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ORIGINAL RESEARCH

Influence of Energy Beverages on the Surface Texture of Glass Ionomer Restorative Materials

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ABSTRACT

Background and objective: The objective of the study was to find whether energy beverages have an erosive effect, leading to a risk in the clinical performance of glass ionomer restorative materials.

Aim: This study evaluated the influence of energy beverages on the surface texture of glass ionomer restorative materials.

Materials and methods: Glass ionomer materials used were Ionofil Plus AC, GC EQUIA, and Ketac Molar; energy beverages are Code Red, Red Bull, and Power Horse. Specimens prepared were discs of 8 mm diameter and 3 mm thickness; specimens from each material were evaluated following aging with Code Red, Red Bull, and Power Horse energy beverages. Distilled water was used as a control. The surface roughness (Ra) was assessed by surface scanning interferometry. The surface roughness values (ΔRa and Ra) were measured for each specimen. The data were analyzed statistically using multiple repeated measures [analysis of variance (ANOVA)] and paired data t-test ($p < 0.05$ was considered as the significance level).

Results: The surface roughness (ΔRa and Ra) values before and after aging using Code Red, Red Bull, and Power Horse energy beverages differ significantly for all the materials regardless of the immersion time ($p < 0.05$). All the materials showed roughness changes after immersion periods of 1 day, 1 week, and 1 month.

Conclusion: It can be concluded that all energy beverage solutions used in this study had an adverse effect on the surface roughness degradation of the tested glass ionomers with increasing immersion time.

Clinical significance: Energy beverages have an erosive effect on glass ionomer, which influences the clinical importance of the material; it also has anticarious property because it releases the fluoride.

Keywords: Energy drink, Glass ionomer, Red Bull, Surface roughness.

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INTRODUCTION

There are various types of wears and tears of dental tissue while functioning in the oral cavity, such as erosion, abrasion, and attrition. Dental erosion is loss of dental tissues due to a chemical process, which is irreversible and without the involvement of microorganisms. The cause of erosion can be endogenous or exogenous. Acidic drinks and food are major exogenous sources of erosion.[1] Red Bull was introduced in Australia in 1987 and in the USA in 1997. Since then, energy beverages have grown exponentially. Hundreds of different brands are now available and marketed all around the world. USA is the largest community to consume energy drinks (~290 million gallons of beverages). Now, it is very common in the Middle East and Asian countries among youngsters.[2]

Glass ionomer cements (GICs) are used for different applications in dentistry including cementation and various kinds of restorations.[3] None of the dental materials nowadays have an ideal property for any dental application. On the contrary, GICs have a few shortcomings, for example, brittleness, poor wear resistance, and poor surface properties including sensitivity to moisture.[4] The GICs that have a smaller filler size distribution exhibited a smoother surface and are easier to polish and finish. Studies have established that no matter what size of filler is present in the resin-modified GICs, their surface roughness and hardness remain significantly lower compared with the resin composites. In addition, GICs are more prone to mechanical and chemical degradation, higher solubility, and wear.[5]

Glass ionomer restorative materials have unique properties, such as adhesion to tooth structure and anticariogenicity. Although these materials are tested for mechanical properties, they are rarely explored for the effects of aqueous media found in the mouth.[6] Studies have identified the consumption of acidic carbonated and noncarbonated beverages as one of the main causes of dental erosion. The roughening of the surface caused can affect the gloss and occlusal height of glass ionomer fillings. Consumption of energy beverages has been shown to produce dental erosion intraorally.[7,8] The current study has assessed the effects of energy beverages on the surface texture of the glass ionomer restorative materials.

MATERIALS AND METHODS

The surface roughness of three glass ionomers—Ionofil Plus AC self-adhesive restorative system (Voco, Cuxhaven, Germany), GC EQUIA self-adhesive posterior restorative system EQUIA (GC, Japan), and Ketac Molar self-adhesive restorative system (3M ESPE, Germany)—was assessed. We evaluated the effects of the three different solutions of energy beverages—Code Red, Red Bull, Power Horse, and distilled water was used as a control. The solutions were aged for 1 day, 1 week, and 1 month and stored at 37°C. The glass ionomers and energy beverages used are tabulated in Table 1.

Sixty specimens of the glass ionomer restorative materials were prepared, with five specimens for each tested material of different immersion groups (energy beverages).

All the prepared specimens of the tested materials were dispended and manipulated according to the manufacturer's instructions. Teflon molds, measuring 8 mm internal diameter and 3 mm height, were used to fabricate the specimens. The mold was completely filled with the material using the injecting gun method for all the tested materials within all groups. A glass microscope slide, overlaid with a cover glass (BDH Borosilicate glass) to act as a separator, was placed at each open end of the mold. The dual functions of the cover glass were to compact the material into a flat surface and act as a separator between the glass microscope slide and the mold. The specimens were stored at room temperature at ambient conditions.

To obtain surface standardization and clinical finish while in the Teflon disks, they were polished with 3M Sof-Lex disks, labeled, and then stored in a wide-mouthed bottle filled with distilled water (37°C/24 hours). This rehydration simulated the first day of service for glass ionomer restorations in the oral environment. The materials used in the current study imbibe water within the initial 24 hours of immersion.[9-11]

The surface roughness profile (baseline) of all the specimens measured before aging with different four groups measured before exposure to all energy beverages with a surface scanning interferometry (Contour GT-K0 BRUKER, Tucson, USA) Since the surface roughness values were being tested, before each measurement session, the surface scanning interferometry was calibrated according to the manufacturers' recommendations. The surface Ra parameter was selected from many other parameters, where Ra is the arithmetical mean roughness of all the values of the R profile within the measuring length.

The aging of the tested specimens of glass ionomer restorative materials was done by the preparation of a standard amount of energy beverage solution for immersing in medium prepared in all groups, i.e., about 150 mL of each type of energy beverage according to the manufacturers' suggestion, with group I being Code Red, group II Red Bull, group III Power Horse, and group IV distilled water (control).

The tested specimens were immersed in the energy beverage solution (energy drinks) in different groups to evaluate the surface roughness of the glass ionomer restorative materials at different immersion time intervals. The 15 specimens of each of the three glass ionomer

Table 1: Glass ionomers and energy beverages used

Material	*Type*	*Shade*	*Manufacturer*
Ionofil Plus AC	Glass ionomer	A_2	Voco, Germany
GC EQUIA	Self-adhesive posterior restorative system EQUIA	A_2	GC, Japan
Ketac Molar	Glass ionomer	A_2	3M ESPE, Germany
Code Red	Carbonated water, sugar, citric acids, trisodium citrate E331, taurine, caffeine, preservative sodium benzoate E211, inositol, vitamins, niacin, pantothenic acid, vitamins, approved colors	–	Saudi Arabia
Red Bull	Sucrose, glucose, acidity regulatory sodium, caffeine, vitamins, natural flavors, colors	–	Red Bull GmbH, Austria
Power Horse	Carbonated water, sucrose, glucose, citric acid, taurine, caffeine, color, inositol, niacin, pantothenic acid, vitamins	–	S. Spitz GmbH, Attnang-Puchheim, Austria

restorative materials were immersed in the solution of groups I, II, III, and IV (control), for periods of 1 day, 1 week, and 1 month at 37°C.

After the removal of the tested specimens from the immersion solution in all the groups, they were dipped in a cleansing solution, which consists of 15 mL soap and 850 mL distilled water; the specimen, following the removal, was shaken up and down 10 times, and subsequently flushed with running tap water. After that, each specimen was dipped in distilled water and shaken by moving up and down 10 times. Any excess fluid on the surface was dried using a clean tissue paper. Following this step, the specimens were ready for the surface roughness measurements at the time intervals indicated, and all the specimens were reimmersed in fresh solutions following measurement of surface roughness at each interval.

Measurements were repeated five times for each specimen of tested glass ionomer restorative materials in all the groups with different time periods of 1 day, 1 week, and 1 month, and the surface roughness measurement was done at baseline (before) and at time intervals of 1 day, 1 week, and 1 month.

The measured mean values of Ra (before and after at each time period for all the groups) and ΔRa data were calculated and are tabulated in Table 2 for all the materials in each group. The ΔRa surface roughness difference for each measurement of the specimen was calculated from the mean of Ra parameter before and after aging (immersion) with different elapsed time period values for each specimen of the tested material.

Statistical analysis was done for the mean estimated from the specimens of the materials aged (immersed) with the energy beverage groups at different time intervals of 1 day, 1 week, and 1 month. The mean values of the different groups at different aging (immersion) times were compared using analysis of multiple repeated measures analysis of variance (ANOVA) and paired data t-test. In the present study, $p < 0.05$ was considered as the level of significance.

RESULTS

In this study, the surface roughness parameters for each glass ionomer restorative materials used were calculated. The effects of the glass ionomer restorative materials on the surface texture (the surface roughness) for the tested materials with aging (immersion) at different time elapsed durations of 1 day, 1 week, and 1 month in each different group of energy beverages Code Red, Red Bull, Power Horse, and distilled water (control) were observed

The mean values of the surface roughness parameters of ΔRa and Ra changes for the tested materials before (baseline) and after immersion in the energy beverages for all glass ionomer restorative materials aged at different time elapsed durations of 1 day, 1 week, and 1 month, after its exposure to the different groups of Code Red, Red Bull, Power Horse, and distilled water (control) are summarized in Table 2.

The surface roughness Ra, the total surface roughness differences ΔRa, and the values postaging for all tested materials in this study with different time periods (immersion) of 1 day, 1 week, and 1 month with different groups of energy beverages (energy drinks), Code Red, Red Bull, Power Horse, and distilled water as a control, were statistically analyzed using multiple repeated measures

Table 2: Total surface roughness difference ΔRa and Ra pre- and postaging for tested glass ionomer materials immersed in energy beverages for different aging periods

	Ionofil Plus AC			*GC EQUIA*			*Ketac Molar*			
Duration	*Ra before*	*Ra after*	*ΔRa difference*	*Ra before*	*Ra after*	*ΔRa difference*	*Ra before*	*Ra after*	*ΔRa difference*	*p-value*
Surface roughness Ra in nm (Code Red medium)										
1 day	7.72	148.6	140.9	23.3	170.3	147.0	13.27	118.1	104.8	p = 0.000
1 week	7.72	153.3	145.6	23.3	176.9	153.6	13.27	125.4	112.1	
1 month	7.72	206.9	199.2	23.3	217.9	194.6	13.27	143.8	130.5	
Surface roughness Ra in nm (Red Bull medium)										
1 day	7.72	192.8	185.1	23.3	222.8	199.5	13.27	147.2	133.9	p = 0.000
1 week	7.72	215.8	208.1	23.3	246.1	222.8	13.27	160.4	147.1	
1 month	7.72	279.8	272.1	23.3	306.1	282.8	13.27	218.3	205.0	
Surface roughness Ra in nm (Power Horse medium)										
1 day	7.72	146.2	138.5	23.3	172.2	148.9	13.27	106.8	93.5	p = 0.000
1 week	7.72	155.4	147.7	23.3	178.3	155.0	13.27	110.2	96.9	
1 month	7.72	186.3	178.6	23.3	230.0	206.7	13.27	151.1	137.8	
Surface roughness Ra in nm (distilled water medium)										
1 day	7.72	10.4	2.7	23.3	25.9	2.6	13.27	10.6	−2.67	p = 0.019
1 week	7.72	10.0	2.3	23.3	25.2	1.9	13.27	10.8	−2.47	
1 month	7.72	11.5	3.8	23.3	25.6	2.3	13.27	13.4	0.13	

ANOVA and paired data t-tests at $p < 0.05$ level of significance. It was found that there were highly significant differences in the surface roughness Ra changes among materials at three different immersion periods of times for each aging solution ($p < 0.05$; Table 2).

With all the tested glass ionomer restorative materials, it was consistently observed that GC EQUIA specimens which were immersed in Red Bull for 1 month revealed the highest ΔRa values and the surface roughness increased with the time elapsed, whereas the lowest ΔRa values were observed in the Ketac Molar specimens after being immersed in Code Red for 1 month. When comparing the three glass ionomer materials immersed in Code Red, Red Bull, and Power Horse energy beverages, highly significant differences were observed after immersion for periods of 1 day, 1 week, and 1 month ($p = 0.000$). For specimens immersed in distilled water, significant surface roughness Ra difference was observed between the materials after the three different time periods of aging ($p = 0.019$). All the tested materials revealed an increase in the total surface roughness differences (ΔRa and Ra) postaging (immersion) with different time elapsed durations; however, this was clinically unacceptable (Ra < 0.5 μm) after aging.

The surface roughness Ra of the three glass ionomer specimen materials before aging with the initial measurement is also different from those postaging with the final measurement Ra, which reflects the surface degradation of the materials.

DISCUSSION

The glass ionomer restorative materials are well known clinically. Their unique properties make them useful as adhesive and restorative material, with adhesion to tooth structure and the metal base. Glass ionomer materials have anticariogenic properties with the fluoride release. This material has low coefficients of thermal expansion and thermal compatibility similar to tooth enamel and low cytotoxicity.[6,12]

The ability of materials to withstand against the functional force and exposure to different media in the oral cavity plays an important role of the requirement for their clinical performance for different periods of time.[6] Although material properties have been improved, the surface roughness is still a challenge for restoration longevity.[13] However, the major disadvantage of glass ionomer restorative materials is their tendency to cause surface texture degradation due to an increase in their surface roughness, which may be a major factor in the failure of restorations.[13] Hence, the restorative materials are desired to mimic the initial surface properties and maintain the same over time in the restored tooth.[14]

The energy beverages are popular worldwide, and are designed to provide a short-term energy boost; they derive their energy boost from sugar and caffeine.[15] They supply carbohydrates to augment the available energy and provide electrolytes.[16]

The materials are exposed to varying environmental conditions in the mouth, such as temperature changes and acid–base conditions; the materials should be able to withstand such changes and undergo minimal changes in such situations. Therefore, long periods of immersion time were used in this study to evaluate the extensive effects of acidic drinks on the glass ionomer restorative materials.[17]

The glass ionomers are susceptible to surface roughness degradation following exposure to energy drinks, cola, acidic juices, and coffee. However, to find out the associated effects of immersion in solutions, few studies have been carried out to demonstrate the results of changes in the physical properties of glass ionomer materials.[6,8] The previous studies have shown that glass filler particles tend to fall out from the materials,[18] and the matrix component decomposes when exposed to low pH environments (acidic).[18,19] Most of the energy and soft acidic drinks have a pH of 3.0 or lower. Therefore, consumption of acidic drinks for a prolonged period of time may erode the dental tissues as well as glass ionomers.

The surface profile (Ra) of the three dental glass ionomers was evaluated for the effects of acidic energy beverages, which are commonly consumed by the general population. The three tested materials in this study revealed significant surface roughness changes postperiods of immersion time—1 day, 1 week, and 1 month—in all groups of solutions.

The surface roughness (Ra) of the GC EQUIA specimens which were immersed in Red Bull for 1 month revealed the highest ΔRa values. The surface roughness increases with time and the specimens were the most prone to surface roughness (Ra) change with the Red Bull solution, whereas the lowest ΔRa values were observed in the Ketac Molar specimens after being immersed in Code Red for 1 month. The increase in the surface roughness (Ra) of the glass ionomers was associated with the type of acidic energy drinks and staining agent.[20] Glass ionomers are sensitive to water and are capable of absorbing acidic fluids with pigments, resulting in surface degradation. The water acts as a medium to facilitate acidic penetration, thus leading to material degradation and dimensional changes.[21,22] Acid and other liquid solution components, such as pigment penetration increase surface roughness (Ra).[21]

Outstanding the acidity of energy beverages (energy drinks), containing citric/carboxylic acid, which is capable of chelating ions were presents in glass ionomer material, such as calcium (Ca) and to form complexes of sufficient solubility in water.[16,23] The glass ionomer specimens were immersed in the energy beverages for specified time periods of 1 day, 1 week, and 1 month to evaluate the surface roughness (Ra) change that can be assessed by specific instruments. The surface quality and susceptibility to external degradation of the energy beverages on the surface profile (Ra) in this study was investigated. The same procedure and measurements were carried out on each type of material for all groups of immersion (aging beverages), using the same equipment. The current study uses a surface scanning interferometry (Contour GT-K0 BRUKER), and the Ra surface roughness parameter was selected from many other parameters of the surface profile coordinate system.[14] The Ra is the arithmetical mean roughness of R profile within the measuring length of the surface measured.

Surface roughness profile coordinate system is recommended for most of the dental applications.[14] The Ra surface roughness parameter was used to assess the surface profilometry and was considered suitable for the determination of minor changes.[24] The surface roughness calculated between 0.5 and 10 µm is rough enough to retain the bacterial plaque and is clinically not acceptable.[25] Low pH results in loss of minerals adsorbed on the dental hard tissues, thus affecting the surface.[26,27]

Surface roughness Ra parameter increases with time in different tested energy beverages, and it was highly significantly different in all glass ionomer restorative materials immersed with Code Red ($p = 0.000$), Red Bull ($p = 0.000$), and Power Horse ($p = 0.000$); the surface roughness values were measured using surface scanning interferometry. The study results of ΔRa and Ra before (baseline) and after immersion are tabulated in Table 2, which revealed that all materials had clinically unacceptable values of ΔRa and Ra.

The surface roughness change of the tested materials that were immersed in Code Red (pH = 3.0) for periods of 1 day, 1 week, and 1 month increased with time, and the highest values of the surface roughness Ra parameter in this group were obtained with Ionofil Plus AC after a period of 1 month (ΔRa 199.2 nm) compared with all the other materials in the group, and the lowest values were obtained with Ketac Molar after a period of 1 month (ΔRa 130.5), which were highly significant ($p = 0.000$).

ΔRa surface roughness values in specimens immersed in Red Bull (pH = 3.1) for the assigned periods were clinically unacceptable in the all periods of aging for all glass ionomer materials. GC EQUIA revealed a ΔRa surface roughness value of 282.8 nm (the highest value) among all materials in all groups. The Ketac Molar shows the lowest values in this group—1 day ΔRa 133.9 nm, 1 week ΔRa 147.1 nm, and 1 month ΔRa 205.0 nm—whereas for all the other materials, there is increase in the ΔRa surface roughness values, which were statistically highly significant ($p = 0.000$) as tabulated in Table 2.

The total surface roughness difference ΔRa in specimens of all tested materials immersed in Power Horse beverages (pH= 2.8) increased with time and was statistically highly significant ($p = 0.000$). The Ra surface roughness of Ketac Molar was clinically acceptable for periods of 1 day (Ra 93.5 nm) and 1 week (Ra 96.9 nm), whereas the ΔRa for GC EQUIA was the highest for 1 month (ΔRa 206.7 nm) and the ΔRa for Ketac Molar was the lowest for 1 month (ΔRa 137.8 nm). The acidic effect of this type of energy drinks after a period of 1 month of aging was the least among other types as is shown in Table 2.

All restorative materials are subject to wear; however, wear behaviors vary from one to the other.[28] This study has reported a variable surface degradation of glass ionomers exposed to beverages for periods of 1 day, 1 week, and 1 month. This finding is in agreement with the previous findings.[6] The results obtained from this study are in agreement with those of the other studies, which support the reliability of the measurement of surface roughness parameter technology using the surface scanning interferometry system.

CONCLUSION

The energy beverages have adverse effects on the surface roughness degradation of the tested glass ionomer materials with increasing immersion time. As indicated, the results reveal that carbonated energy beverages with low pH had more erosive effects on glass ionomers. The erosive potential of the beverages may depend on the type of solution acidity or the composition of the beverages (drink).

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