

## Evaluation of the Surface Roughness and Microleakage of Dental Composites Exposed to Different Beverages

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### ABSTRACT

**Aim:** The purpose of this study was to determine the effect of different solutions cola soft drink (CSD) and coffee on roughness and microleakage of composite resin restorations.

**Materials and methods:** Sixty bovine incisors were prepared and restored using Filtek Z350 XT (3M/ESPE) nanoparticulate resin. The samples were divided into three groups (n = 20): A (control)-Immersion in artificial saliva (14 days); B: Immersion in coffee (14 days), for 15 minutes (3x/day) and C: Immersion in CSD for 14 days (3x/day). Then the samples were analyzed for microleakage (dye penetration) and surface roughness (atomic force microscope). The one-way analysis of variance (ANOVA) was applied to assess the surface roughness and microleakage. The Tukey's test was set at 0.05.

**Results:** Group A (roughness-GA<sub>R</sub>) presented significantly the lowest average surface roughness. Group C (microleakage-GC<sub>M</sub>) showed significantly the highest average microleakage.

**Conclusion:** It was concluded that CSD and coffee change the surface roughness and increase the microleakage of restorations.

**Clinical significance:** Nowadays there is a high consumption of artificially sweetened soft drinks, sports drinks, high-energy beverages and coffee products by people that cause problems in composite resin restorations.

**Keywords:** Artificial saliva, Beverages, Dental restoration, Microleakage, Surface roughness.

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### INTRODUCTION

Recently, there was an increased in the consumption of artificially sweetened soft drinks, sports drinks, high-energy beverages and coffee products by people.<sup>1</sup> Attention has been given to the role of diet in the etiology of resin composite degradation.<sup>2</sup> Dental materials placed in oral cavity undergo thermal, mechanical and chemical influences, promoting a frequent oral degradation process. The fact of coffee, teas, and cola soft drink (CSD) contain acids in their composition and be highly consumed may jeopardize the properties of dental composite.<sup>3</sup>

One of the most important properties that determine the durability of dental materials in the oral cavity is strength to dissolution or disintegration.<sup>4</sup> The critical oral environment conditions, i.e. pH changes and humidity, may increase resin composite degradation over time.<sup>5</sup> It has been known for a long time that acidic food and drinks may soften dental hard tissues. This process may also deteriorate the mechanical properties of the material and reduce the clinical life of composite resin restorations.<sup>6</sup>

Dental erosion not only affects the dental enamel. When reaching dentin the erosion can cause hypersensitivity, or in severe cases, pulp exposure and even tooth fracture.<sup>7</sup> Studies reported that acidic condition degraded glass

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ionomer cements, polyacid modified resin composites, and restorative composite.<sup>8</sup>

There was always great interest in the fit of restorative materials to the walls of cavities and in the retentive ability of the material to seal the cavity against the penetration of microorganisms and saliva.<sup>9</sup> Microleakage in restorative materials is a big problem in clinical dentistry.<sup>10</sup> Composite may exhibit reduced properties along time, which increases its susceptibility to wear and marginal microleakage when in contact with liquids.<sup>11</sup>

Thus, coffee and CSD were selected for this study to evaluate the influence of these beverages on the superficial roughness and marginal microleakage of composite resin restorations. The hypothesis was that the roughness and microleakage of dental composite would be affected by CSD and coffee.

## MATERIALS AND METHODS

### Specimens Preparation

A total of 60 bovine incisors were used, free of stains, caries, cracks and other defects visible. The bovine teeth were cleaned and stored in physiological solution at 37°C until the moment where the cavities were prepared. The teeth were sectioned 3 mm from the amelo-cement junction by IsoMet<sup>®</sup> 1000 (Buehler, Lake Bluff, IL, USA).

The cavities were performed on vestibular surface of the bovine incisors, using a diamond bur (KG Sorensen, Barueri, SP, Brazil). A silicon cursor (Ângelus, Londrina, PR, Brazil) was placed 2 mm from the end of the bur's active tip to standardize the cavities depth. Then, the cavities showed a rectangular form with 6 mm in the medial-distal, 3 mm in the cervical-incisal, 2 mm in depth directions, and a cavosurface angle in the enamel.

After the cavities preparation, the teeth were cut in blocks with approximately 1 cm<sup>2</sup>. The surfaces were sandpapered (600, 1200 grit) and polished with a diamond disk (KG Sorensen, Barueri, SP, Brazil). The cavities were cleaned using pumice stone/water and by ultrasound.

The samples were restored with Filtek Z350 XT (3M/ESPE, St Paul, MN, USA), shade A2E, Adper Single Bond 2 adhesive (3M/ESPE, Sumaré, SP, Brazil) and 37% phosphoric acid (SDI, São Paulo, Brazil), following the manufacturer's instructions. The composite resin was placed in a single increment (2 mm) and photo-cured for 40 seconds with a light-emitting diode-LED (Gnatus, Ribeirão Preto, SP, Brazil). The light output was constantly monitored by a radiometer with an average of 1200 mW/cm<sup>2</sup> (Demetron, Kerr Corp, Orange, CA, USA).

After the specimens were polished with Diamond PRO (2–4 µm) polishing disks (FGM, Joinville, SC, Brazil), diamond paste (0.03 µm) and water, similar to clinical practice. Then, the specimens were cleaned ultrasonically and dried.

### Cycling of the Specimens

The specimens were divided into three groups (n = 20) as described in Table 1. It was used 14 bottles of CSD (Coca-Cola<sup>®</sup>, Maceió, AL, Brazil) and a coffee (Pilão<sup>®</sup>, Jundiaí, SP, Brazil). The coffee was prepared using a 1:10 ratio (powder: water). The composition is listed in Table 2. Between the cycles, each specimen was stored in 1.2 ml of artificial saliva at 37°C (Farmacêutico<sup>®</sup>, Maceió, AL, Brazil). An amount of 10 ml of the corresponding solution (coffee and CSD) was added in a glass container with each sample. The samples were cleaned and dried using absorbent paper. The pH was determined using a portable pH meter (Orion Model 420 A, Analyzer, São Paulo, Brazil). The testing period and solution immersion period followed the protocol used by von Fraunhofer and Rogers.<sup>12</sup> Then, roughness and microleakage of the specimens were analyzed.

### Roughness Evaluation by Atomic Force Microscopy (AFM)

For the analysis of roughness ( $R_a$ ), 30 samples were used (n = 10) and divided into three groups ( $GA_R$ ,  $GB_R$ ,  $GC_R$ ). Roughness was analyzed in an atomic force microscope

**Table 1:** Treatment cycle of dental composite

Groups	Treatment cycle
GA	Immersion in artificial saliva for 14 days (control group)
GB	Immersion in coffee for 14 days, for 15 minutes, 3x/day
GC	Immersion in CSD for 14 days, for 15 minutes, 3x/day

**Table 2:** Chemical composition of the beverages

Solutions	Manufacturer	Composition	pH	Batch number
Artificial saliva	Farmacêutico <sup>®</sup> , Maceió, AL, Brazil	CMC, potassium chloride, dibasic potassium phosphate, sodium chloride, anhydrous calcium chloride, magnesium chloride and aspartame	7.1	2357/11
Coffee	Pilão <sup>®</sup> , Jundiaí, SP, Brazil	Caffeine, amino acids, lipids, sugars and B-complex vitamins	6.8	1346
Cola soft drink	Coca-Cola <sup>®</sup> , Maceió, AL, Brazil	Carbonated water, sugar, vegetable extracts, flavorizers, acidulant, caffeine, phosphoric acid and caramel food coloring	2.7	459879

(SPM-9500J3 Shimadzu®, Japan) equipped to an optical microscope (0.8–5× magnification) and a light source (Kyowa Optical, Kanagawa, Japan) with a Victor TM-A14 seconds video monitor. The images were recorded and mapping procedure 50 × 50 μm imaging was used.

The  $R_a$  value was determined to define the specimen’s surface topography as the average deviation of a section profile calculated by equation:

$$(1) R_a = \frac{1}{L} \int_0^L |f(x)| dx.$$

$L$  = length of the section;  $f(x)$  = displacement function.

**Microleakage Evaluation**

For the analysis of microleakage, 30 samples were used ( $n = 10$ ) and divided into three groups ( $GA_M, GB_M, GC_M$ ). The groups were submitted to aging tests thermal cycled for 1000 times ( $5 \pm 2^\circ C$  and  $55 \pm 2^\circ C$ ) maintained for 15 seconds at each temperature. After these procedure, samples were submitted to the mechanical cycling. The samples were inserted to the mechanical cycling machine (Erios International, São Paulo, Brazil) and submitted to 100 thousand load cycles, frequency of 1 cycle/second to receive an intermittent vertical load of 50N on the restoration. During the test, the samples were maintained in distilled water at  $37^\circ C$ . The samples were stored in water at room temperature for 24 hours. After they were placed in 2% methylene blue for 48 hours. Then, the samples were rinsed and dried. Teeth were cut into three portions with a low speed saw (IsoMet® 1000 Buehler) and assessed for dye penetration with a magnifying glass (Nikon Eclips E600, Tokyo, Japan) at 20× magnification (occlusal and cervical margins). A blind investigation was performed to score a mean of all interfaces. The score of dye penetration at the dental composite/tooth interface was made for enamel margins on a nonparametric scale as: 0 = no microleakage; 1 = dye penetration less than ½ of axial wall; 2 = dye penetration more than ½ of axial wall; 3 = dye penetration spreading along the axial wall.

**STATISTICAL ANALYSIS**

After recording the data, a comparison was made of the experimental and control groups. The one-way analysis of variance (ANOVA) was applied to assess the surface roughness and microleakage. The Tukey’s test was set at 0.05 significance level.

**RESULTS**

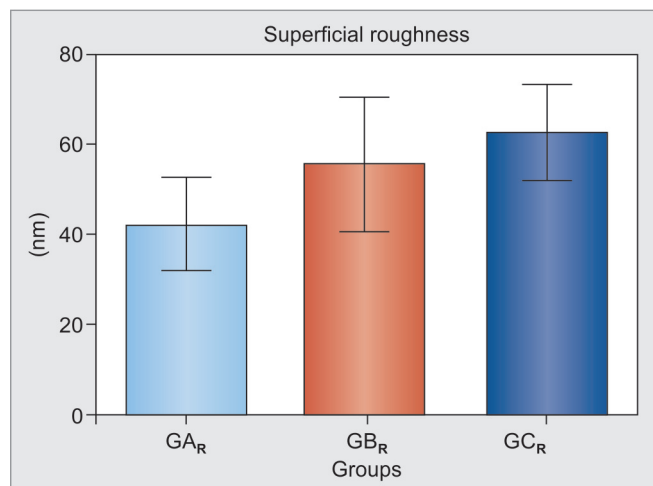
Atomic force microscopy evaluation revealed that the results of surface roughness to  $GC_R$  presented the highest roughness, 62.69 nm, while  $GA_R$ , 42.30 nm, exhibited lowest values the roughness after cycling. Graph 1 showed  $R_a$  mean values of different experimental groups.

The t-test showed a statistically significant difference between  $GA_R$  and  $GB_R$ , and  $GA_R$  and  $GC_R$ , with ( $p < 0.05$ ). No significant differences were found between groups  $GB_R$  and  $GC_R$  ( $p > 0.05$ ).

Figures 1 and 2 present the images concerning  $R_a$  values of experimental groups captured by AFM.

The frequency and differences of the microleakage obtained from different groups are showed in Table 3. The results of dye penetration for  $GC_M$  presented the highest average microleakage of restorations.

No significant differences were found between groups  $GA_M$  and  $GB_M$  ( $p > 0.05$ ). The Mann-Whitney test, presented a statistically significant difference between  $GA_M$  and  $GC_M$ , and  $GB_M$  and  $GC_M$ , with ( $p < 0.05$ ).



Graph 1: Surface roughness ( $R_a$ ) of the different experimental groups

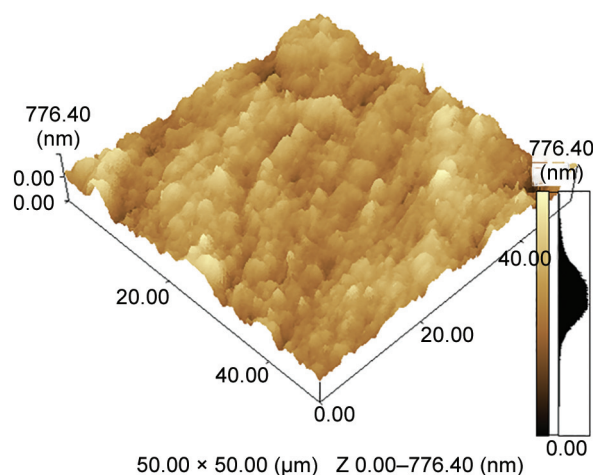
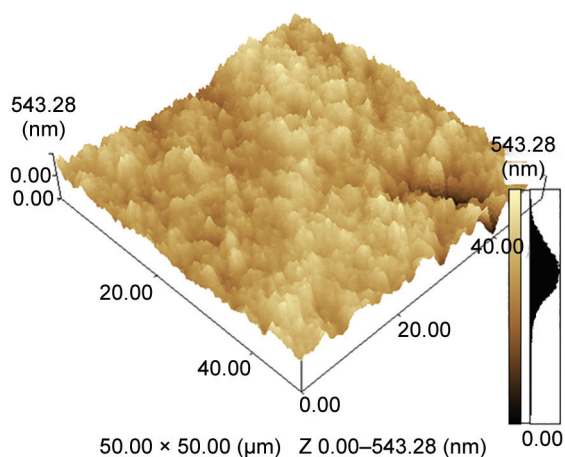


Fig. 1: Atomic force microscopy image of the tooth surface of  $GB_R$  specimens

Table 3: Frequency of the microleakage scores obtained from the groups

Groups	Enamel margins (scores)			
	0	1	2	3
$GA_M$	10	6	4	0
$GB_M$	5	9	5	1
$GC_M$	0	6	12	4



**Fig. 2:** Atomic force microscopy image of the tooth surface of  $GC_R$  specimens

## DISCUSSION

The potential for dental erosion with consumption of acidic beverages is an important consideration for nutritionists, dentists, and physicians counseling patients. Prolonged contact time between the beverage and enamel, dentin or composite surface increases the opportunity to occur erosion.<sup>13</sup> In this study, to avoid interference of the resin's chemical composition on the beverages used, only one type of restorative material was used.

The testing period and period of immersion in the solution followed the protocol developed by von Fraunhofer and Rogers.<sup>12</sup> These drinks are regularly consumed during the day and can take about 15 minutes to be ingested. Thus, the samples were immersed in drinks for 15 minutes and then in artificial saliva. The teeth were maintained in saliva between the beverage immersions to reproduce the conditions of normal oral environment.<sup>14</sup>

The results of this study showed changes in the surface of the composite resin Z350 XT (3M/ESPE) being exposed for 14 days, accepting the hypothesis.  $GB_R$  and  $GC_R$  groups showed no significant differences, but had greater roughness compared with the group of  $GA_R$  immersed in artificial saliva. According to Zero,<sup>15</sup> pH is the major factor to determine the erosive potential of a solution. When immersed in artificial saliva, resin Z350 XT (3M/ESPE) showed lower roughness values. This can be explained by the neutral pH of saliva. This result disagreement with Kitchens and Owens<sup>16</sup> that found that the surface roughness not increase when the material was immersed in the coffee for the same period used in this study. However, the results of this study are in agreement with study of Dos Santos, et al,<sup>17</sup> where found a significant degradation of the resin matrix in immersion in coffee at a high temperature. This higher temperature may have accelerated the degradation process, although in this

study the different temperature were not considered. Atomic force microscopy analysis showed that there were areas where occurred a severe loss of matrix on the surface of the sample, as  $GB_R$  where were found regions noticeably stained. This was probably caused because this beverage contains yellow dyes with high polarity which can penetrate in the organic matrix.<sup>18</sup>

The restorations subjected to  $GC_R$  had higher roughness than those immersed in artificial saliva, which is consistent with previous studies.<sup>19</sup> This result can be explained by the presence of inorganic acids, such as phosphoric acid, which can promote the erosion of the resin surface. The penetration in the organic matrix of polymers causes disruption of the union between the filler particles and organic matrix. The composite Z350 XT (3M/ESPE) containing a combination of zirconia nanoparticles (diameter 10.5 nm) and silica nanoparticles (nanoparticle diameter 75 nm). Furthermore, these particles form nanoclusters (0.6–1.4  $\mu\text{m}$ ) of zirconia and silica. These nanoclusters act as a single unit. The acids present in the CSD may spread through the matrix causing hydrolysis of the bond between the silane and the filler in the surface, removing these nanoclusters.

Marginal microleakage is an important factor for the success of restorative materials and it has been used in laboratory studies as an indicator of the maintenance of restorative materials. The clinical effects of the marginal microleakage are the penetration of bacteria and their sub-products in the interface tooth-restoration, contributing to the formation of secondary caries and postoperative sensibility.<sup>20</sup>

Thermal and mechanical load cycling increased significantly the microleakage for  $GB_M$  and  $GC_M$ . Thermal cycling induces stress and degradation in interface due to the difference between tooth structures and restorative materials.<sup>21</sup> Mechanical load cycling produces stress in the composite resin, and it is transmitted to the bonding interface. Interfaces less affected by microleakage before the aging test were more susceptible to thermal and load cycling.<sup>22</sup>

The deterioration of physical property and changes in morphology of dental composites may be related with bond hydrolytic breakdown between matrix/silane and filler particles or fillers degradation.<sup>23,24</sup> The long-term maintenance of the surface quality of materials is fundamental to improving the longevity of esthetic restorations. Another explanation for increased microleakage in specimens immersed in CSD may be degradation of adhesive bonding by phosphoric acid present in this drink. The results of presents study are consistent with the results reported by Navarro et al.<sup>25</sup>

Cola beverages and coffee have a low pH and can be sweetened with carbohydrates, which are metabolized by biofilm microorganisms, promoting organic acids which can contribute to the erosive potential of the hard dental tissues and restorative material.<sup>7,12</sup> Therefore, further research into the intraoral environment is needed to confirm the results of this study.

## CONCLUSION

Cola soft drink and coffee beverages change the surface roughness and increase the microleakage of restorations.

## CLINICAL SIGNIFICANCE

Nowadays there is a high consumption of artificially sweetened soft drinks, sports drinks, high-energy beverages and coffee products by people that cause problems in composite resin restorations.

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