Effect of whitening toothpaste on superficial roughness of composite resin

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This study sought to evaluate the effect of different toothpastes with whitening action on the average surface roughness (Ra) of a microhybrid composite resin. Twenty-five specimens of composite resin were prepared and distributed randomly among 5 experimental groups (n = 5). Groups 1-3 were treated with whitening toothpastes: Close-Up Extra Whitening, Colgate Ultra White, and Colgate Total 12 Whitening. Group 4 was a negative control group (with samples brushed with deionized water), and Group 5 was a positive control group (with samples brushed using a non-whitening toothpaste). A profilometer was used to determine Ra before and after brushing. A simulated brushing machine was used for all groups, providing horizontal back and forth movement with an amplitude of 3.8 cm applying an axial load of 200 g and a speed of 356 rpm, totaling 20,000 cycles. To determine the Ra in each specimen, 6 readings were taken at various positions before and after brushing. The results were submitted to variance analyses and Tukey’s test (P < 0.05).

Groups 1, 2, 3, and 5 demonstrated statistically significant differences between initial and final averages. Based on these results, it was determined that brushing with toothpaste, regardless of formulation, significantly increased the Ra of the resin composite evaluated in this study.

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A person’s physical appearance and emotional state can be strongly affected by their smile and the color of their teeth. Therefore, a large number of toothpastes with whitening action in various formulations have been introduced to the market.1,2 Changes in tooth color can affect both teeth and esthetic restorations. These changes have multifactorial causes that involve external factors, such as plaque accumulation, surface degradation due to the penetration of coloring agents, and micromorphological aspects of the tooth surface and restorative materials, which may lead to degradation of the organic resin matrix and surface roughness (Ra).3,4 Degradation of the composite resins in the oral environment can result from chemical or abrasive action. For that reason, the impact of brushing must be considered when evaluating the prognosis and durability of composite restorations. Hygiene procedures should not contribute to the formation of large superficial defects, which would result in increased roughness, biofilm retention, and staining.1,5,10

The use of toothpastes that promote whitening by removing or controlling extrinsic stains on the tooth surface through abrasion has become common.12,13 Typically, hydrated silica, calcium carbonate, dehydrated dicalcium phosphate, calcium pyrophosphate, alumina, sodium bicarbonate, and perlite are the abrasive agents used in whitening toothpastes.2,12-16

Restorative materials with surface roughness would have a negative effect on the aesthetic appearance of the restorations (that is, staining and tearing) and lead to greater accumulation of biofilm, which could in turn result in cavities and periodontal disease.17

Comparatively few studies have discussed the long-term effect of whitening toothpaste used without prescription or professional supervision on the Ra of resin composite restorations. Since the abrasive action of brushing is considered a contributing factor to the disintegration of dental materials, an evaluation by means of simulated toothbrushing in vitro may be a parameter to evaluate the ability of a restorative material to resist deterioration, prevent staining, and maintain luster and smoothness.19-20 This study sought to evaluate the in vitro effect of different whitening toothpastes on the Ra of a composite resin.

Materials and methods

A microhybrid composite resin (Four Seasons enamel shade A2, Ivoclar Vivadent AG), was submitted to the action of 3 toothpastes with different bleaching formulations (Table 1): Close-Up Extra Whitening (Unilever) (Group 1), Colgate Ultra White (Colgate-Palmolive Company) (Group 2) and Colgate Total 12 Whitening (Colgate-Palmolive Company) (Group 3). There were also 2 control groups: Group 4 was a negative control group, as samples were brushed using only deionized water, while Group 5 was a positive control group, using a common nonwhitening toothpaste (Sorriso, Colgate-Palmolive Company).

The response variable was the average Ra, determined using a digital profilometer (SurfTest SJ-201P, Mitutoyo America Corporation). To determine the roughness, the diamond tip of the profilometer went through the test specimen at a constant speed of 0.25 mm/second using a force of 4 mN. The cut-off value was adjusted to operate at 0.25 µm and a Ra was characterized by the arithmetic mean of the highest and lowest measurements found in a central line along the evaluated area measured in µm. Six readings were taken on each specimen in the x- and y-axis directions before and after brushing. The average of these readings was used for statistical analysis.

Preparation of specimens

Twenty-five specimens of composite shade A2 (Four Seasons, Ivoclar Vivadent AG) were prepared. Each specimen was made from a bi-parted matrix (10 mm in diameter with a 2 mm deep central circular perforation) and placed on a glass plate. The circular perforation was filled with a single increment of composite resin inserted...
Table 1. Compositions of all toothpastes used in the present study, based on the packaging label provided with each product.

<table>
<thead>
<tr>
<th>Group (n = 5)</th>
<th>Toothpaste</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Close-Up Extra Whitening</td>
<td>Calcium carbonate, sorbitol, water, silica sodium lauryl sulfate, flavor,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sodium monofluorophosphate (1,450 ppm fluoride), trisodium phosphate,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>titanium dioxide, cellulose gum, perlite, sodium saccharine, formaldehyde,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CI 74160</td>
</tr>
<tr>
<td>2</td>
<td>Colgate Ultra White</td>
<td>1,450 ppm fluoride, sorbitol, calcium carbonate, aluminum oxide, carboxymethylcellulose, sodium saccharin, sodium lauryl sulphate, sodium silicate, aroma, methylparaben, water, sodium monofluorophosphate</td>
</tr>
<tr>
<td>3</td>
<td>Colgate Total 12 Whitening</td>
<td>Sodium fluoride (1,450 ppm fluoride), 0.3% triclosan, sodium lauryl sulfate, sorbitol, hydrated silica, gantrez, sodium saccharine, aromatic composition, dyes, water, triclosan, fluoride, carrageenan, sodium hydroxide</td>
</tr>
<tr>
<td>4</td>
<td>Deionized Water (negative control)</td>
<td>n/a</td>
</tr>
<tr>
<td>5</td>
<td>Sorriso (positive control)</td>
<td>Sorbitol, water, hydrated silica, sodium lauryl sulphate, PEG-12, aroma, cellulose, gantrez, sodium saccharin, fluoride, CI 77891, CI 74160, sodium fluoride (1,100 ppm fluoride)</td>
</tr>
</tbody>
</table>

using a composite spatula. The resin was placed on a strip polyester matrix and covered by a glass plate 20 mm thick (accommodating both the matrix and the overflow of excess resin), which received a 500 g load for 10 seconds. Photopolymerization of the resin was performed over three 20-second periods, using a curing light (Dabi Atlante) at 600 mW/cm². The first exposure occurred when the glass plate was placed on the specimen, the second after the removal of the glass plate, and the third after the removal of the polyester matrix. Once removed from the matrix, all of the specimens were stored in deionized water at 37°C and polished after 24 hours. The simulated toothbrushing of specimens then considered each specimen’s Raf. After the readings were complete, the specimens were stored for 24 hours in deionized water (at 37°C) until the final surface roughness was measured.

**Simulated toothbrushing procedure**

The simulated toothbrushing of specimens was performed in a controlled toothbrushing simulation machine, designed and conceived at the Federal University of Santa Maria. This machine utilizes an engine and pulleys to produce back and forth movements of 10 arms to which toothbrushes (Oral-B Indicator Plus, Procter & Gamble) were affixed. The machine was set to perform along a horizontal path of 3.8 cm (1.5 in.) on each specimen, at a speed of 356 rpm, applying an axial load of 200 g to simulate the force used during normal oral hygiene procedures.²¹,²² 20,000 cycles were performed and registered in a cycle counter, corresponding to two years of brushing, as based on standards introduced by Goldstein & Lerner.²³ Once the tests were completed, the specimens were removed from the brushing machine, washed thoroughly with air/water spray, and then stored in deionized water (at 37°C) for 24 hours until the final surface roughness (Raf) reading. The Raf was determined in the same way as the Rai, wherein 6 measurements were performed on the perpendicular x and y axes of each specimen; that generated an arithmetic average, which was then considered each specimen’s Raf.

**Statistical analysis**

The nominal Ra values were tabulated and analyzed using descriptive statistical software (SPSS version 18.0, IBM Corporation). The distribution normality in each group was checked by using the Shapiro-Wilk test, and the homoscedacity between groups was checked using the Levene test. The data of surface roughness (Ra) were compared among the 5 experimental groups in each experimental period using ANOVA and Tukey test (P < 0.05). Variation in roughness was calculated and this variable was then compared with the 5 experimental groups by the same tests mentioned above (Table 2).
Results
In analyzing the data in Table 2, which shows the variation of the average roughness (Ra) in the 5 experimental groups, Groups 1-3 and 5 had similar increases in roughness of the resin. The only significant difference in Ra occurred in Group 4 (negative control), where brushing was performed using only deionized water.

Discussion
The surfaces of restorative materials in the oral cavity are subjected to a variety of factors that can influence surface quality. Oral hygiene procedures can increase the Ra of restorative materials, thus promoting bacterial growth and staining.17 The present study tested how brushing with a toothpaste with whitening action affected the Ra of a microhybrid composite resin. For the groups that brushed with different toothpastes, there were significant (although statistically similar) differences between the mean Rai and Raf values. These Ra values increased similarly, regardless of the toothpaste. However, brushing with deionized water only failed to significantly alter the Ra of Group 4. These results are similar to those reported by Tellefsen et al, who found that toothbrushing alone did not have the capability to promote a significant increase in roughness, but that brushing with toothpaste could affect surface texture due to the retention of the abrasive agent.24 In addition, Goldstein & Lerner reported that brushing with water resulted in lower Ra for composite resin compared to brushing with toothpaste.24

The presence of abrasives in the composition of toothpastes is responsible for brushing-related abrasion.25 Hydrated silica is the only abrasive component in both Sorriso and Colgate Total 12 Whitening, while the others have different abrasive agents in their composition (such as calcium carbonate, alumina, sodium silicate, perlite, and silica). However, despite this difference in composition, the behavior of all 4 toothpastes in this study was the same. The increase in resin Ra may be due to the abrasion of the organic matrix and the subsequent exposure of particles.

According to Amaral et al, larger abrasive particles means more abrasion from the toothpaste; however, silica is more abrasive than calcium carbonate when their particles are the same size.1 As a result, brushing composite with a toothpaste containing alumina, silica, and calcium carbonate produces a lower Ra than toothpastes containing sodium bicarbonate.3 The present study showed contrasting results, as the Ra of composite resins increased similarly among toothpastes containing different abrasives. Methodological differences may have contributed to this disparity.

A 2010 study by da Costa et al concluded that low-abrasion dentifrices produced smaller changes in the Ra of composite resins after brushing, while the present study reported similar results after brushing with any of 4 different toothpastes, regardless of their abrasive qualities.24 Heintze et al evaluated the changes in Ra after simulated brushing of 9 different composites in relation to brushing time and load in vitro.26 In general, hybrid composites show the highest increase in Ra values. It is worth noting that the Colgate Total 12 Whitening toothpaste has the same abrasive (hydrated silica) as Sorriso, the non-whitening toothpaste; however, the former costs on average 3 times more than the latter.

Previous studies concerning the long-term effects of different toothpastes on the Ra of composite resins show mixed and inconclusive results. If the surface characteristics of a restorative material are considered to be important for maintaining their optical and esthetic properties and the health of the periodontal tissue, additional studies should be conducted so that the proper dentifrices may be recommended, based on scientific evidence.

Conclusion
The results of the present study indicate that brushing with toothpaste, regardless of its formulation, significantly increased the Ra of the composite resin.

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References


