Effect of Acidic and Energy Drinks on Surface Roughness of Three Types of Bulk Fill Composite Materials

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ABSTRACT

Background: This study aimed to study the effect of some acidic drinks (Vinegars and fresh Orange juice) and energy drinks (Red bull) on surface roughness of three types of bulkfill composite materials: Filtek posterior bulkfill (3M), Sonicfill (Kerr) and Filtek p60 (3M).

Materials and Methods: Total number of 120 samples are prepared by using a mold of (12mm diameter and 3mm height), which were divided into three groups forty samples for each group: Group A: Filtek bulkfill posterior composite (3M), Group B: Sonicfill composite (Kerr), Group C: Filtek P60 (3 M) which then divided into four sub- groups (n=10) (1) samples were kept in distilled water as a control group (2) samples were immersed in Redbull (3) samples were immersed in fresh Orange juice (4) samples were immersed in Vinegars. Immersion of samples were made manually for 5 seconds for 10 cycles at room temperature daily for one month then surface roughness was measured by the use of profilometer ,The data were recorded and statistically analyzed, by the ANOVA and the Tukey test.

Results: Data were statistically analyzed using ANOVA and Tukey test which revealed that there were a high significant ($p<0.001$) increase in surface roughness of the three composite materials after immersion in Vinegar and Redbull drinks after one month with highest value for Filtek Bulkfill posterior composite (3M), than Sonicfill composite (Kerr) and Filtek p 60 (3 M) and there was non-significant difference ($p> 0.05$) in surface roughness value for the three composite materials after immersion in Fresh orange juice.

Conclusions: The effect of energy and acidic drinks depend upon exposure time, composition of the composite material

Keywords: Energy drinks, Bulkfill composite, Red bull, roughness. (J Bagh Coll Dentistry 2016; 28(3):8-14).

INTRODUCTION

Composite resins are widely used in restorative and pediatric dentistry. Most of the available composites contain a polymer matrix of dimethacrylate monomers, such as Bis-GMA, UDMA, TEGDMA and Bis-EMA, inorganic filler particles coated with a methyl methacrylate functional silane coupling agent to bond the filler to the organic matrix, and a photoinitiator system to allow photoactivation by light units [(1)].

To be clinically successful, restorative materials are required to have long-term continuousness, a quality which is strongly influenced not only by the intrinsic characteristics of the materials, but also by the environment to which they are exposed to [(2)]. But the oral cavity is a complex, aqueous environment where the restorative material is in contact with saliva [(3,4)].

In addition, other factors such as low pH due to acidic foods and drinks may influence the material's mechanical and physical characteristics. In a clinical environment, a material's decrease of hardness may contribute to its deterioration [(5)]. However, "under in vivo conditions, composite resin materials may be exposed either discontinuously or continually to chemical agents found in saliva, food, and beverages [(6)]. Consequently, in the short- or long-term, these conditions may have a deleterious effect on the polymeric network, modifying its structure physically and chemically [(3,4)].

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Physical characteristics of restorative materials are an important concern when determining suitable restorative materials because they strongly influence the clinical longevity of restorations [(3)].

Bulk-fill composites are popular restorative materials that have been on the market for several years. Unlike traditional composites, which typically are placed in maximum increments of 2 mm, bulk-fill composites are designed to be placed in 4 mm, or sometimes greater increments. Restoring a tooth in one step certainly appears to save time, there are some concerns. For example, manufacturers claim that bulk-fill materials have greater depth of cure and lower polymerization-induced shrinkage stress [(3)].

Bulk fill composite had the advantages of time saving and easy handling, nowadays bulk fill composites become widely used amongst practitioners. However, only few studies were published on comparing the light-curing efficiency and mechanical properties of the commercially available bulk fill composite. Therefore, the aim of the this study is to evaluate the surface roughness of three types of bulkfill composite: Filtek bulkfill posterior composite (3M), Sonicfill composite (Kerr) and Filtek P 60 (3M) after immersion in acidic solutions used daily by people such as energy drinks Redbull (due to it is consumption has gained high popularity among the adolescent population especially 18-35 years olds in recent years) [(6)], Vinegars, Orange juice for 1 month.

MATERIALA AND METHODS

Three bulkfill materials were used Filtek bulkfill (3M), Sonicfill composite (Kerr) and Filtek P60 (3M) their composition and shade presented in table (1), the acidic solution used in this study their composition, pH presented in table (2).

Table 1: Composition of the tested materials and drinks used in this study

Products	The resin matrix	The filler	Manufacture	Filler loading wt/vol	Filler size	Shade
Filtek Bulk Fill, Posterior restorative	AUDMA, UDMA, and 1, 12-dodecane-DMA.	Silica filler, a zirconia fill and ytterbium trifluoride filler	3M ESPE, St. Paul, USA	76.5% wt	4-20 nm	A3
Sonic fill	Bis-EMA TEGDMA	Silicon dioxide Glass, oxide, chemicals Zirconium compound Ytterbium triflouride	Kerr	83% wt	0.4-30 nm	A3
Filtek P60	Bis-GMA,UDMA and Bis-EMA	Zirconia/silica	3M ESPE, St. Paul, USA	83 % wt	0.19-3.5 µm	A3

Table 2: Acidic drinks used in this study

Material	Composition	pH	Manufactures
Red bull	Sucrose, glucose, acidity regulatory sodium, citric acid, caffine, vitamins, natural flavours, colors	3.11	GMbh, Austeria
Fresh orange juice	Carbohydrate, proteins, vitamins, minerals, citric acid, water	3.5	Hand made
Apple vinegars	Acetic acid 5-8%, water and flavoring	2.5	Zer, Turkey

Grouping:

Group A: 40 samples were made from Filtek Bulkfill posterior composite (3 M)
Group A1: 10 samples were immersed in Distilled water (control group)
Group A2: 10 samples were immersed in Red bull energy drinks
Group A3: 10 samples were immersed in Orange juice.
Group A4: 10 samples were immersed in Vinegar.
Group B: 40 samples were made from Sonicfill comoposite (Kerr)
Group B1: 10 samples were immersed in Distilled water (control group)
Group B2: 10 samples were immersed in Red bull energy drinks
Group B3: 10 samples were immersed in Orange juice.
Group B4: 10 samples were immersed in Vinegar.
Group C: 40 sample were made from Filtek P60 (3M)
Group C1: 10 samples were immersed in Distilled water.
Group C2: 10 samples were immersed in Red bull energy drinks
Group C3: 10 samples were immersed in Orange juice.
Group C4: 10 samples were immersed in Vinegar.

Samples preparation:

By utilizing cylindrical Teflon molds (3mm in height and 12mm in diameter) [8].The molds were placed on a transparent celluloid strip that fixed on a glass cement slab. The materials were inserted and pressed into the mold until it were intentionally overfilled. Then the materials were covered with another celluloid strip and a glass microscopic slide.

100 gm pressure was applied to expel excess material from the mold. Each specimen were light-cured by LED (Wood pecker, china) with 600 mw/cm^2 for 20 second for all tested materials as recommended by their manufacturer's through the application of the tip of light cure directly on the top glass slide (distance about 1.2mm, which is the thickness of the glass slide and celluloid strip), all samples were stored in vials that contained distilled water (pH 6.58) in an incubator at 37 ^{O}C for 24 hours before they were tested. The acidity of solutions were measured with a pH meter (model 3320). The pH meter was calibrated using test solutions of known pH (Fisher Scientific International, Loughborough, UK) [8]

Immersion of specimens in solutions

One group was stored in vials containing 5 ml of distilled water and kept in an incubator at 37°C as a control group and the distilled water

was renewed daily up to 1-month. The other specimens from each experimental group were individually immersed in vials containing 5mL of energy drinks Red bull, Vinegars, Orange juice for 5 second daily at room temperature (23±1°C).

After the immersion period in the test solutions, the samples were washed with distilled water and the specimens were maintained in distilled water at 37°C during the rest of the day. Newly opened test solutions were used for each day, The pHs of the solutions were measured daily with a pH meter (Fisher Scientific International, Loughborough, UK) before immersing the specimens, for the entire experimental period, Thereafter, in order to evaluate the change in surface hardness over time, surface roughness test were carried after 1-monthafter the start of storage for the control [9] by the use of profilometer (Federal Mahr pocket surf, USA) figure (1) each sample was measured three times in various locations within the area of experimental zone, the roughness value Ra was the average of these measurements in (µm).

Figure 1: Profilometer

RESULTS

Statistics for tested composite materials

Descriptive statistics:

Means, standard deviation, minimum, maximum of surface roughness values for the three tested composite materials are listed in table (3). The results showed that there was increasing in means of roughness values of all types of composite after immersion in acidic drinks, also the data revealed that the Filtek p60 had the lowest roughness values and Filtek Bulkfill posterior composite had the highest value

Inferential statistics:

Statistical analysis of data by using ANOVA test for all groups of tested composite revealed that there is a high significant differences ($p< 0.001$) in surface roughness values Ra among the groups for each composite material after immersion in acidic drinks and distilled water which show a high significant differences in surface roughness Ra values among the tested composite with as shown in table (3).

Table 3: Descriptive and ANOVA test among the three tested composite

Groups	Subgroups	Descriptive statistics					Comparison		
		N	Mean	S.D.	Minimum	Maximum	F-test	p-value	Sig.
Bulk fill	A1	10	0.15	0.01	0.14	0.16	329.974	.000	HS
	A2	10	0.27	0.02	0.25	0.29			
	A3	10	0.17	0.03	0.14	0.24			
	A4	10	0.39	0.01	0.37	0.40			
Sonic fill	B1	10	0.09	0.02	0.07	0.12	179.791	.000	HS
	B2	10	0.18	0.02	0.16	0.21			
	B3	10	0.10	0.02	0.08	0.13			
	B4	10	0.28	0.02	0.25	0.31			
P60	C1	10	0.05	0.02	0.02	0.08	28.147	.000	HS
	C2	10	0.07	0.01	0.06	0.08			
	C3	10	0.04	0.01	0.03	0.07			
	C4	10	0.10	0.02	0.08	0.12			

The data revealed from ANOVA test analyzed by Tueky test for all tested material which showed that there was a high significant increase in surface roughness value Ra of the three types of composite ($p> 0.001$) after immersion in both Red bull and Vinegar and there was non-significant differences ($p< 0.05$) in surface roughness value for the three materials after immersion in orange juice as shown in table (4) and fig (2).

Table 4: Tueky test among the groups for the tested materials

Groups	Subgroups		M. Differe	p-value	sig
Bulk fill	A1	A2	-0.12	.000	HS
		A3	-0.02	.077	NS
		A4	-0.24	.000	HS
	A2	A3	0.10	.000	HS
		A4	-0.12	.000	HS
	A3	A4	-0.22	.000	HS
Sonic fill	B1	B2	-0.09	.000	HS
		B3	-0.09	.759	NS
		B4	-0.19	.000	HS
	B2	B3	0.08	.000	HS
		B4	-0.09	.000	HS
	B3	B4	-0.18	.000	HS
P60	C1	C2	-0.02	.006	HS
		C3	0.00	.895	NS
		C4	-0.05	.000	HS
	C2	C3	0.03	.001	HS
		C4	-0.03	.002	HS
	C3	C4	-0.05	.000	HS

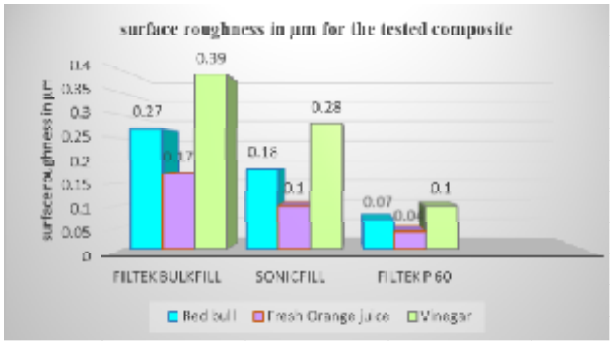

Figure 2: surface roughness of the three tested composite

Another statistical analysis were made between the subgroups for the tested material to analyze the effect of each acidic drinks on the three tested materials as shown in table (5), which consist of both descriptive and ANOVA test, Vinegars had the highest mean value for increasing surface roughness value Ra on all the tested groups followed by Red bull drink, while orange juice had the lowest increase in surface roughness values on all the tested composite materials.

ANOVA test showed that there was a high significant differences ($p < 0.001$) in surface roughness increase for all tested composite materials.

Table 5: Descriptive and ANOVA test for acidic drinks on each material

Media	Subgroups	Descriptive statistics					Comparison		
		N	Mean	S.D.	Minimum	Maximum	F-tesrt	p-value	sig
Control	A1	10	0.15	0.01	0.14	0.16	99.862	.000	HS
	B1	10	0.09	0.02	0.07	0.12			
	C1	10	0.05	0.02	0.02	0.08			
Red Bull	A2	10	0.27	0.02	0.25	0.29	398.052	.000	HS
	B2	10	0.18	0.02	0.16	0.21			
	C2	10	0.07	0.01	0.06	0.08			
Orange juice	A3	10	0.17	0.03	0.14	0.24	82.835	.000	HS
	B3	10	0.10	0.02	0.08	0.13			
	C3	10	0.04	0.01	0.03	0.07			
Vinger	A4	10	0.39	0.01	0.37	0.40	669.949	.000	HS
	B4	10	0.28	0.02	0.25	0.31			
	C4	10	0.10	0.02	0.08	0.12			

Data revealed from ANOVA test analyzed by Tukey test which showed that there was a high significant increase in surface roughness value ($p<0.001$) among the subgroup of the tested composite materials for each type of acidic drinks as shown in table (6) and fig (3).

Table 6: Tukey test between the subgroup of the tested materials according to acidic drinks

Media	Subgroups		Mean Difference	p-value	sig
Control	A1	B1	0.06	.000	HS
		C1	0.10	.000	HS
	B1	C1	0.04	.000	HS
Red bull	A2	B2	0.09	.000	HS
		C2	0.20	.000	HS
	B2	C2	0.11	.000	HS
range juic	A3	B3	0.07	.000	HS
		C3	0.13	.000	HS
	B3	C3	0.06	.000	HS
Vinger	A4	B4	0.11	.000	HS
		C4	0.29	.000	HS
	B4	C4	0.18	.000	HS

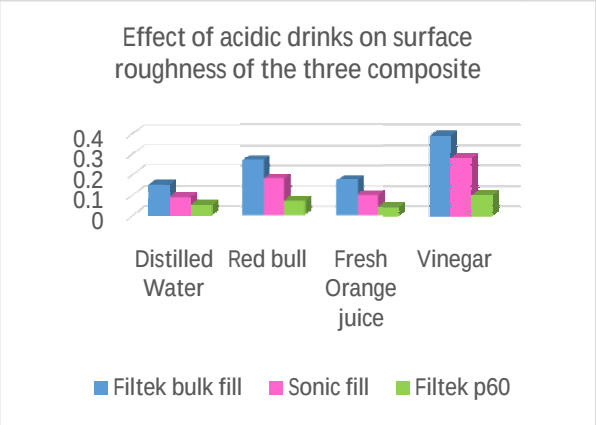

Fig. 3: Chart showed the effect of acidic drinks on the three tested composite

Another analysis were made to determine the difference of roughness increasing Δ Ra after immersion in all tested drinks by using this equation: after-before= Δ Ra[6]

The data revealed that the lowestΔ Ra value for all tested composite materials was in distilled water followed by the orange juice and the highest Δ Ra of roughness increase was in Vinegars and Red bull drinks as shown in table (7) and fig (4).

Table 7: Δ Ra difference between after and before surface roughness values.

variables		before	after	Δ Ra
bulkfill	control	0.14	0.15	0.01
	Red bull	0.14	0.27	0.13
	orange jui	0.14	0.17	0.03
	vinegar	0.14	0.38	0.24
sonicfill	control	0.09	0.092	0.002
	Red bull	0.09	0.184	0.094
	orange jui	0.09	0.101	0.011
	vinegar	0.09	0.278	0.188
p60	control	0.046	0.047	0.001
	Red bull	0.046	0.071	0.025
	orange jui	0.046	0.05	0.004
	vinegar	0.046	0.1	0.054

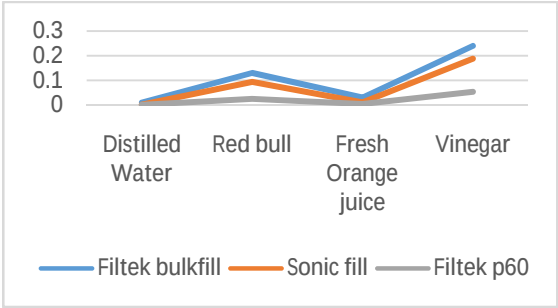

Fig. 4: A chart showed Δ Ra for the three composite after immersion in acidic drinks for one month.

DISCUSSION

Despite the improvement in composite resins physical and chemical properties, surface roughness is still the limitation on the longevity of the restoration[10],in this study all tested composite materials have shown increase in their surface roughness value after immersion in acidic solutions for 1month as shown in table (7) and fig. (4).

Base line surface roughness measurements

In this study the baseline surface roughness mean values for Filtek Bulkfill posterior composite were (0.14)µm for Sonic fill composite were (0.09)µm and for Filtek p 60 were (0.046)µm as shown in table (7).

Filtek p 60 had the lowest surface roughness values (Ra) than Sonic fill composite and Filtek bulk fill posterior composite which could be attributed to (1) the size, volume and distribution of filler particles, from table (1) the high filler content present in Filtek p 60 then Sonicfill composite then Filtek bulkfill posterior composite, these results agreed with the findings of previous studies [10] who found that roughness of composite is related to the size of filler particles with increasing of filler size and volume particles exhibited higher surface roughness.

(2) Type of resin matrix (table 1) and (3) the effect of silane surface treatment on the fillers, so surface degradation may be happened when the filler and the matrix resin were too weakly bonded, this might be attributed to insufficient surface treatment with silane was thought to result in filler erosion and it has been suggested that silanization of filler particles plays an important role as does the type of the resin used in the resin based composites [11].

Influence of distilled water on the three types of composite:

Distilled water exhibited less reduction on surface roughness value Ra of the three composite materials than the other acidic drinks after one

month as shown in table (7) and figure (4) in which Filtek p 60 had a lowest Δ Ra (0.001) µm then Sonicfill composite had Δ Ra value (0.002)µm and Filtek bulkfill posterior composite had Δ Ra value (0.01) µm this represent the lowest values for increasing surface roughness as compared to the other tested drinks and this can be explained by(1) neutral PH for water [12] (2) Another explanation to this increasing in Ra values may be attributed to the water absorption and hydrolytic degradation of the filler surface caused by filler/matrix cracking, this depend on type of resin such as UDMA exhibit functional groups (i.e. hydroxyls) that are prone to form hydrogen-bond with water molecules [11], thereby being able to absorb and retain in their resultant polymers a certain amount of water [13], Bis-GMA copolymer is highly susceptible to chemical softening, with a broad increasing range of solubility parameters. The extent of softening of Bis-GMA copolymer depended on the soaking chemicals, BisEMA (Ethoxylated Bis-phenol A Methacrylate) unlike the Bis-GMA, does not present the pendant hydroxyl groups that form the hydrogen bonds among the molecules and increase viscosity [14]. As shown in table (1) Filtek bulkfill posterior composite resin composed mainly from UDMA while Sonicfill resin mainly Bis-EMA while Filtek p60 resin composed from Bis-GMA, UDMA and Bis-EMA. This results are in agreement with previous studies [13,15,16].

Also resin composite materials that can absorb water capable of absorbing other acidic fluids resulting in surface degradation.it is assumed that water acts as a conductor for the acidic penetration into the resin matrix [13].

Distilled water was selected instead of artificial saliva to simulate the washing effect of saliva and also the artificial saliva storage medium is not considered to be a more clinically relevant environment, in addition previous studies [13] evaluated the influence of storage media upon the micromorphology of the resin based materials and achieved similar results for distilled water and artificial saliva

Influence of acidic drinks on the three types of composite:

In this study surface roughness values for the three composite materials had a high significant increase after immersion in Vinegars than Red bull drinks and the lowest increase in Fresh Orange juice after 1 month, with highest mean value for Filtek Bulkfill posterior composite than Sonicfill composite and the lowest mean value for Filtek p60 as shown in tables (5, 6) and figure (3). This can be related (1) potency of the acidic drinks, it is assumed that this finding is related to the titratable acidity as shown in table (2), in which Vinegars had lowest pH value (2.5), Red bull had pH value of (3.11) and fresh Orange juice had pH value of (3.5). The probable mechanism of acidity in composite resin degradation may be explained by the hydrolysis of ester radicals present in dimethacrylatemonomer, i.e. Bis-GMA, Bis-EMA, UDMA and TEGDMA. Although previous studies assumed PH as a reliable indicator of the acidity of the drinks, this parameter gives only the initial concentration of +H ions and does not represent the presence of undissociated acid in the medium. So titratable acidity can be considered as amore accurate measure of the total acid content present in substances and may represent their erosive effect more realistically this finding is in agreement with previous studies [17].

(2) Chemical composition,the kind of acid in the solutions might have reduced the surface hardness of the tested restorative materials. It has been reported that organic fillers can be damaged by citric acid [18]. In this study energy drinks contained citric acid and low PH value (3.11) as shown in table (2) they were found to be the one of the most aggressive storage medium for the composite as in tables (5,7) and figures (3,4) they have highly significant effect on surface roughness value Ra and ΔRa on the tested composite materials and this finding in agreement with previous studies [17,18] also an attempt to decrease erosion potential of beverage have been made by adding calcium, increasing their PH or adding ingredients such as casein, phosphopeptide stabilized amorphous calcium phosphate[19].

For Orange juice there was non -significant increase in surface roughness value Ra and Δ Ra as shown in tables (3,5,6) and diagrams of the three composite materials in spite of it is acidity (contain citric acid) and (3.5) pH value as shown in table (2)this result could be due to it is calcium and phosphours content[17]. This finding in agreement with [17,19,20].

Vinegar have (acetic acid 5-8%) and lowest PH value (2.5) among the tested drinks as shown in table (2) and have a highly significant increase in surface roughness value Ra for all tested material as shown in tables (4,5,7) although acetic acid is a weak acid but the speciation of weak acids in aqueous systems is depend on solution PH also the erosive capability of acidic drinks will be determined by the individual PH value, titratable amount of base as well as the phosphate and fluoride content [17]. This result was agreed with previous studies [17].

Finally it is important to notice that surface roughness means measure between 0.5 to 10

(clinically unacceptable) were sufficient for retaining most of bacteria and thus not protected against removal forces [21]. In this study Δ Ra and Ra values before and after table (7) showed that all the tested materials had values of Δ Ra and Ra parameter which is clinically acceptable.

In conclusion, all types of acidic drinks used in this study can cause surface degradation on composite material. The effect of energy and acidic drinks depend upon it is composition and acidity.

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