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Evaluation of Surface Roughness of Different Esthetic Restorative Materials after Immersion in Different Acidic Media

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Abstract

BACKGROUND: Dental erosion that resulted from increasing the acidity of oral conditions not only affects tooth substrates but also the performance of some esthetic restorations.

AIM: The aim of the present study was to measure and evaluate the surface roughness of different tooth colored restorative materials (resin composites) after immersion for certain time in different acidic food and drinks.

MATERIALS AND METHODS: Three types of composite restoration have been used in this study. The three types were of three main groups. Each group of 20 specimens (n = 20) were divided; according to type of acidic media, they were immersed in into five subgroups (n = 4). Different acidic beverages and drinks were used in this study include Coke Cola soft drink, orange juice, Pepsi soft drink, sports drink, and lemon juice. Immersion of specimens' in previously mentioned acidic drinks were for 5 min; then, they have been immersed in distilled water to simulate to great extent what happened in oral cavity. These procedures repeated daily for 14 days. Surface roughness for specimens has been measured by a profilometer (Talysurf CLI 1000, Leicester, England) device before and after immersion. Data were collected, tabulated, and analyzed using one-way analysis of variance (ANOVA).

RESULTS: The assessment of surface roughness by one-way ANOVA and Tukey's *post hoc* tests showed significant differences for composite material types as well as an interaction between these parameters for each composite after immersion in different acidic beverages ($p < 0.05$).

CONCLUSION: Within the limitation of this study, results revealed that composition of both resin composite and different acidic beverages and drinks plays an important role in initiation and conduction of surface roughness at the outer surface of resin composite restoration.

Introduction

The acidic dissolution from outside origin (i.e., not from bacterial plaque origin) was the most common cause of dental erosion [1], [2]. The presence of proper amount of saliva can neutralize or dilute the acidic effect on tooth substrates [2], [3]. One of the main sources of acids from outside origin is consumption of acidic beverages that initiate the dental erosive activity with subsequent mineral loss of tooth substrates [3], [4]. Fruit juices, sour, spicy food, and carbonated soft drinks have a relation with progress of dental erosion [5], [6], [7]. As media in modern societies give a big concern to the nature of healthy food and drinks for children, youth and adults, knowledge about the components, and ingredients of the popular food-stuff and drinks and their relation with initiation and progression of dental erosion became an important issue in these modern societies [7], [8]. Dental erosion that resulted from increasing the acidity of oral conditions not only affects tooth substrates but also the performance of some esthetic restorations. Biodegradation of conventional GIC and its modified forms is severely affected by acidic nature of food stuff and beverages. Surface roughness and some physical properties of resin composite and its derivatives are also influenced by acidity and erosive activity [9], [10]. Surface roughness and hardness are significant clinical indicators of the success of restorations. On rough restoration surfaces, plaque accumulation, discoloration, gingival irritation, and secondary caries can be seen. Furthermore, materials with a lower surface stiffness are more prone to deformation. The structural properties of the material, such as monomer form, filler type, and percentage, impact the surface roughness and hardness of composite restorations. Roughness and hardness of composite materials are also affected by finishing and polishing of the restorations [11]. An increase in superficial roughness is clinically relevant, and regardless of the cause, it leads to the accumulation of food residues and the development of biofilms, which leads to periodontal tissue diseases especially in class V restorations [12], [13]. Microhybrid resins are one of the most widely used resin types. Materials scientists have recently developed wide varieties of nanofilled composites, which have recently been introduced to the dental industry [14], [15]. These nanocomposites were created to provide mechanical strength as well as well-polished surfaces that maintain their integrity over time, including the posterior regions of the mouth [16], [17]. The aim of the current study was to measure and evaluate the surface roughness of different tooth colored restorative materials (resin composites) after immersion for certain time in different acidic beverage and drinks.

Materials and Methods

Before starting this *in vitro* study, the ethical approval was obtained from the Scientific Research Unit of Vision College for Dentistry and Nursing. The research proposal was approved by Institutional Review Board at Vision College for Dentistry and Nursing in Riyadh, Saudi Arabia.

Selection of composite resin

Three types of resin composites were used in this *in vitro* study. Selection criteria for the composite brands include that they could be of Nano fill category with same curing time, same shade and depth of cure.

1. Ceram.x sphereTEC one universal nanoceramic restorative (dentsply DeTrey GmbH De-Trey-Str.178467 Konstanz GERMANY)
2. Filtek Z350 XT Universal Restorative (3M ESPE 2510 Conway Avenue St. Paul, MN 55144-1000 USA)
3. Tetric N-Ceram Refill (Ivoclar Vivadent AG FL-9494 Schaan/Liechtenstein.

The specifications of each composite resin brand are described in Table 1.

The composite resin specimens were made using a custom-made stainless-steel mold with orifices of 10 mm in diameter and 2 mm in thickness. The mold was positioned on a glass plate and filled with composite resin. A polyester strip was then placed on the composite resin followed by a glass plate to obtain a flat surface. The composite resin was then light cured with the light emitting diode unit Radii-cal (SDI, Australia) for 20 s at 1 mm distance from the surface of the specimen. Surface roughness of composite was measured before starting immersion of specimens in acidic beverages and any measurement values that exceed 0.02 was discarded. The three composite types will be of three main groups (n = 15). Each main group will be divided; according to type of acidic media, they will immersed-in into five sub-groups (n = 3). Different acidic beverages and drinks will be used in this study include Coke Cola soft drink, orange juice, Pepsi soft drink, Bison sports drink, and lemon juice. Immersion of specimens' in previously mentioned beverages and drinks was for 5 min then immersed in distilled water to simulate to great extent what happened in oral cavity. These procedures were repeated daily for 14 days. Surface roughness for specimens was measured by a profilometer (Talysurf CLI 1000, Leicester, England) device before and after immersion. Data were collected, tabulated, and analyzed using one-way Analysis of variance (ANOVA).

Sample grouping

Group 1: Represent (Ceram.x sphereTEC one universal nanoceramic restorative) and it referred to as (ST). Then divided into five subgroups (n = 3) according to type of acidic media, they were immersed-in.

Group 2: Represent (Filtek Z350 XT Universal Restorative) and it referred to as (3M). Then divided into five subgroups (n = 3) according to type of acidic media, they were immersed-in.

Group 3: Represent (Tetric N-Ceram Refill) and it referred to as (T). Then divided into five subgroups (n = 3) according to type of acidic media, they were immersed-in.

Measurement of surface roughness

Surface roughness of the samples was measured using a profilometer (Talysurf CLI 1000,

Table 1: Specifications and manufacturers of nano fill resin-based composites

Composite resin	Composition	Manufacturer
Ceram.x® sphereTEC™ one universal nanoceramic restorative	A blend of spherical, pre-polymerized SphereTEC™ fillers (d3,50≈15 μm), non-agglomerated barium glass (d3,50≈0.6 μm) and ytterbium fluoride (d3,50≈0.6 μm). Depending on the shade, the filler load ranges from 77 to 79 weight-% total (59%–61% by volume) resin matrix contains highly dispersed, methacrylic polysiloxane Nano-particles	DENTSPLY DeTrey GmbH De-Trey-Str. 178467 Konstanz GERMANY
Filtek™ Z350 XT Universal Restorative	Nonagglomerated/nonaggregated 20 nm silica filler, non-agglomerated/non-aggregated 4 to 11 nm zirconia filler and an aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles). Cluster particle size of 0.6 to 10 microns. The inorganic filler loading is about 78.5% by weight (63.3% by volume) bis-GMA, UDMA, TEGDMA, PEGDMA and bis-Ema resins	3M ESPE 2510 Conway Avenue St. Paul, MN 55144-1000 USA
Tetric N-Ceram Refill	Consists of dimethacrylates (19–20 weight %). The fillers contain barium glass, ytterbium trifluoride, mixed oxide and copolymers (80–81 weight %). Additives, initiators, stabilizers and pigments are additional contents (<1 weight %). The total content of inorganic fillers is 55–57 vol.%. The particle size of inorganic fillers is between 40 nm and 3000 nm	Ivoclar Vivadent AG FL-9494 Schaan/Liechtenstein

Leicester, England). The device was calibrated as recommended by the manufacturer instruction. Each sample was subjected to measurements in triplicate, and the mean value was calculated and reported. For the purpose of standardization, surface roughness was measured at the center of samples and at two other points with 2-mm distance from the center.

Statistical analysis

The surface roughness measurements and data were statistically analyzed using the one-way ANOVA and Tukey's tests through SPSS version 21 (SPSS Inc. Chicago, IL, USA). The assessment of surface roughness was done using one-way ANOVA and Tukey's *post hoc* tests. $p < 0.05$ was considered statistically significant.

Results

The assessment of surface roughness by one-way ANOVA and Tukey's tests showed significant differences for composite material types as well as an interaction between these parameters after immersion in different acidic beverages ($p < 0.05$).

- Results of Group 1: Ceram.x sphereTEC one universal nanoceramic restorative (Dentsply) that has been referred to as (ST) and are collected in Table 2.

Table 2: Surface roughness measurements (mean values) for Group 1 (ST)

Sample number	Samples of subgroup ST				
	ST1	ST2	ST3	ST4	ST5
Acidic Beverage	Orange juice	Lemon juice	Bison	Coca cola	Pepsi cola
Before immersion	0.110	0.114	0.130	0.081	0.083
After immersion	0.465^{++}	0.582^{++}	0.478^{++}	0.227	0.294

$^{++}$Statistically significant.

- Results of Group 2: Filtek Z350 XT Universal Restorative (3M ESPE) that has been referred to as (FZ) are collected in Table 3.

Table 3: Surface roughness measurements (mean values) for Group 2 (3M)

Sample number	Samples of subgroup 3M				
	3M1	3M2	3M3	3M4	3M5
Acidic beverage	Orange juice	Lemon juice	Bison	Coca cola	Pepsi cola
Before immersion	0.123	0.145	0.189	0.081	0.083
After immersion	0.282	0.465^{++}	0.478^{++}	0.156	0.494^{+}

$^{++}$Statistically significant.

- Results of Group 3: Tetric N-Ceram Refill (Ivoclar Vivadent) that has been referred to as (T) is collected in Table 4.

Table 4: Surface roughness measurements (mean values) for Group 3 (T)

Sample number	Samples of subgroup T				
	T1	T2	T3	T4	T5
Acidic beverage	Orange juice	Lemon juice	Bison	Coca cola	Pepsi cola
Before immersion	0.127	0.132	0.126	0.099	0.083
After immersion	0.182	0.406^{++}	0.278	0.177	0.116

$^{++}$Statistically significant.

Discussion

This investigation purposed to analyze and evaluate the surface roughness of resin composites before and after immersion in different acidic beverages and drinks. Three types of resin composites were used in this *in vitro* study. Selection criteria for the composite brands include that they could be of Nano fill category with same curing time, same shade, and same depth of cure. This is done for reduce the variables and for more standardization of factors for more accurate results. Based on gaining more valid predictions of surface roughness of various restorative materials, the present methodology was designed based on the average profilometer results and measurements and data were statistically analyzed using the one-way ANOVA and Tukey's tests through SPSS version 21 (SPSS Inc. Chicago, IL, USA).

Results of the present study revealed that lemon juice has an aggressive effect on the surface roughness of the three types of composites. This is in agree with study of Wattanapayungkul *et al*. [18] about the effect of artificial lemon juice that commonly used by young person's their teeth restored with resin composite filling. Results of that study revealed that lemon juice affected the surface roughness of nanofilled composites Grandio and Supreme after 3rd and 4th weeks, respectively, but microhybrid composite resins were not significantly affected ($p > 0.05$). Wattanapayungkul *et al*. [18] found that when another concentration of diluted lemon juice was used, Filtek Z350 was the only material that has not affected by this beverage over time. Filtek Z250, Grandio and Opallis demonstrated an increase in roughness with an increase in consumption time, but final and initial roughness were not statistically different ($p > 0.05$). Results of the present study revealed that lemon juice caused great changes in surface roughness for all tested composite materials; this effect could be due to the low PH that indicates high acidity of lemon. It has been shown in the literature that lemon juice can affect surface roughness [17], [19]. This roughening probably occurs due to attack of the organic matrix, causing a softening of the material and leading to gloss loss [20]. Because different compounds are present in both the organic and inorganic fractions of restorative materials, even in products that are similarly categorized, these materials can react differently to the same treatment. This possibility was confirmed in this study. Low PH can increase the effects of lemon juice on the surface roughness of restorative materials.

Regarding the effect of Bison sports drink, results revealed different responses of the resin composite materials. The material (ST): Ceram.x sphereTEC one universal nanoceramic restorative (Dentsply) was not as affected as (T): Tetric N-Ceram Refill (Ivoclar Vivadent), while the most affected one was (3M): Filtek Z350 XT Universal Restorative (3M

ESPE), indicating a better performance of some types of nanofilled materials compared to others. This is in agree with another studies that showed greater alterations in surface roughness of composite materials of same category when undergone at Bison Sport Drinks over extended period of time [20], [21]. These data reinforce the statistical analysis that indicated an interaction between factors, because the performance of the materials was not the same. Ulukapi H. [22] and Gurgan and Yalcin [17] demonstrated that the performance of different composites is strongly influenced by different composition, especially due to monomers. This relationship indicates an interaction between the organic matrix and PH of consumed beverages. Musanje and Ferracane [23] verified the effect of monomers on experimental hybrid resins associated with no silanized nanofilled. In that study, the results also showed a major susceptibility of composite organic matrix to affected by Sport drinks. The influence of different acidic drinks depends on the high acidity that strongly penetrates the composite organic matrix, which can facilitate water absorption and lead to loss of particles, reducing superficial integrity and microhardness [24]. In an extensive review based on original articles that investigated the action of different acidic beverages on different esthetic restorative material surfaces, Attin *et al*. [25] found that when patient of teeth restored by composite resins is subjected to low PH drinks, roughness can be a relevant tool to assess surface changes. Roughness of composite resin seems to be more affected by low PH value than composite shade. However, when saliva is present, adverse consequences are reduced, because saliva acts as a protective barrier. Mor *et al*., [26] Steinberg *et al*. [27], and Ulukapi *et al*. [22] also demonstrated both the ability of saliva to re-mineralize enamel after dropping of PH due to acidic drinks consumption and its fluoride benefits. In the present study, as saliva was not considered, we could assess the potential of acidic beverages uptake without this interference. Erosive effect of low PH beverages can also alter the optical properties of composite resins, which depend on the composition of resin composite materials as well as on the acidity of consumed drinks [20], [28]. Results of the present study revealed that orange juice has a statistically significant effect on surface roughness of Ceram.x sphereTEC one universal nanoceramic restorative (Dentsply) that has been referred to as (ST) but has no effect on the other two types of tested composites. Results of the present study revealed that Pepsi Cola has an effect on surface roughness Filtek Z350 XT Universal Restorative (3M ESPE) that has been referred to as (FZ) but has no effect on the other two types of tested composites. Results of the present study revealed that Coca Cola has no statistically significant effect on surface roughness of all types of tested composites.

Results of the present study confirm that the basic environment can lead to chemical interactions in the oral scenario [21]. In this case, one of the main speculations refers to the hydrolytic action caused by chemical solutions on the organic matrix of resin composites, which is composed of hydrophobic monomers and diluents [29], [30]. It is also noteworthy that specimens were stored in distilled water during the experimental study period, and so, specimens were stored under hydrolytic environment. There is evidence in the literature that demonstrates that water causes changes in the properties of restorative materials. These changes mainly occur at the interface between the filler and organic matrix [29], [30]. Alterations in the molecular structure of the matrix are under evaluation, and studies are being performed to make the matrix more resistant to chemical and mechanical challenges [31]. The inorganic filler content of resin composites, however, offers resistance to acidic beverages. Form this point of view, the amount and distribution of fillers is all aspects that determine the clinical performance of these restorative materials [31], [32]. Despite advances in the evolution of composites, no material yet exists that is totally resistant to erosion/corrosion that may be resulted after composite resin subjected to acidic beverages for long period. Recent studies have reported that the durability of resin-based materials can be assured by polishing the composite restorations after subjecting to acidic beverages [25], [33]. An interesting reaction between acidic drinks and composite resins was reported by Cho *et al*. [34] Study revealed that fracture toughness, which is the measure of a material's ability to resist crack propagation, is considered to be a reliable indicator of the ability of dental materials to resist failure under load. The results of the Cho *et al*. [34] study showed a significant increase in fracture toughness values in the nanofilled composites after immersion in low PH drinks. Cho *et al*. [34] also showed that the initial maximal polymerization of the control groups of other composites resulted in no change in fracture toughness values after immersion in acidic beverages. These reports indicate that the interactions of low PH drinks with resin composites require further investigation. In the present study, we detected differences in roughness between composite resins, even though they were from the same category. Reactions to each tested acidic beverages were shown to be material and time dependent. By the results presented in this study, we cannot affirm that all types of nanofilled composites were more resistant to acidic bevereges and drinks than another types of resin composite in the market as it was material and time dependent.

Conclusion

Although consumption of different acidic beverages is a very common habit among populations, but their effects on teeth and dental materials have been studied in several studies. Within the limitation of this study, results revealed that composition of both resin composite and different acidic beverages and drinks play an important role in initiation and conduction of surface roughness at the outer surface of resin composite restoration. Despite advances in the evolution of composites, no material yet exists that are totally resistant to erosion/corrosion that may be resulted after composite resin materials subjected to any acidic beverages for a long period.

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