roughness of resin composite is an important consideration in the restorative process; this is especially true at the cervical region where rough surface leads to plaque retention and periodontal problems with subsequent recurrent decay [6]. The aim of this in vitro study was to evaluate and compare the surface roughness for Composan LCM and Composan Ceram after exposure to acidic drink (Pepsi Cola).

Material and Methods

Two types of composite restorative materials (Shade A2) were investigated (Table 1). Sixteen composite resin disc specimens were prepared by placing the material into a stainless steel mold split ring (10 mm internal diameter and 2 mm thickness) (Figure 1). The mold was placed on a transparent celluloid strip and glass slide then the material was placed into the mold using a plastic instrument. The filled mold was covered with a second transparent celluloid strip and glass slide; light pressure was applied to expel excess material from the mold. The material was photopolymerized using light curing unit (Astralis 5, Vivadent, Austria) by applying the tip of the light probe directly against the glass slide. Light activation was carried on for 40 seconds on both sides. Polymerizing the composite materials against a glass surface is a method commonly used by researchers to produce a standardized surface finish for testing [7],and was preferred to exclude air from the composite surface and thereby minimizing oxygen absorption which produce an oxygen inhibited layer. The set disc was then separated from the mold; the excess material was removed with a scalpel blade. The specimens of each group were kept in individual containers in 20 ml of deionized water at 37 ˚C for 24 hours, to allow aging of the samples. The surface profile of the specimens were obtained with a surface profile testing machine (Hand-Held Roughness Tester, TR 200, TIME Group Inc. China) (Figure 2). The mean arithmetic roughness (Ra) was used to assess surface changes. Several measurements were performed for each specimen; the mean value of these measurements on one specimen was used as the Ra of that specimen. The Ra values were automatically calculated by the profilometer. The high Ra values indicates a rough surface whilst the low values represents a smooth surface .The mean Ra values of each group was recorded, as a baseline surface roughness measurement (control). Then the samples in each group were immersed in fresh (Pepsi cola, Baghdad soft drinks company, Iraq) container of 20 ml. Each group was immersed for 5 minutes; three times daily (every 8 hours) which represents a medium frequency of intake [8]. Before and after immersion in Cola drink, specimens were rinsed with deionized distilled water. Specimens, when not exposed to the acidic drink, were stored in deionized distilled water at 37˚C. After 10 days (1st period) second surface roughness measurements were taken, then the cycle of immersion was continued for other 30 days (2nd period) where third surface roughness measurements were taken. Finally, the

forth measurements were taken after 60 days. Then all measurements were compared using paired t-test.

Results

The results of the present study showed that there is an increase in surface roughness (Ra) values after immersion in Cola drink for both types of composite tested. Table (2) shows the descriptive statistics (mean and standard deviation) of the surface roughness (Ra) values in µm for all the tested specimens. Figure (3) shows the difference in mean surface roughness (Ra) values among groups represented in bar chart graph. Paired t-test was performed between the different time intervals for each type of composite. At a 60- days interval, the results showed that there is a statistically highly significant difference ($P<0.001$) in surface roughness (Ra) values for both types of composites. The rate of changes in surface roughness (Ra) values over the selected time intervals is presented in Table (3). Paired t-test was also performed between the two types of composite. Results showed that there is no statistically significant difference ($P>0.05$) between Composan LCM and Composan Ceram at all corresponding time-intervals except at the 60-days interval, where the result was statistically significant ($P<0.05$); as shown in Table (4).

Discussion

The wide spread use of resin based restorative materials and their exposure to the harsh conditions of the oral environment require them to be resistant to degradation. However under acidic conditions composite resins may suffer degradation over time, which can be predicted by changes in the surface roughness, and decrease in hardness and wear resistance [6]. All these shortcomings will decrease the materials physical and mechanical properties as well as create predisposing factors to bacterial colonization which could potentially increase the risk of oral diseases. Machado et al [9] stated that the acidity effect of carbonated beverages is mainly due to phosphoric acid. Phosphoric acid is an organic acid that may produce high levels of tooth erosion and harmful effect on tooth colored restorative materials due its chelating properties [10]. Under the conditions of this study all composite resin specimens presented a significant increase in surface roughness after immersion in acidic drink (Pepsi Cola) at all time intervals used in this study (10, 30, and 60 days); which could be considered as a process of degradation and erosion. Initially the surface of the composite is very smooth and any process of erosion has a tendency to cause surface roughening as the relatively soft resin matrix is worn preferentially leaving the filler particles protruding from the surface. As a function of time an increase in surface roughness is greatly expected due to leaching of fillers. This fact will depend on several variables such as filler composition, filler content, surface area, type of matrix and silanization. This finding coincides with the results of Salama [11], Badra et al [8], and Tahir et al [12]. Since the specimens in this study were rinsed and stored in deionized distilled water after immersion on cola drink; this may have another dramatic effect on surface changes. Water which has entered the polymer through sorption can also cause hydrolytic degradation of the resin matrix, the filler matrix interface, or the fillers. The effect of hydrolysis includes loss of molecular weight, filler debonding, and decreased physical and mechanical properties. This is in agreement with the finding

of Ramoglu et al [13], but disagree with that of Nayif et al [6], who claimed that deionized distilled water is the least solution that cause filler debonding in comparison with the oral environment. Under the same experimental conditions, statistically no significant difference in surface roughness values (Ra) were observed among the pretreated specimens of the two tested materials (Composan LCM, and Composan Ceram) as shown in Table (4). After immersion in acidic drink (Pepsi Cola), Composan LCM presented a significantly higher surface roughness values than Composan Ceram after 60 days of immersion as shown in Table (4). Although the two tested materials are manufactured by the same parent company (Table 1), there are many differences in their molecular structure , and composition. Composan LCM presents larger filler particle size (0.7 up to 2 µm), which may increase its roughness' values. The smaller filler particles become more closely packed and the resin between the fillers becomes protected from further chemical degradation. Also if the particles that are stripped out from the surface are very small, they will leave small holes which produce little roughness. This finding coincides with that of Bagheri et al [14], and Valinoti et al [9], but disagrees with that of Mandikos et al [15], who suggested that filler particle dimension and chemistry did not represent substantial difference in surface roughness among materials. Composan Ceram has higher filler content (77% vol) than those of Composan LCM (60% vol). Composite resins with higher filler content seemed to have higher resistance to acid erosion; filler fallout may not occur easily where there is a little exposure of the matrix resin in between fillers. This agrees with the results of Soderholm [16], and Han et al [17], who suggested that a relatively higher filler loading increases the stability of resin composite surface against low PH conditions. Composan Ceram contains a unique combination of silica nano filler particles (> 0.05 µm), and nano cluster fillers. The nano cluster agglomerates act as a single unit thus enabling a high filler loading and high resistance to surface degradation. This finding agrees with that of Han et al [17].Although in vitro tests may not reflect intraoral conditions, but such findings under controlled conditions are helpful and can be applicable to clinical performance. It may be concluded that exposure to soft drink (Pepsi Cola) for 60 days significantly affects the surface integrity of resin composite materials measured by profilometer. Composite resins with larger filler particle size, and lower filler volume, might be more susceptible to degradation when submitted to acidic environments.

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Table (1): Technical profiles of the evaluated composite resins.

Composite type	Filler type	Filler size	Filler Volume	Resin system	Manufacturer
Composan LCM (Microhybrid)	Barium Glass, Silica Dioxide	0.7-2 µm	60%	BIS-GMA UDMA TEGDMA	Promedica Germany Lot no. 0850066
Composan Ceram (Glass, ceramic Microhybrid)	BariumGlass, SilicaDioxide, Barium alumino flouroSilica glass 4%Nano- fillers	0.5µm 0.05 µm	77%	BIS-GMA UDMA TEGDMA	Promedica Germany Lot no. 0829064

Table (2): Descriptive statistics (mean and standard deviation) of surface roughness (Ra) values in µm for all tested specimens.

Type of composite / Subgroups	Composan LCM		Composan Ceram	
	Mean	SD	Mean	SD
Control	0.055375	0.0054347	0.054225	0.0051947
10-days period	0.058850	0.0076547	0.056138	0.0061314
30-days period	0.194388	0.0179068	0.174762	0.0127645
60-days period	0.328925	0.0617148	0.268588	0.0370908

Table (3): Paired t-test of the different time intervals for each composite type.

Type of Composite	Immersion time: Control	10-days	30-days	60-days
Composan LCM		0.054 (NS)	0.000 (HS)	0.000 (HS)
			0.000 (HS)	0.000 (HS)
				0.000 (HS)
Composan Ceram		0.067 (NS)	0.000 (HS)	0.000 (HS)
			0.000 (HS)	0.000 (HS)
				0.000 (HS)

Table (4): Paired t-test between the two composites for each time intervals.

Immersion time	Type of Composite: Composan LCM	Composan Ceram
Control		0.733 (NS)
10-days		0.515 (NS)
30-days		0.066 (NS)
60-days		0.040 (S)

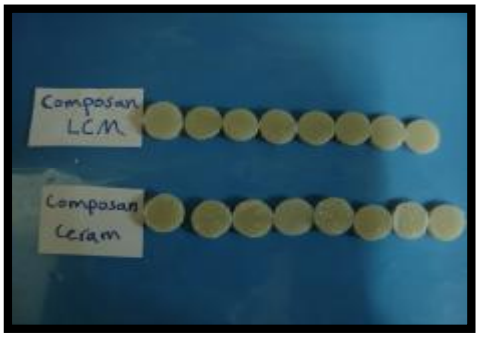

Figure (1): Composite resin disc specimens.

Figure (2): Specimen during testing by the profile testing machine.

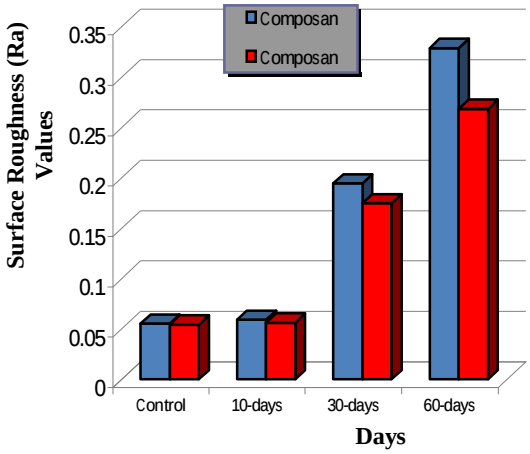

Figure (3): Bar chart show the difference in mean surface roughness (Ra) values among groups.