Staining susceptibility of resin composite materials

DUC, Olivier, et al.

Abstract

To evaluate the color stability of three resin-based materials continuously exposed to various staining agents.

Reference


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Staining susceptibility of resin composite materials

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ABSTRACT: Purpose: To evaluate the color stability of three resin-based materials continuously exposed to various staining agents. Methods: 144 disc-shaped specimens were made of each of the three tested composites (Essentia, Brilliant, Inspiro). Half of them were 1 mm thick, the other half 1.2 mm thick. The thicker group was then polished up to 4,000 grit and reduced to 1 mm thickness, also. All specimens, after 24-hour dry storage in an incubator, received an initial color measurement by means of a calibrated reflectance spectrophotometer (SpectroShade). Specimens were then divided into six groups (n=6) and immersed in five staining solutions or artificial saliva (control). All specimens were kept in an incubator at 37°C for 28 days. Staining solutions (red wine, curry mixed in water, curry mixed in oil, tea and coffee) were changed every 7th day to avoid bacteria or yeast contamination. After 28 days of storage, spectrophotometric measurements were repeated and L*a*b* scores once more recorded to determine the color (ΔE00) changes. Results: All tested materials showed significant color changes after 28 days staining immersion. ΔE00 of polished samples varied from 1.1 (Essentia/distilled water measured over a white background as well as Essentia, Inspiro/distilled water measured over a black background) to 32.5 (Inspiro/wine measured over a white background). (Am J Dent 2019;32:39-42).

CLINICAL SIGNIFICANCE: Staining of restorative materials seems to be dependent on the composition of the product itself. Unpolished samples were more prone to staining than the polished ones.

Introduction

Resin composites are widely used worldwide as they can reproduce a tooth-like appearance. They use allows for minimal invasive dentistry, which implies lower cost and less chair time if compared to the more invasive prosthetic approach based on ceramic crowns. Furthermore, adhesive dentistry is less time consuming and does not require dental technician intervention.

Some disadvantages are evident when comparing resin composites to ceramics: gloss retention is lower over time and they have a much higher staining susceptibility.

Specifically, resin composite staining potential has been evaluated. So far, no consensus was found if polishing was detrimental or advantageous for composite staining resistance and how results present in the literature can be compared. Furthermore, the presence of polished and unpolished parts or a restoration are a common clinical situation and it is of interest to investigate how different surfaces will react to staining agents. Class II, III, and IV resin composites always will have the contact surface unpolished while the rest of the mass is mainly polished.

This laboratory study evaluated, in vitro, the staining potential of recently developed resin composites submitted to different food coloring liquids with or without surface polishing. The obtained data could be predictive of in vivo medium term clinical behavior.

The first hypothesis tested was that the materials included in the study do not significantly change their color after 4 weeks immersion in the staining solutions. The second hypothesis was that resin composite polishing does not significantly influence their staining susceptibility.

Materials and Methods

A total of 72 disc shaped specimens were made of each of the three tested composites (Essentia, Brilliant, Inspiro) (Table 1). All specimens were light-cured for 20 seconds at a distance of 1 mm with a LED curing device (Valo) in "standard mode" with a power density of >1,000 mW/cm² (checked by LED Demetron radiometer). Half of them were 1 mm thick, the other half 1.2 mm thick. The thicker group was then polished with 500-, 1,200-, 2,400-, and 4,000- grit Sic abrasive paper and also reduced to 1 mm thickness. Polishing was performed for 60 seconds for each grit of abrasive paper under continuous water cooling at a constant force of 2 N, according to the methodology proposed by Ardu et al. and as carried out in previous studies. After 24-hour dry storage in an incubator, all specimens used an initial color measurement with a calibrated reflectance spectrophotometer (SpectroShade). Specimens were then divided into six groups (n=6) and immersed in five staining solutions or artificial saliva (control). All specimens were stored in an incubator at 37°C for 28 days. Staining solutions (red wine, curry mixed with water, curry mixed with oil, tea and coffee) were changed every 7th day to avoid bacteria or yeast contamination. The details of staining solutions are summarized in Table 2. After 28 days of storage, samples were cleaned for 60 seconds with a high pressure hot water airbrush (0.4 MPa, 135°C, MiniVapor, 9.5) and air dried. Spectrophotometric measure-ments were repeated and L*a*b* scores were recorded once more to determine the color changes according to the classical ΔE00 formula.

All the details of the methodology employed in this study were widely explained in a previous publication.

Statistical analysis was performed by ANOVA after testing data by means of Kolmogorov-Smirnov test in order to investigate the effect of the staining solutions (first goal of the study). Polished and unpolished values of each resin composite were analyzed by means of Fisher's LSD post-hoc
Table 1. List of materials evaluated.

<table>
<thead>
<tr>
<th>Composite</th>
<th>Composition</th>
<th>Filler % by weight</th>
<th>Filler % by volume</th>
<th>Water sorption μm/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essentia (dentin)</td>
<td>MD dentin (Universal restorative radiopaque)</td>
<td>76</td>
<td>63</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td>UDMA, Bis-MAPEP, silicon dioxide, fluoro-alumino-silicate glass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brilliant Everglow</td>
<td>A2/B2 body (Submicron hybrid universal)</td>
<td>79</td>
<td>64</td>
<td>15.1</td>
</tr>
<tr>
<td>(body)</td>
<td>Aluminum zirconium silicate, zinc oxide, Bis GMA based resins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspiro SN</td>
<td>Enamel Skin Neutral (Nano-hybrid)</td>
<td>82</td>
<td>65</td>
<td>20.0</td>
</tr>
<tr>
<td>(enamel)</td>
<td>Dental glass, silicon dioxide, Bis GMA based dental resin</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Staining solutions used.

<table>
<thead>
<tr>
<th>Artificial saliva (control)</th>
<th>Glandosan solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tea</td>
<td>English breakfast</td>
</tr>
<tr>
<td>Coffee</td>
<td>Nespresso</td>
</tr>
<tr>
<td>Red wine</td>
<td>Grand Palais Côtes du Rhone</td>
</tr>
<tr>
<td>Curry with water</td>
<td>Curry COOP</td>
</tr>
<tr>
<td>Curry with oil</td>
<td>Curry COOP and Oil into 4</td>
</tr>
<tr>
<td>Water</td>
<td>Tap water</td>
</tr>
</tbody>
</table>

Table 3. Medians ΔE and groupings according to the Fisher’s LSD test applied on ΔE00 values. Groups with the same letter are not significantly different (P< 0.05) and where A indicates the best material performance and C the worst material performance. The “All together” line shows medians ΔE and groupings when all staining solutions are pooled together.

<table>
<thead>
<tr>
<th>Background</th>
<th>Staining</th>
<th>Medians ΔE00 – Polished</th>
<th>Medians ΔE00 – Unpolished</th>
<th>Medians ΔE00 – Polished</th>
<th>Medians ΔE00 – Unpolished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Control</td>
<td>2.4</td>
<td>1.7</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>White</td>
<td>Tea</td>
<td>5.1</td>
<td>5.5</td>
<td>11.2</td>
<td>5.7</td>
</tr>
<tr>
<td>White</td>
<td>Coffee</td>
<td>19.9</td>
<td>22.9</td>
<td>30.6</td>
<td>22.7</td>
</tr>
<tr>
<td>White</td>
<td>Red wine</td>
<td>28.7</td>
<td>30.4</td>
<td>32.5</td>
<td>29.9</td>
</tr>
<tr>
<td>White</td>
<td>Curry w/Water</td>
<td>16.3</td>
<td>17.7</td>
<td>25.5</td>
<td>19.0</td>
</tr>
<tr>
<td>White</td>
<td>Curry w/Oil</td>
<td>9.8</td>
<td>11.5</td>
<td>19.0</td>
<td>13.5</td>
</tr>
<tr>
<td>White</td>
<td>All together</td>
<td>12.6</td>
<td>14.7</td>
<td>21.9</td>
<td>16.3</td>
</tr>
</tbody>
</table>

The results are summarized in Table 3. All tested materials showed significant color changes (P< 0.01) after 28 days staining immersion.

When evaluated over a black background, ΔE00 of polished samples varied from 1.7 (Brilliant/distilled water) to 24.1 (Brilliant/wine).

When analyzed over a white background, ΔE00 of polished samples varied from 1.1 (Essentia/distilled water) to 32.5 (Inspiro/wine).

When tested over a black background, ΔE00 of unpolished samples varied from 1.1 (Essentia, Inspiro/distilled water) to 25.8 (Essentia/wine).

When evaluated over a white background, ΔE00 of unpolished samples varied from 1.1 (Inspiro/distilled water) to 33.1 (Inspiro/wine).

When all staining solutions’ means of polished samples were pooled together and analyzed over a black background, mean ΔE00 values varied from 11.7 (Essentia) to 16.3 (Inspiro) while over a white background were 12.6 (Essentia) to 21.9 (Inspiro).

When all staining solutions’ means of unpolished samples were pooled together and analyzed over a black background, mean ΔE00 values varied from 17.7 (Essentia) to 21.5 (Inspiro) while over a white background were 16.3 (Essentia) to 23.8 (Inspiro).

Finally, the Fisher’s LSD post-hoc test showed that polishing had an influence on staining results by lowering their staining susceptibility.

**Results**

The results are summarized in Table 3.

**Discussion**

Different factors influence staining of resin-based materials; insufficient polymerization time, surface roughness and diet. The present study investigated dietary staining in this in vitro study. Specifically, some of the most staining beverages such as tea, coffee, red wine and curry mixed with water or oil were selected for this study. A spice like curry, (composed of turmeric, coriander, cumin, mustard and pepper) which is widely used in eastern countries, and has an evident staining potential was included in this study. Also, curry was alternatively mixed with water or oil (according to different food recipes) in order to see if some differences could be seen. As a control, the current study used artificial saliva (Glandosan®) as a control as in other studies.

The second aim of the study was to investigate if surface polishing could influence the staining potential of the tested resins. The literature is, in fact, not in agreement as of this
writing. The choice of 28 days of immersion in the staining solutions was selected in order to be consistent with the most recent literature reviews\textsuperscript{35,40} representing around 2.5 years of clinical service.

The spectrophotometric measurements with a black and a white background were done in order to simulate different clinical conditions such as Class IV restorations and Class III with no tooth substance remaining (black background), or Class I, II, and III with some remaining tooth substance and veneers (white background).\textsuperscript{52}

In this study, red wine had the most staining potential, followed by coffee (when considered over a black background) or curry mixed with water (when considered over a black background) and tea. The low pH of 4.5 of the red wine used in this study and its relatively high level of tannins may serve as an explanation for its high staining capacity, especially if compared to the coffee brewed in "long" (weak black coffee) mode. These results are in line with a previous study\textsuperscript{40} performed on unpolished samples. It is interesting to underline the high staining potential of curry only when mixed with water. When mixed with oil, in fact, its staining potential was lowered. This can be due to its insolubility in oil, thus, oil may have acted as a staining buffer by covering the resin composite surface not allowing a direct contact by curcumin particles with the surface.

Generally, Essentia showed the best results (least staining susceptibility) in the study followed by Brilliant and Inspiro, independently of the background considered. Manufacturers do not describe the exact composition of the products, which enhance difficulties interpreting the results. Even if filler percentage in volume and weight is, substantially, the same in the three tested materials, differences exist in their basic chemical composition. Essentia is based on UDMA chemistry, which is a hydrophobic monomer; this can be one of the key factors of its good performance.

On the other hand, even the small amount of TEGDMA, higher in Inspiro than in Essentia (Brilliant does not contain it), may explain its higher staining values when exposed to high polarity molecules as tea and curry mixtures. The results of Inspiro might be due to its relatively high translucency, which may accentuate the perceptibility of staining.

In general, the influence of the background on the ranking of the materials tested was low. When small differences were present, they were explainable by the different degree of transparency of the material. Generally, all values obtained on white background were always higher than the ones obtained on black background.

It is important to mention that the staining susceptibility of unpolished composite surfaces were around 30% higher, showing a higher discoloration potential of samples without polishing compared to the polished samples. This is easily explainable by the possible effect of the free radicals present on the surface, which could react with the staining molecules of the tested solutions.

The small color variations obtained with artificial saliva could be due to the natural aging of the materials and can be related to the relatively low pH of the Glandosan solution (5.5); different artificial saliva compositions could lead to different results and should be tested.

Both study hypotheses were rejected. All resin composites tested showed significant changes in color after 4 weeks of immersion in staining solutions. Polishing significantly decreased staining susceptibility of the resin composites.

Under the conditions of this laboratory experiment, Essentia performed better in terms of resistance to staining. Clinical studies should confirm these observations.

References