

# Comparative Evaluation of the Influence of Different Sports/Energy Drinks and Alcoholic Beverages on the Surface Roughness of Three Different Flowable Esthetic Restorative Materials: An *In Vitro* Analysis

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Received : 02-05-20  
Revised : 24-05-20  
Accepted : 06-06-20  
Published : 28-09-20

**ABSTRACT** **Objective:** This study aimed to evaluate the surface roughness of three flowable esthetic restorative materials after exposure to sports/energy drinks and alcoholic beverages. **Materials and Methods:** A total of 210 specimens of dimension (2 cm diameter and 2 mm thickness) with giomer, compomer, and composite (70 samples with each esthetic material) were made with the help of plastic rings. The prepared samples were tested in six experimental sports/energy drinks (beer, whiskey, vodka, Gatorade, Red Bull, and Sting) and distilled water was considered as the control group. Profilometric analyses of all samples were recorded before immersing into the experimental and control solutions. Then, the samples were stored in the experimental and control group solutions for 5 min for 30 days. The profilometric analysis was repeated after 30 days and records were statistically analyzed. **Results:** Flowable composite showed the minimum surface roughness, whereas the flowable compomer showed the maximum surface roughness in the present test conditions. When the erosive potential of the test solutions was evaluated, surface roughness values were more for sports/energy drinks when compared to that of alcoholic beverages. **Conclusion:** All the sports/energy drinks and alcoholic beverages evaluated in this study altered the surface roughness of the tested restorative materials. The effects ranged from slight to a markedly negative impact on the surface roughness of the test restorative materials.

**KEYWORDS:** Flowable compomer, flowable composite, flowable giomer, profilometry, sports drinks, surface roughness

## INTRODUCTION

Greater health consciousness among the new generation along with greater permissibility in the society has seen an increase in the consumption of health drinks as well as alcoholic beverages. The consumption of sports/energy drinks has gained high popularity not only among the young population but also among senior citizens as well. There is a pressing need for tooth-colored restorative materials that possess comparable mechanical properties to that of natural dentition.<sup>[1]</sup> Among tooth-colored restorations, resin-based composites and glass ionomers have wide

usage in the regular day-to-day clinical practices. The development of these materials had focused on modifying their biphasic compositions to improve chemical and mechanical properties.<sup>[2,3]</sup>

The surface degradation of resinous materials is dependent on the composition of the resin matrix, content, distribution of the fillers, and the effect of

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**How to cite this article:** Vaidya N, Kumar P, Pathak K, Punia SK, Choudhary A, Patnana AK. Comparative evaluation of the influence of different sports/energy drinks and alcoholic beverages on the surface roughness of three different flowable esthetic restorative materials: An *in vitro* analysis. J Int Soc Prevent Communit Dent 2020;10:585-90.

Access this article online	
<b>Quick Response Code:</b> 	<b>Website:</b> www.jispcd.org
	<b>DOI:</b> 10.4103/jispcd.JISPCD_246_20

silane surface treatment on the fillers.<sup>[4]</sup> Filler content correlates with color, depth of polymerization, stability, compressive strength, and stiffness of the composite materials.<sup>[5]</sup> Increased filler loading has been seen to result in lower water absorption, thus leading to less surface degradation.<sup>[6]</sup> The increased filler content may result in increased surface roughness, which may also aid in bacterial retention over the restorative surfaces.<sup>[7]</sup> The bacterial accumulation on the surfaces of restorative materials can provide the bacterial source a suitable biome leading to the development of secondary caries and periodontal diseases.<sup>[7]</sup> Acidic beverages such as soft drinks or ethanol can produce erosion of resin composites leading to the greater formation and adherence of a biofilm.<sup>[5]</sup> Many soft drinks are acidic in nature and the pH is 3.0 or lower. Phosphoric acid is a common constituent of most of the soft drinks along with citric, malic, tartaric, benzoic, oxalic, and succinic acids, and these acids are well known for their erosive properties.<sup>[8]</sup>

Thus, considering the importance of surface finish of the restorative materials, this *in vitro* study was planned to evaluate the surface roughness of sports/energy drinks (Gatorade, Redbull, and Sting), and alcoholic beverages viz. (beer, vodka, and whiskey) on three restorative materials (giomer [Beautiful Flow, Shofu], compomer [Dyract Flow, Dentsply], and composite [Fusion Flo, Prevest]). The primary objective of the study was to evaluate the effect of different alcoholic concentrations of sports/energy drinks and beverages on the surface roughness of three flowable esthetic restorative materials. The secondary objective of the study was to have a comparative evaluation of surface roughness caused by exposure to sports/energy drinks and beverages on three esthetic restorative materials.

## MATERIALS AND METHODS

This *in vitro* study was carried out in the Department of Conservative Dentistry and Endodontics in a

Dental College and Hospital. Three flowable esthetic restorative materials viz. giomer, compomer, and composite were analyzed using six sports/energy drinks (Gatorade, Redbull, and Sting), and alcoholic beverages (beer, vodka, whiskey). Disks of specified size and shape (2cm diameter and 2mm thickness) were fabricated using the three restorative materials. A total of 210 specimens of predefined dimensions were prepared using the help of plastic rings. Seventy samples with each restorative materials were prepared and each restorative material samples (70) were tested for surface roughness using six experimental solutions viz. Gatorade, Redbull, Sting, beer, vodka, whiskey (10 samples each), and one control group solution, distilled water (10 samples).

The samples were prepared by placing the plastic ring on a glass slab and filling the cavitation with the specified restorative material. The ring was slightly overfilled and a glass slide was then placed under pressure to remove excessive restorative material and to attain a uniform and smooth surface. The samples were then light-cured as per manufacturer's instructions (40 s) [Figure 1]. All specimens were subjected to profilometry analysis for the recording of initial surface roughness before being subjected to the experimental procedure [Figure 2]. The samples were then randomly subdivided into six subgroups of 10 samples each for each of the beverages tested and were then immersed into six test beverages (viz. beer, whiskey, vodka, Gatorade, Redbull, Sting) for 5 min at room temperature daily over a 30-day test period. In the control group, 10 samples of each restorative material were immersed in distilled water and the same protocol as mentioned above was followed. During the experimentation period when not immersed in test beverages, the samples were stored in artificial saliva (Aqwet, Cipla, Satara, India). Surface roughness was then evaluated by profilometry (Surftest SJ-210, MITUTOYO) and results subjected to statistical analysis.

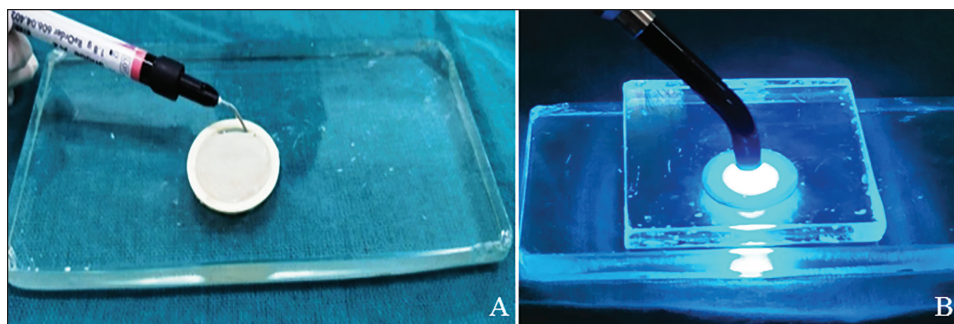


Figure 1: (A) Sample preparation. (B) Light curing of the sample

**STATISTICAL ANALYSIS**

Descriptive analysis was done to calculate the mean and standard deviation values for all the experimental groups. One-way analysis of variance (ANOVA) test was used to evaluate the significant difference between the experimental group solutions. Statistical analysis was done using the Statistical Package for the Social Sciences (SPSS) software, version 21.0 and a value of  $P < 0.05$  was considered as statistically significant.

**RESULTS**

Surface roughness values of three esthetic restorative materials after exposure to different alcoholic beverages are presented in Table 1. All alcoholic beverages increased the surface roughness of all the esthetic

restorative materials when immersed for 5 min every day for 30 days. The maximum value for surface roughness was seen in specimens immersed in whiskey with an alcohol concentration of 42.8% and a pH of 4.0. It was observed that vodka with an alcohol concentration of 42.8% and a pH of 6.8 caused the least surface roughness. Beer with an alcohol concentration of 8% and a pH of 6.4 showed greater surface roughness as compared to vodka and showed comparatively less surface roughness to that of whiskey.

Table 2 shows the mean surface roughness values before and after immersion in different alcoholic beverages and energy drinks on the flowable composite, Giomer, and Compomer materials. Composite esthetic restorative material showed maximum surface roughness when immersed in Gatorade with a mean value of 1.23 and the least surface roughness was observed when the specimens were immersed in vodka with a mean value of 0.82. Giomer esthetic restorative material caused maximum surface roughness when immersed in Gatorade with a mean value of 1.53 and the least surface roughness was observed when the specimens were immersed in vodka with a mean value of 1.23. Compomer esthetic restorative material caused maximum surface roughness was observed when the specimens were immersed in vodka with a mean value of 1.28.



Figure 2: Surface roughness analysis of prepared samples

**Table 1: Comparison of the surface roughness of three esthetic restorative materials caused by different alcoholic beverages**

Flowable esthetic restorative material	Surface roughness preimmersion						Surface roughness postimmersion					
	Beer		Vodka		Whiskey		Beer		Vodka		Whiskey	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Composite	0.63	0.27	0.61	0.26	0.62	0.27	0.84	0.27	0.82	0.29	0.93	0.26
Giomer	1.01	0.62	1.03	0.69	1.02	0.69	1.26	0.63	1.23	0.69	1.28	0.69
Compomer	0.45	0.41	0.38	0.27	0.54	0.39	1.30	0.59	1.28	0.69	1.35	0.57

SD = standard deviation

A value of  $P < 0.05$  was considered statistically significant

**Table 2: Mean surface roughness values before and after immersion in different alcoholic beverages and energy drinks on the flowable composite, giomer, and compomer material**

Test material	Before		After												Control	
	Mean	SD	Alcoholic drinks						Energy drinks						Mean	SD
			Beer		Vodka		Whiskey		Gatorade		Red Bull		Sting			
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Composite	0.59	0.25	0.84	0.29	0.82	0.29	0.93	0.26	1.23	0.27	1.08	0.44	1.12	0.25	0.75	0.26
Giomer	0.88	0.60	1.26	0.63	1.23	0.69	1.28	0.69	1.53	0.58	3.43		1.33	0.54	0.92	0.26
											4.13					
Compomer	0.41	0.32	1.30	0.59	1.28	0.35	1.35	0.57	1.65	1.19	4.33		1.37	0.26	1.1	0.30
											3.93					

SD = standard deviation

A value of  $P < 0.05$  was considered statistically significant



## DISCUSSION

The key current topics of modern restorative dentistry are esthetics and the minimal invasive concept.<sup>[9]</sup> The use of tooth-colored restorative materials has increased substantially over the last few years as a result of improvements in the formulation, simplification of adhesive procedures, and increased esthetic demands by patients.<sup>[10]</sup> In today's world under the influence of mass media, there is a marked increase in the consumption of alcoholic sports/energy drinks and beverages.<sup>[11]</sup> Consumption of sports/energy drinks and beverages negatively alters the mechanical properties of all composite resin material.<sup>[8]</sup> The surface roughness of composite materials was greatly affected by the acidic concentration of beverages.<sup>[12,13]</sup> The increase of surface roughness facilitates the staining of the tooth-colored restorative materials and bacterial adherence on its surfaces which further lead to secondary caries formation. According to Hamouda, the roughness of all intraoral hard surfaces should approximate to a *Ra* value of 0.2  $\mu\text{m}$  or lower to reduce bacterial retention and *Ra* value of 0.5  $\mu\text{m}$  is sufficient for retaining most bacteria.<sup>[14-16]</sup>

In this study, the surface roughness of three flowable esthetic restorative materials was assessed under the action of sports/energy drinks and alcoholic beverages. The observations of this study show that even the control group having distilled water as a test solution caused surface roughness of all the three test materials. This observation is corroborated by other studies that have shown that water plays an important role in hydrolytic degradation and erosion of resin-based materials by filler matrix debonding. According to the self-catalytic reaction of distilled water, it attacks the siloxane bond by hydroxyl ions leads to hydrolytic degradation of the filler surface in water.<sup>[17]</sup> The degradation process is associated with the swelling of the matrix during the sorption process. The swelling causes formation of pores inside the material from which organic substances can be released, resulting in a mass loss.<sup>[18,19]</sup> Two main mechanisms may cause a release of substances from polymeric materials: (1) unbound monomers and/or additives are eluted by solvents after setting and (2) erosion of the surfaces also releases components over a long time.

Further, the observations of this study show that of all the three esthetic restorative materials when subjected to experimental beverages, composites showed minimum surface roughness followed by giomer, whereas compomers showed the maximum surface roughness. In this study, nanohybrid composite with 70% filler

content presented the lowest surface roughness both in the absence and presence of acid challenge. Small filler particle composites are more homogenous and have less surface roughness as their particles are less prominent. Although the type of filler and size and quantity of the particles influence the properties and quality of polishing of composite resins, the reduction in space between the inorganic nanoclusters is possibly responsible for superior physical properties of nanohybrid composites.

Due to the surface pre-reacted glass (S PRG) fillers, giomer was found to be less susceptible to erosion than compomer when exposed to sports/energy drinks and alcoholic beverages.<sup>[8]</sup> In addition, giomer had higher filler content approximately 68.6% when compared to compomer which had a filler content of approximately 47% and hence showed lesser changes in surface roughness when compared to compomer. The presence of less filler content in compomer (approximately 47%) could be one of the reasons for the higher erosion for compomer when compared to the other materials (giomer approximately 68.6%; and composites approximately 70%).

Apart from the filler volume, its properties, distribution, and surface treatment are also important factors for resin materials, for their erosion resistance to acidic and/or alcoholic solution. From the findings of this study, it is suggested that the hybrid restorative materials, especially compomers, can show great changes in the surface roughness when immersed in various test beverages. An increase in surface roughness observed on the exposure of the compomer to the high frequency of immersion could be due to hydrolysis of the silane coupling agent or due to the plasticizing process of the resin matrix which may due to prolonged immersion in the acidic solutions.

This study also evaluated the surface roughness caused by alcoholic beverages. According to the results, whiskey with an alcohol concentration of approximately 42.8% caused maximum surface roughness. Beer having an alcohol concentration of 8% caused more amount of surface roughness than vodka, but lesser than whiskey. Vodka having an alcohol concentration of 42.8% showed the least amount of surface roughness when compared to other beverages. Although vodka had a pH of 6.8, it still showed surface roughness of restorative materials. This result may be explained by the alcoholic content of the vodka (approximately 42.8%) that penetrates the organic matrix causing hydrolysis.

Low pH and alcohol concentrations affect the surface properties of composite restorative materials. The change in surface roughness of the composite

materials can be explained by the absorption of alcohol molecules in beverages into the composite resins and resulting in the softening of the composite resin matrix.<sup>[20]</sup> Interestingly beer despite having a significantly low concentration of alcohol and a low value of pH (alcohol concentration of 8% and pH of 6.4) than vodka (which has a high concentration of alcohol 42.8% and slightly higher pH of 6.8) showed more potential for surface erosion than vodka. Dental erosion usually occurs when the surface pH reduces below to a critical threshold value of 5.5 which could be the reason for increased surface roughness values after exposure to alcoholic beverages.<sup>[21]</sup>

In this study, from the sports/energy drinks used as test solutions, Gatorade which has a pH of 2.9 showed the maximum surface erosion potential. The other two solutions viz. Red Bull having pH 3.4 and Sting having pH 3.2 were also proved to have less erosive potentials than Gatorade. However, no statistically significant difference was observed between these groups. It has been established that the erosive potential of an acidic solution is related to its pH, titrable acidity, and buffer capacity. In addition, these drinks in their composition have a strong inorganic acid called citric acid.

The surface roughness of the restorative materials could be due to the association of low pH and the presence of strong inorganic acid. The acidic nature of the energy drinks also causes surface degradation of calcium, aluminum, and silicon ions of the restorative resins which further lead to the roughening of the surfaces. The acids in the sports/energy drinks further penetrate the resin matrix and release the unreacted monomers into the environment and this may result in surface erosion of composite resins.<sup>[21]</sup>

#### STRENGTHS AND LIMITATIONS

This *in vitro* study evaluated the effect of six types of experimental sports/energy drinks and alcoholic beverages on surface roughness of three esthetic materials. Every effort was taken to mimic the clinical scenario (artificial saliva was used to simulate the oral environment) and proper care was taken during test sample preparation and profilometric analysis. However, the results of this *in vitro* study need to be implemented to the clinical scenario carefully and further clinical trials with these materials and experimental solutions are warranted to increase the validity of this study results.

#### CONCLUSION

Within the limitation of the study, the following conclusions can be drawn:

1. Of all the test restorative materials used in this study, flowable composite showed the minimum surface roughness when subjected to immersion into test beverages, whereas flowable compomer showed the maximum surface roughness.
2. In the group of alcoholic beverages, vodka with an alcohol concentration of 42.8% and a pH of 6.8 showed the minimum surface erosion potential, whereas whisky with an alcoholic concentration 42.8% and a pH of 4 showed the maximum surface roughness.
3. In the sports/energy drink group, gatorade with a pH of 2.9 showed the maximum surface erosion.
4. Sports and energy drinks resulted in greater surface roughness when compared to alcoholic beverages.

#### ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

Not applicable (*in vitro study*).

#### DATA AVAILABILITY STATEMENT

The data of this research was made publicly available using Mendeley database (DOI: 10.17632/cx6jfn5hz.1).

#### ACKNOWLEDGMENT

None.

#### FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

#### CONFLICTS OF INTEREST

There are no conflicts of interest.

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Study conception, literature search, data collection, data acquisition, data interpretation, manuscript writing, editing and review, final approval.
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Study conception, literature search, data collection, data acquisition, data interpretation, manuscript writing, editing and review, final approval.

**DECLARATION OF PATIENT CONSENT**

Not applicable (*in vitro study*).

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