ORIGINAL ARTICLE

Erosive Effect of Canned Juices and Soft Drinks on Surface Roughness of Restorative Materials Used in Pediatric Dentistry: An *Ex Vivo* Study

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Abstract

Aim: To evaluate and compare the effect of fruit juice (orange) and cola drink (noncarbonated) on the surface texture of composite (3M ESPE Filtek Bulk Fill) and glass ionomer cement (GIC) (ChemFil Superior).

Materials and methods: A total of eighty pellets each were prepared with composite (3M ESPE Filtek Bulk Fill) and GIC (ChemFil Superior) material using a brass mold with an inner diameter of 3 mm and a thickness of 3 mm according to the manufacturer's instructions. Around 10 pellets of each material were placed in airtight plastic containers. The baseline surface texture value was obtained by profilometer. An 8-day immersion regime was carried out according to Maupome et al. After the 8-day test period, pellets were reevaluated for surface texture final value. The values were statistically analyzed.

Results: A statistically significant lower surface roughness of composite restorative material was observed when treated with high-concentration orange juice and medium-concentration. Conversely, a statistically significant lower surface roughness of GIC restorative material was observed when it was treated with the low-concentration group, high-concentration orange juice, and medium-concentration orange juice.

Conclusion: The surface roughness patterns of restorative materials increased as the number of immersion regimes increased.

Keywords: Carbonated drinks, Dental erosion, Noncarbonated drinks, Restorative materials.

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Introduction

Dental erosion (DE) is defined as "an irreversible loss of dental hard tissue by a chemical process that does not involve bacteria."[1] There have been several cases of DE reported among medieval populations since the 1900s, and the world has witnessed increasing interest in DE and its significant role in tooth wear in recent times.[2] There is a multifactorial characteristic attached to DE which results as a consequence of the interaction between the tooth enamel and environmental factors, including various sources of dietary acids that might be extrinsic (beverages, sports drinks, cola, fruits and fruit juices, medicaments, etc.) or intrinsic (gastric acid resulting due to bulimia, anorexia, persistent regurgitation, gastrooesophageal reflux disease (GORD), and rumination).[3]

Research results convey the fact that the consumption of acidic beverages dominates the list of reasons causing DE.[4] These days, there is a profound reach to such acidic beverages, which makes them easily available in every corner of the world, thereby increasing the consumption of such products. This, in turn, establishes DE as a health concern on a global scale.[5] Morphological changes to the dental enamel owing to intake of sweetened and refined carbohydrates and acidic beverages have been reported in multiple research findings.[6] Increased occurrence of the pulpal opening, broken tooth, and dentin hypersensitivity are the repercussions of DE.[7,8] For every drop in pH value by 1 unit, there is a 7–8 times increase in the pH of the oral cavity, which is a determining factor for the dissolution of the dental tissues. Understanding the erosive nature of the different beverages and getting concrete numbers on their erosion potential could help in advising patients, counseling them against consuming such drinks, and educating these individuals with tangible data.[4]

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The structural difference between primary and permanent dentitions, slower clearance of salivary sugars, and decreased salivary flow rates among young children elevate their risk of DE. In turn, these children become more liable to frequent instances of occlusal alterations, dental hypersensitivity, pulpal involvement, and abscesses.[9] Using different adhesive restorative materials, including resin changes, glass ionomer cement (GIC), and resin composites, helps arrest the progression of the disease. However, these restorative materials do not exhibit everlasting immunity when exposed constantly to acidic conditions, and hence, there are higher possibilities for altered mechanical properties and surface integrity.[3]

Keeping all these in mind, the present study was conducted to understand the aftermath of consuming fruit juice (orange) and cola drinks (noncarbonated) on the surface texture of composite (3M ESPE Filtek Bulk Fill) and GIC (ChemFil Superior).

Material and Methods

Study Design

An *ex vivo* study was conducted in the College of Dentistry, Jazan University, Jizan, Saudi Arabia. Before initiating the data collection for this study, a research protocol was submitted to the Institutional Review Board, CODJU 2032I.

Materials used for the study:

- The experimental drinks used in the study were commercial orange juice, cola drink, and water as a control group.
- Restorative materials used were composite (3M ESPE Filtek Bulk Fill) and GIC (ChemFil Superior), deionized water, and 0.1M phosphate-buffered saline (PBS) (pH 7.2)

Sample Size and Sampling Frame

Materials used for Surface Texture Study

Brass molds with an inner diameter of 5 mm and a thickness of 3 mm were used to conduct the surface texture study. Besides this, matrix strips, glass plates, airtight containers, tweezers, and mixing pads were also utilized in the study. Surface roughness was analyzed and measured using the profilometer method.

Sampling for the Surface Texture Study

As directed by the manufacturer instructions, a composite (3M ESPE Filtek™ Bulk Fill) and GIC (ChemFil Superior) material was used on a brass mold having an inner diameter of 3 × 3 mm thickness to come up with 80 pellets in total. Pellets of various materials were available, and 10 of each material went into different airtight containers. The pellets of every material were divided into three groups (groups I, II, and III) (Table 1). Once again, each group was subdivided into three parts (as shown below), which would help in using them for immersion regimes. Airtight plastic containers came in handy, segregating 10 pellets of every material into them.

Baseline Surface Texture Evaluation

Every specimen available was placed on a flat table, and its baseline value was fetched using the profilometer's tip that ran on their surface.

Immersion Regimes for Surface Texture

Evaluation of the surface texture was possible using the immersion regime as given below (Fig. 1). Six airtight plastic containers containing 25 mL fruit juice (orange) and 25 mL cola drink (noncarbonated) were used to submerge 10 pellets of each material. The number of pellets immersed varied depending on the high immersion regime—pellets underwent one immersion, 5 immersions, or 10 immersions every day depending on low, medium, and high immersion regimes. The immersions happened over 12 hours daily for both medium and high immersions. Every pellet underwent copious rinsing using a 0.1M (PBS pH 7.2) solution, both preimmersion and postimmersion. Anytime the pellets were not subjected to the immersion regime, they remained in deionized water that was maintained at room temperature.

Control Group for Surface Texture

Around 10 pellets of each restorative material were immersed in water available in an airtight container for 8 days. The water in these containers was changed every day without fail. (Fig. 2)

Final Surface Texture Testing

The pellets were reevaluated for surface texture at the end of the test period, which was similar to the baseline evaluation. The new

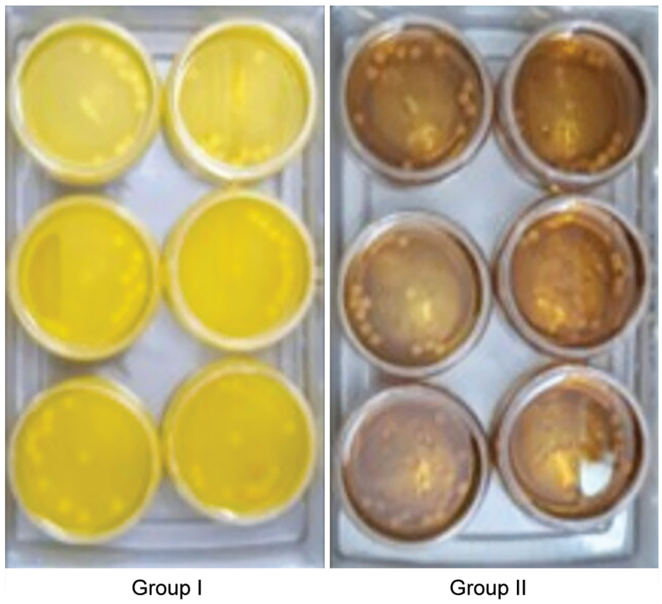

Fig. 1: Immersion regimes for surface texture

Table 1: Table describing groups and immersion regime

Groups	*Low immersion 1 time/day*	*Medium immersion 5 times/day*	*High immersion 10 times/day*
Group-I: Fruit juice (orange)			
IA: Composite (3M ESPE Filtek Bulk Fill)	10	10	10
IB: GIC (ChemFil Superior)	10	10	10
Group-II: Cola drink (noncarbonated)			
IIA: Composite (3M ESPE Filtek Bulk Fill)	10	10	10
IIB: GIC (ChemFil Superior)	10	10	10
Group-III: Water (control)			
IIIA: COMPOSITE: (3M ESPE Filtek Bulk Fill)	10		
IIIB: GIC: (ChemFil Superior)	10		

surface texture values were obtained. The values obtained both at the start and end of the test period were tabulated and analyzed statistically.

Results

The study discussed here was mainly done to understand the surface roughness of GIC (ChemFil Superior) and composite (3M ESPE Filtek™ Bulk Fill) using various concentrations of orange juice and noncarbonated cola drink. The unpaired *t*-test was done to differentiate the surface roughness between GIC and composite. The test was used to analyze the statistical difference in the surface roughness when different concentrations of orange juice and cola drinks were used.

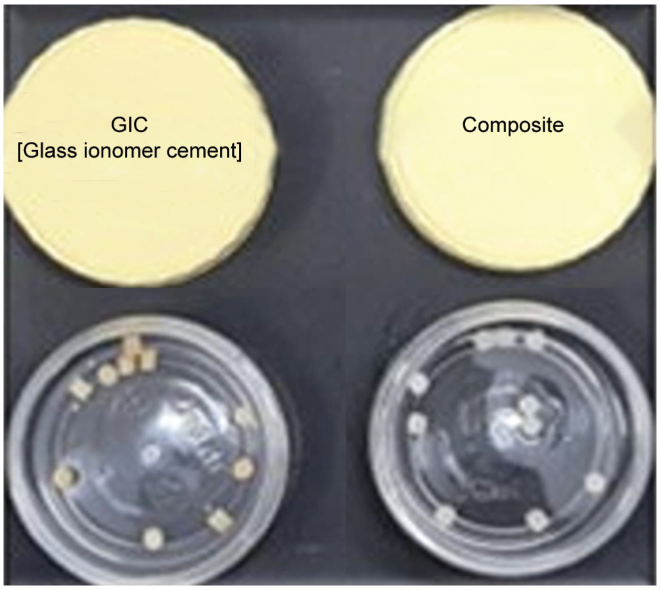

Fig. 2: Immersion regime for control group

Table 2 shows the results of the unpaired *t*-test that was performed to compare the different effects of orange juice and noncarbonated cola drink on composite (3M ESPE Filtek™ Bulk Fill). The surface roughness values differed at the start and end of the testing period. The high-concentration orange juice had a mean surface roughness of 0.20 at the start, decreasing to a value of 0.10 at the end of the 8th day. Such variations in the surface value (p-value = 0.003) clearly showed the dominating effect that could be imposed by a high-concentration of orange juice on the surface roughness of a composite material. The medium-concentration of orange juice also displayed similar effects with values of 0.21 and 0.12 at the beginning and end of the 8th day, reestablishing the statistical difference in the surface roughness of the composite. However, the low-concentration of orange juice and the control group did not trigger any changes in the surface roughness of the composite.

Similar to the orange juice, low, medium, and high-concentrations of cola drink displayed a statistically significant difference in the surface roughness of the composite with p-values of 0.003, 0.003, and 0.002, respectively. The mean surface roughness of low, medium, and high-concentrations of the cola drink at the start of the study was 0.19, 0.20, and 0.21, in contrast to their values of 0.13, 0.10, and 0.10 at the end of the study.

The results of the unpaired *t*-test conducted to study and compare the effects of orange juice and noncarbonated cola drinks on GIC (ChemFil Superior) are tabulated in Table 3. In the study, a statistically significant difference in the surface roughness of the GIC was clearly observed at the beginning and end of the 8^{th} day of the study when low, medium, and high-concentrations of orange juice and cola drinks were used. The low-concentration orange juice with a surface roughness of 0.24 at the start, a value of 0.15 at the end of the 8th day, and a p-value of 0.004, the medium-concentration orange juice with a p-value of 0.001, a surface roughness of 0.29 at the start and a value of 0.11 at the end of the study's 8th day and the high-concentration orange juice with a p-value of 0.001, a surface roughness value of 0.39 at the beginning and 0.1 at the end of the 8th day clearly prove the existence of statistically significant differences in the

Table 2: Comparison of surface roughness of composite (3M ESPE Filtek™ Bulk Fill) restorative material at the beginning and on the 8th day of using orange juice and cola drink

			N	*Mean*	*SD*	*SE*	*t-value*	*p-value*
Orange	High-concentration	At the beginning	10	0.205	0.068	0.021	4.034	0.003*
		On the 8th day	10	0.106	0.041	0.013		
	Medium-concentration	At the beginning	10	0.214	0.080	0.025	3.917	0.004*
		On the 8th day	10	0.124	0.015	0.005		
	Low-concentration	At the beginning	10	0.121	0.011	0.003	0.51	0.623
		On the 8th day	10	0.117	0.017	0.005		
	Control	At the beginning	10	0.170	0.125	0.039	−0.193	0.851
		On the 8th day	10	0.179	0.052	0.016		
Cola	High-concentration	At the beginning	10	0.217	0.067	0.021	4.427	0.002*
		On the 8th day	10	0.109	0.021	0.007		
	Medium-concentration	At the beginning	10	0.205	0.068	0.021	4.034	0.003*
		On the 8th day	10	0.106	0.041	0.013		
	Low-concentration	At the beginning	10	0.198	0.045	0.014	4.097	0.003*
		On the 8th day	10	0.137	0.017	0.005		
	Control	At the beginning	10	0.205	0.100	0.032	1.99	0.077
		On the 8th day	10	0.141	0.007	0.002		

*, Statistical significance set at 0.05

Table 3: Comparison of surface roughness of GIC material at the beginning and on the 8th day of using orange juice and cola drink

			N	*Mean*	*SD*	*SE*	*t-value*	*p-value*
Orange	High-concentration	At the beginning	10	0.39	0.06	0.02	13.24	0.001*
		On the 8th day	10	0.10	0.03	0.01		
	Medium-concentration	At the beginning	10	0.29	0.11	0.03	5.38	0.001*
		On the 8th day	10	0.11	0.02	0.01		
	Low-concentration	At the beginning	10	0.24	0.06	0.02	3.84	0.004*
		On the 8th day	10	0.15	0.03	0.01		
	Control	At the beginning	10	0.12	0.02	0.01	−1.37	0.203
		On the 8th day	10	0.14	0.03	0.01		
Cola	High-concentration	At the beginning	10	0.33	0.07	0.02	6.57	0.001*
		On the 8th day	10	0.14	0.02	0.00		
	Medium-concentration	At the beginning	10	0.37	0.14	0.04	5.33	0.001*
		On the 8th day	10	0.13	0.03	0.01		
	Low-concentration	At the beginning	10	0.33	0.14	0.04	4.48	0.002*
		On the 8th day	10	0.14	0.06	0.02		
	Control	At the beginning	10	0.11	0.02	0.01	−1.37	0.203
		On the 8th day	10	0.13	0.03	0.01		

*Statistical significance set at 0.05

surface roughness of GIC. The high-concentration cola drink (surface roughness at the beginning—0.33, on the 8th day—0.14 and *p*-value—0.001), medium-concentration cola drink (surface roughness at the beginning—0.37, on the 8th day—0.13, and *p*-value—0.001) and low-concentration cola drink (surface roughness at the beginning—0.33, on the 8th day—0.14 and *p*-value—0.002) showed statistically significant differences in the surface roughness of the GIC. No statistically significant effect on the surface roughness of GIC was observed in the control group.

Discussion

Hypersensitivity, enhanced exposure to dentin with incisor grooving, presence of smooth enamel surfaces, increased translucency of incisal edges, etc., are typical characteristics of DE. Both intrinsic and extrinsic causes contribute to the increased occurrence of DE. When it comes to extrinsic causes, the primary contributing factors towards DE include acids through foodstuffs or any materials with an iatrogenic nature, and in the case of intrinsic causes, it's primarily because of the acids that are regurgitated due to gastroesophageal reflux disease (GERD) or because of any other factor that results in the regurgitation of food.[10]

Almost 38.96% of GERD-affected adults and 98.1% of GERD-affected children also suffered from DE. On the contrary, only 20.8% of adults and 19% of kids without GERD were victims of DE.[11] A study conducted by Hanoon in 2021 showed that a decrease in saliva flow and pH resulted in a mean DE of 10.2% in kids, with the rates only growing higher.[12] Whereas, the prevalence rate of DE in the present study is based on the surface roughness of composite and GIC restorative materials in the presence of orange juice and noncarbonated cola.

Composite restorative material demonstrated high surface roughness when it was treated with high-concentration orange juice ($p = 0.003$) and medium-concentration ($p = 0.004$), whereas the surface roughness was high when the same material was treated with high-concentration ($p = 0.002$), medium-concentration ($p = 0.003$), and low-concentration ($p = 0.003$) cola drink. Such results clearly convey that treatment with noncarbonated cola drinks resulted in high surface roughness irrespective of the drink's concentration. The phenomenon is because of the resin matrix present in the composite that absorbs the acid present in the food beverages and softens easily.[10,13] Similarly, high surface roughness was observed with respect to GIC restorative material in the presence of both orange juice and cola drink in all three concentrations, high ($p = 0.001$; $p = 0.001$), medium ($p = 0.001$; $p = 0.001$), and low ($p = 0.004$; $p = 0.002$) clearly showing that the GIC restorative material possesses the nature of softening easily compared to composite restorative material when the beverage contains various acids. All this is predominantly because of the hydrogel matrix available in the GIC restorative material. While the acids in the beverage try to chelate the metal cations available in the hydrogel matrix, the metal cations available outside the hydrogel try to compensate for the lost metal cations. Such actions result in the dissolution of the restorative material's matrix. A study conducted by Aliping-McKenzie investigated the surface roughness of resin modified GIC, compomers, and conventional GIC by immersing in orange juice, Coca-Cola, and apple juice. The results demonstrated that the restorative materials could withstand Coca-Cola drinks for a period of 1 year, whereas the orange juice and apple drink totally dissolved the restorative materials.[14] Another study conducted by Hemalatha and Nagar in the year 2018 demonstrated an increase in surface roughness of nanofilled composite and light-cured GIC upon exposure to various food drinks.[15] In comparison, our study displayed variations in results primarily because of the changes in the composition of restorative materials and changes in the pH of various beverages used in the study.

Our study's primary forte is the exposure of the restorative materials over a period of 8 days, as prolonged exposure simulates the condition where the oval cavity is continuously exposed to different acids. Certain stabilized conditions, such as the specific pH of the beverages, the specific concentration of the restorative material, and a stable environment, have been adhered to for this study. In the oral cavity, these conditions might be altered because of saliva, type and composition of restorative material, and pH of various beverages, which can be considered as one of the limitations of the study.

Conclusion

The present study, despite certain limitations, showed that the noncarbonated cola drink had a more debilitating effect on the composite restorative material compared to orange juice. Both orange juice and noncarbonated cola drinks had an equal impact on the GIC restorative material. There is no statistical significance in the difference here, but orange juice presented higher adverse effects than noncarbonated cola drinks. Besides these, the surface roughness of restorative materials is affected by the pH of beverages, the type and composition of the restorative material, many other environmental factors, and the pH of saliva. Future prospective studies need to be conducted with various restorative materials to help us arrive at a definitive conclusion.

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