Stomatologija. Baltic Dental and Maxillofacial Journal, 21: 47-52, 2019

Effects of fruit drinks on surface roughness of two esthetic restorative materials

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SUMMARY

Objectives. Restorative materials may be exposed in the oral cavity to chemical agents found in beverages, which may lead to their biodegradation. The purpose of this in vitro study was to evaluate the effect of two fruit drinks commonly used by children on surface roughness of two esthetic restorative materials.

Materials and methods. One resin composite (RC), one resin-modified glass ionomer (RMGI) and two fruit drinks (orange and cocktail) were used in this study. Specimens (n=20) of each material were fabricated against Mylar strip. Baseline measurements of surface roughness were recorded for each group using noncontact surface profilometer. Each specimen was placed in the tested fruit drinks for 24 hours and then surface roughness was recorded.

Results. The mean (±SD) surface roughness of RC before and after immersion in orange and cocktail were 0.04±0.02, 0.12±0.05, 0.06±0.03 and 0.11±0.06, respectively and for RMGI were 0.72±0.14, 0.60±0.19, 0.56±0.11, and 0.52±0.15. For RC there was significant difference between surface roughness (Sa) before and after immersion in orange and cocktail ($P<0.05$). For RMGI, there was significant difference between surface roughness before and after immersion in orange ($P<0.05$), but no significant difference before and after immersion in cocktail ($P>0.05$).

Conclusions. The surface roughness of the RC and RMGI examined showed a significant change in the surface roughness after immersion for 24 hours in the tested fruit drinks.

Key words: surface roughness, optical surface profiler, biodegradation, surface Area, resin composite.

INTRODUCTION

Fruit drinks are largely consumed in most populations (1). In Saudi Arabia, it was found that canned fruit drinks were provided by 87% of the primary schools in Riyadh City (2). Another study reported that 92% of 13-15 year-old school children in Riyadh City consumed fruit drinks on a daily bases and that more than half of them consumed these drinks in schools (3). The excessive consumption of fruit drinks, poses hazard to young children especially in their primary dentition due to the reduced amount of tooth structure (1). The production of acid by bacteria after consumption of fruit drinks would lead to enamel demineralization (1). Similar to demineralization of enamel; acidic drinks may cause surface degradation of restorative materials (4). Also, resin-based restorative materials exposed to acids in the plaque, enzymes, and some food may undergo softening and their ingredients leak out when resin composite are exposed to particular substances in the food and drinks (5). Materials used for restorations of primary teeth may be subjected to continuously or intermittently to different substances found in different types of drinks, which may cause their deterioration (5, 6). Low pH drinks can affect solubility, surface roughness, and microhardness of compomer and glass ionomers while resin composite is relatively less affected (6).

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Different types of resin composite are commonly used because of their higher esthetic properties and ease of use (7). Resin-modified glass-ionomer cements are formed by the addition of polymerizable hydrophilic resins to conventional glass-ionomer cement which make them less sensitive to desiccation with minimal surface crazing, brittleness, solubility and with high strength (8). Surface roughness of different restorative materials governs the quality, color and performance of materials in the oral cavity (9). Roughness could also worsen buildup of plaque and diminish longevity and esthetics of the restorations (9). Experimental data demonstrated that high surface roughness of restorative materials is correlated to presence of more biofilm on its surface (10). The surface roughness influences the biofilm formation and maturation on restorative materials and a more complex biofilm can be formed on a rougher substrate rapidly 11, 12).

As far as the authors are aware, little information is known regarding the surface roughness of newer restorative materials after soaking in low pH fruit drinks that are frequently used by children. Therefore, the purpose of this *in vitro* study was to assess the effect of two fruit drinks on surface roughness of two esthetic restorative materials (submicron hybrid resin composite and resin-modified glass-ionomer). The tested null hypothesis was that there are no differences between surface roughness of different restorative materials before and after immersion in low pH fruit drinks.

MATERIALS AND METHODS

Materials and Fruit Drinks

This study was approved by the Ethical Committee of Human Studies, College of Dentistry Research Center, King Saud University. The two fruit drinks chosen to be tested were orange and cocktail drinks and the two restorative materials used in the present study and their manufacturers are presented in Table 1.

Preparation of Specimens

A total of 20 disc specimens were prepared for surface roughness evaluations from each material (Shade A2) using standard Teflon mold of 5-mm diameter and 2-mm thickness. The power sample size was determined as n=10. The materials were used according to the instructions of the manufacturers and compressed within the mold, covered by a Mylar strip (Dental Mylar Strips, Dent America Inc., City of Industry, CA, USA), and a microscopic glass slide (Shandon™ Polysine Slides, Thermo Scientific, Kalamazoo, MI, USA) was placed on the top to press flat the material even with the surface of the mold. Each specimen was then light cured for 20 seconds using an LED curing light (Elipar S10, 3M ESPE, Seefeld, Germany). The

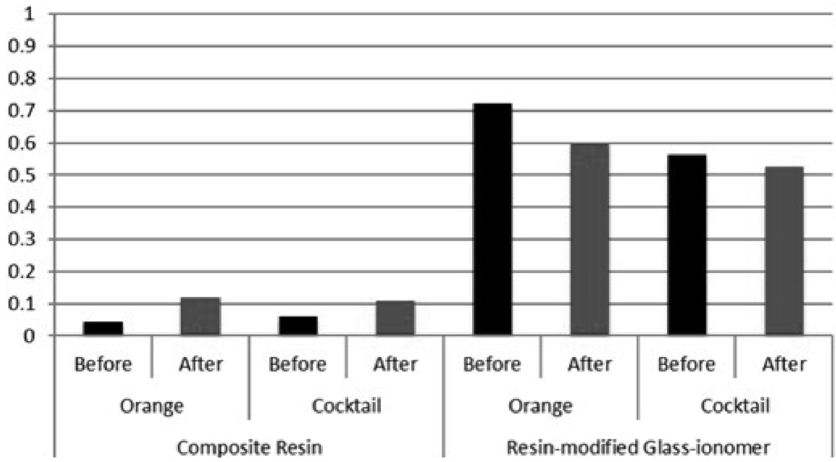

Fig 1. Mean surface roughness of each material after immersion in each fruit drink

Table 1. The esthetic restorative materials and fruit drinks used in the present study

Materials	Manufacturers	Lot Number
Spectrum® TPH®3	DENTSPLY, Surrey, KT15 2PG, UK	1203001231
3M™ ESPE™ Photac™	3M Center, St. Paul, MN , USA	479684
Orange Drink pH 2.99	Al Rabie Saudi Foods Co. Ltd., Riyadh, KSA	6281026165100
Cocktail Drink pH 3.47	Al Rabie Saudi Foods Co. Ltd., Riyadh, KSA	6281026083602

Table 2. Descriptive statistics of surface roughness for each restorative material before and after immersion in each fruit drink

Restorative Material	Fruit Drinks		Mean	Std. deviation	N	Sig.
Resin Composite	Orange	Before	0.04	0.02	30	0.00*
		After	0.12	0.05	30	
	Cocktail	Before	0.06	0.03	30	0.00*
		After	0.11	0.06	30	
Resin-modified glass-ionomer	Orange	Before	0.72	0.14	30	0.00*
		After	0.60	0.19	30	
	Cocktail	Before	0.56	0.11	30	0.19**
		After	0.52	0.15	30	

Sa – Arithmetic mean height; PPT – Pressure Pain Threshold.

Fig 2. Mean surface roughness of each material according to the fruit drink used

bottom of the cylindrical specimen was also light cured for 20 seconds and marked to identify the bottom surface, so only the top surface was measured for surface roughness. No further finishing or polishing was done except that the top surface of each specimen was finished to a uniform surface using #600 grit silicone carbide papers (standard finished surface) with tap water. Polished with Soflex system (3M ESPE, St. Paul, USA) was accomplished according to the manufacturer's instructions using a slow-speed handpiece immediately after finishing, resembling the clinical situation. The specimens were then stored in distilled water (pH 6.8) at room temperature for 24 hours. The specimens from each material were then randomly divided into 2 groups with 10 each. Baseline measurements of surface roughness were recorded after 24 h storage in distilled water. Groups 1 and 3 were immersed in the orange drink and Groups 2 and 4 were immersed in the cocktail drink. Each specimen was immersed for 24 hours in a closed individual container containing 2.5 mL of the respective immersion fruit drinks. The can of each fruit drink was stirred well before opening as recommended by the manufacture. After the immersion period, all specimens were washed with deionized water and new roughness readings were completed under the same conditions.

Table 3. Comparison of difference in surface roughness between restorative materials when immersed in each fruit drink

Fruit Drink	Material	Mean	Std. deviation	N	Sig.
Orange	Resin Composite	-0.07	0.06	30	0.000
	Resin-modified Glass-ionomer	0.13	0.17	30	
Cocktail	Resin Composite	-0.05	0.05	30	0.007
	Resin-modified Glass-ionomer	0.04	0.16	30	

Table 4. Comparison of difference in surface roughness according to the fruit drink used for each material.

Material	Fruit Drink	Mean	Std. deviation	N	Sig.
Resin Composite	Orange	-0.07	0.06	30	0.062
	Cocktail	-0.05	0.05	30	
Resin-modified Glass-ionomer	Orange	0.13	0.17	30	0.046
	Cocktail	0.04	0.16	30	

Optical Profiler Analysis

The surface roughness of restorative materials was analyzed with a 3D optical noncontact surface profiler (Contour Gt-K1 optical profiler, Bruker Nano, Inc, Tucson, AZ, USA) based on noncontact scanning interferometry to evaluate roughness of each surface. The objective standard camera has a magnification 5X. The profile meter scanned area (3 measurements in different directions) was approximately 1.3×1.0 mm^2 and were situated at the center of each surface. Multi-Core Processor with Vision64™ Software for Accelerated 3D Surface Measurement and Analyses were used for image transfer (Bruker Nano Surface Division, Inc, Tucson, AZ, USA).

Statistical Analysis

Two-way Analysis of Variance (ANOVA) and paired t-test were used to compare and evaluate interactions between the two materials and the two fruit drinks. All statistical analyses were set with a significance level of $p<0.05$. The statistical analysis was carried out with SPSS V16.0 (SPSS Inc, Chicago, Ill).

RESULTS

Generally, the low pH fruit drinks used in this study affected surface roughness of the tested materials. Orange and cocktail drinks adversely affected the resin composite while favorably affected resin-modified glass ionomer. Surface roughness was increased for resin composite and decreased for resin-modified glass ionomer following immersion in orange and cocktail drinks for 24 hours. Hence, the null hypothesis was rejected as there are differences between surface roughness of different restorative materials before and after immersion in low pH fruit drinks. Two-way ANOVA showed no interaction between resin composite and resin-modified glass ionomer. Mean (±SD) of surface roughness {Sa = Arithmetic mean height} for each material in micrometer (μm) before and after immersion in each fruit drink is presented in Table 2. Figures 1 and 2 show mean surface roughness of each material after immersion in each fruit drink. Paired t-test showed that for resin composite there was significant difference between Sa before and after immersion in orange and cocktail ($P<0.05$) (Table 2). For resin-modified glass ionomer there was significant difference between Sa before and after immersion in orange ($P<0.05$) but there was no significant difference between Sa before and after immersion in cocktail drink ($P>0.05$) (Table 2). In general, resin composite showed the smoothest surface before and after immersion in fruit drinks compared to resin-modified glass ionomer.

Comparison of difference in surface roughness between materials when immersed in each fruit drink showed significant difference after immersion in orange drink while no significant difference was noted after immersion in cocktail drink (Table 3). Comparison of difference in surface roughness according to the fruit drink used showed no significant difference of roughness of resin composite and significant difference of roughness of resin-modified glass ionomer (Table 4).

DISCUSSION

In United States and Saudi Arabia; vending machines in schools provide ready access to highly-refined carbohydrates such drinks as juices and sports drinks (2, 3, 13). Foods and beverages, especially fruit drinks that contain a variety of acids and fermentable carbohydrates were capable to drop the pH of the dental plaque structure (1, 14). It was reported that children who go to schools that had vending machines have increase in caries scores (15). In the present study orange and cocktail drinks which are commonly available to children through school canteens in primary schools were selected as they were considered to be popular brands and have low pH value. The American Academy of Pediatric Dentistry (AAPD) inspires administrators of schools and parents to have healthy selections in vending machines (13).

The goal is to produce restorations with smooth surfaces without irregularities which result in improved esthetics and minimal plaque accumulation (6, 16). In the present study, generally low pH fruit drinks unfavorably affected surface roughness of resin composite and surface roughness was increased following immersion in orange and cocktail drinks for 24 hours. This is similar to another study where low pH beverages adversely affected the properties of conventional glass ionomer, resin-modified glass ionomer, compomer, and resin composite (6). The present study showed that orange and cocktail drinks favorably affected resin-modified glass ionomer and surface roughness was decreased for resin-modified glass ionomer following immersion in orange and cocktail drinks for 24 hours. However, the baseline of surface roughness of resin-modified glass ionomer was higher than that of resin composite. There is no agreement about reference data on the limit roughness below which the bacteria would not adhere (17). The most commonly mentioned limit of surface roughness (Ra) is below 0.2μm for adherence of dental biofilm (10, 18, 19). May be it is most accurate to say, that it depends on the bacteria species. It is important to emphasize that rough surfaces favor bacterial adhesion and biofilm formation on the teeth and restorations, which can further cause secondary caries, gingival and periodontal diseases (18, 19). In the present study, the mean surface roughness of resin composite before and after immersion in orange and cocktail were 0.04, 0.12, 0.06 and 0.11 and for resin-modified glass ionomer were 0.72, 0.60, 0.56, and 0.52 respectively. Although comparisons between surface roughness data of different studies have to be taken with thoughtfulness due to differences in methods and settings of surface analysis as well as test materials. It is not possible to compare roughness values obtained with contact profilometer along one line of the specimen with those values obtained with the non-contact optical interferometers as surface area. It should be noted that, in the present study, generally resin composite showed less surface roughness than resin-modified glass ionomer. Another study reported that resin composite was the smoothest surface with lowest solubility after immersion in low pH beverages (6). The lower surface roughness values of resin composite can be explained by material filler composition. This material is a submicron hybrid resin composite, filled with nanometer size particles, from which some are dispersed and others create nanoclusters, as secondary formed fillers (20). The size of these nanoclusters can range from about 0.6 to 10 μm (20). Also in the present study, there was significant difference between Sa before and after immersion in orange and cocktail as well as for resin-modified glass-ionomer there was significant difference between Sa before and after immersion in orange. A study showed that a greater degree of erosion occurred for the traditional glass ionomer than resin-modified glass ionomer by both the simulated gastric acid and the simulated lemon juice (14). Also, erosion of resin-modified glass ionomer was more superficial than for the traditional glass ionomer where bulk loss of material resulted (14).

Mylar strips and celluloid crowns are usually applied as matrices for shaping restorative materials which more likely require no further surface finishing (10). It was recommended using polyester strips against resin composite to produce the best smooth surface (10) which justified its application in the present study. This is supported by another study which reported significantly higher surface roughness for polished resin composite compared to the one polymerized against Mylar strips (21). It has been reported that the consequence of using different polishing methods on surface roughness and most have indicated that none of these methods could reproduce the surface smoothness initially created by a Mylar strip (22, 23). However, another study observed this phenomenon only for one resin composite material, whereas other resin composites showed no significant differences in surface roughness between the surfaces polished with silicone carbide paper and those polymerized against Mylar strips (16, 23). In the present study; the specimens were cured against a Mylar strip and no further finishing or polishing was done except that the top surface of each specimen was finished to a uniform surface using # 600 grit silicone carbide papers and polished with Soflex system. This protocol was followed for all materials.

In the present study, each specimen was placed in a separate closed container containing 2.5 mL of the tested fruit drinks for 24 hours. This time period was selected to mimic *in vivo* situation of having long term effect of fruit drinks. The study set out to examine the worst case scenarios, such as might occur in a child who likes to frequently drink fruit drinks. It was reported that storing restorative materials in mouthwashes for 12 hours is equivalent to the use of mouthwash for 2 minutes per day for 12 months (24). This may be similar to restorative materials which may either be exposed continuously or intermittently to materials found in different drinks, which may lead to deterioration and biodegradation (5, 6).

As measurement of surface roughness determined by measurement method, the research protocol for roughness is vital (25). The assessment of roughness using scanning electron microscope (SEM) is subjective and descriptive as well as unreliable for quantitative analysis (26). A contact profilometer with a stylus that moves in line is used for the quantitative investigation of roughness and may induce misconception due to holes on the surface (27). Other instruments are available to measure roughness at a much higher resolution and over a larger area such as non-contact optical interferometers and atomic force microscopes (AFM). In this study, the optical interferometry noncontact profilometer was used to measure surface roughness. Compared with a stylus profilometer, the optical interferometry noncontact profilometer is faster, nondestructive, and allow repeatability. In addition, it provides a larger field and does not need sample preparation in comparison with AFM. There are few reports of using optical interferometry noncontact profilometer to determine the surface roughness of restorative materials.

Resin-modified glass ionomers have lower resistance to softening by certain drinks than microfilled composites (6). Resin-modified glass ionomers that use acid monomers instead of polyalkenoic acid have higher resistance to softening than other resin-modified glass ionomers (28). A recent *in vitro* study reported that food-simulating drinks affect surface roughness of restorative materials and biodegradation depend on the material, solution and exposure time (29).

The results of this investigation should consider the limitations of the study, including its *in vitro* setting and immersion of the tested materials in fruit drinks for 24 hours to simulate cumulative long term effect of fruit drinks *in vivo*. This may be different if we immersed the tested materials in fruit drinks for less number of hours such as 8 or 12 hours and repeated the immersion for 24 hours. Also, the clinical condition in the mouth is not easy to mimic in the laboratory (30). However, in this *in vitro* study standardization of experimental conditions was advantage and the results demonstrated a clear correlation between surface roughness of one resin composite and one resin-modified glass ionomer and immersion in fruit drinks. Another limitation is that the specimens were immersed in the fruit drinks without stirring which may allow some component of the fruit drinks to settle down and decrease their effect. The manufacture of the fruit drinks used recommend to shake well the can before opening which was performed before it is use but not during immersion period.

CONCLUSIONS

Under the experimental conditions and within the limitations of this *in vitro* study, the following conclusions can be drawn:

The surface roughness of the tested resin composite and resin-modified glass ionomer showed significant change in the surface roughness after immersion for 24 hours in the two types of fruit drinks.

In general, resin composite showed the smoothest surface before and after immersion in fruit drinks compared to resin-modified glass ionomer.

Surface roughness varied depending on the fruit drink and the restorative material used.

ACKNOWLEDGEMENT

The authors wish to thank College of Dentistry Research Center and Deanship of Scientific Research at King Saud University, Saudi Arabia for funding this research. Also, the authors wish to express sincere thanks to Mr. Nassr Al Maflehi for his valuable help in the statistical analysis.

CONFLICTS OF INTEREST

No any financial disclosures or conflicts of interest for all authors.

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Received: 23 10 2016
Accepted for publishing: 21 06 2019