Effects of different bleaching agent concentrations on surface roughness and microhardness of esthetic restorative materials

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Abstract Objectives: The study assessed the changes in surface roughness and microhardness of three esthetic restorative materials after bleaching with 10%, 20% and 35% carbamide peroxide (CP).

Methods: Standardized cylindrical specimens \((n = 210)\) of 3 esthetic materials (nano composite resin (NC), resin modified glass ionomer (GI), feldspathic porcelain (FP)) were fabricated \((n = 70)\). They were divided into 3 groups \((n = 20)\) and a control group \((n = 10)\). Each group was bleached with different concentrations of CP. The specimens of group 1 and 2 (10% CP and 20% CP) were immersed in the bleaching gels for 6 h daily, while group 3 (35% CP) was immersed for 30 min weekly. The control group was stored in artificial saliva. After 21 days, the morphological changes of the specimens were investigated with surface texture analyzer, while the hardness was assessed by performing superficial microhardness analysis. The data were analyzed with one-way ANOVA, and Scheffe test at \(a = 0.05\).

Results: No significant differences in roughness average (Ra) were recorded among the control group and 10% CP bleached groups of all tested restorative materials (NC \((p = 0.1495)\), GI \((p = 0.0761)\), FP \((p = 0.2848)\)). However, there were significant differences in Ra among the control group, 20% CP, and 35% CP \((p < 0.05)\). There were no significant differences in the micro-hardness of feldspathic porcelain (10% \((p = 0.0786)\), 20% \((p = 0.1041)\), and 35% \((p = 0.2066)\). While nano composite resin and resin modified glass ionomer specimens were significantly affected by concentration of 20% and 35% CP \((p < 0.05)\).
Conclusions: The effects of bleaching depend on the concentrations of CP. The higher surface roughness was produced by 35% CP. Bleaching with different concentrations did not reduce the microhardness of the feldspathic porcelain. However, microhardness of nano composite resin and resin modified glass ionomer specimens was affected by 20% CP and 35% CP.

2. Material and methods

Three different esthetic restorative materials (nano composite resin, resin modified glass ionomer, feldspathic porcelain) of shade A2 (Vita shade guide, Vita Zahnfabrik, Germany) were used (Table 1). Three carbamide peroxide (CP) bleaching products were selected (Table 2). Two at-home bleaching systems (10% and 20% CP) (Opalescence, Ultradent, USA), and one in-office system (35% CP) (Opalescence, Ultradent, USA).

2.1. Preparation of specimens

Seventy cylindrical specimens were prepared for each type of the tested restorative material. All materials were prepared according to the manufacturers' instructions. The control group (n = 10) was stored in Fusayama artificial saliva (KCl (0.4 g/l), NaCl (0.4 g/l), CaCl2 (0.6 g/l), NaH2PO4 (0.69 g/l), and urea (1 g/l) for 21 days). The other test specimens (n = 60) were divided into three groups (n = 20 in each group) according to different bleaching agents (10%, 20%, and 35% CP).

2.2. Composite resin and resin modified glass ionomer

Campos et al.11 mold was prepared: 4 × 2 mm cylindrical acrylic matrixes were fabricated. They were filled with the restorative material. Composite resin or glass ionomer material was placed incrementally. A polyester strip and glass slide was then placed over it with a constant pressure of a weight of 500 g for 30 s. The specimens were cured for 20 s by a LED curing light system (Lume LED 5, Ultradent Products Inc., South Jordan, UT, USA). The light intensity was 650 mW/cm². The light tip was 1 mm away from the specimen. The specimens were then polished (Sof-Lex, 3M ESPE, USA), and stored in distilled water at 37 °C for 24 h.

2.3. Feldspathic porcelain

A stainless steel mold consisting of two plates was prepared.7 It had 4 holes which were 10 mm in diameter. The metal mold was duplicated and porcelain specimens were prepared similar to Turker et al. technique.7

2.4. Bleaching process

The specimens were placed in a plastic box and immersed in the bleaching gel. The first and second group (10% and 20% CP) were left for 6 h daily. The third group (35% CP) was left for 30 min weekly. All specimens were washed with distilled water then kept immersed in Fusayama artificial saliva at
37 °C until the next application. The bleaching procedure was performed for 21 days.

2.5. Surface roughness measurements

Prior to the bleaching process, base-line surface roughness measurements were conducted using surface profilometer with 0.25 mm cut off (zc) at 0.1 mm/s. (Surfanalyzer 4000, Federal Products Corp, USA). Roughness average was recorded. However, other parameters (root mean square, maximal peak-to-valley height, and low-point height) were also used to properly specify the surface finish. On each specimen surface, three parallel measurements in a longitudinal direction were marked and averaged.

2.6. Hardness test

All specimens were analyzed in a microhardness tester (LeitzMiniload2, Ernst Leitzt GmbH, Germany). The Knoop hardness measurement was recorded in five places. A load of 300 g was applied on the porcelain specimens, and 50 g load on the composite and resin modified glass ionomer specimens with a magnification of 500×. The loading time was 30 s for all groups. Then the average of the values was calculated.

2.7. Statistical analysis

Data were analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) was used for comparison among groups and Scheffe test at z = 0.05 was used for multiple comparison among means.

3. Results

A statistically significant difference in roughness parameters was found among different concentrations of bleaching agent (P < .001). The roughness parameter magnitude depends on the restorative material. Table 3 and Fig. 1 present the surface roughness mean values (μm) of all tested groups. In all restorative materials, there were no significant differences in roughness values among the control and 10% CP groups (Filtek Supreme: p = 0.1495; Fuji II LC: p = 0.0761; Duceram: p = 0.2848). However, exposure to 20% CP and 35% CP groups caused a significant increase in roughness after 21 days for all restorative materials (p < 0.05).

Table 4 and Fig. 2 show the mean Knoop hardness values (KHN) of the tested groups. According to multiple comparison among mean values, bleaching with different CP concentrations did not produce any statistically significant effect on the micro-hardness of Duceram (p = 0.2066). However, there is a significant difference by concentration (20% and 35% CP) in the mean hardness for Filtek Supreme and Fuji II LC (p < 0.05).

4. Discussion

Although there is widespread use of bleaching agents, there is no agreement on the effect of bleaching agents on the restorative materials. The physical alteration of tooth-colored
Effects of different bleaching agent concentrations on esthetic restorative materials

Figure 2

Mean Knoop hardness values (KHN) of tested restorative materials.

Table 4

<table>
<thead>
<tr>
<th>Material</th>
<th>Hardness mean and standard deviation</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtek Supreme</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>45.9 ± 1.3</td>
<td></td>
</tr>
<tr>
<td>10% CP</td>
<td>44.8 ± 6.2</td>
<td>0.5860</td>
</tr>
<tr>
<td>20% CP</td>
<td>42.9 ± 4.4</td>
<td>0.0458</td>
</tr>
<tr>
<td>35% CP</td>
<td>40.3 ± 3.1</td>
<td>0.0001</td>
</tr>
<tr>
<td>Fuji II LC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>47.5 ± 3.3</td>
<td></td>
</tr>
<tr>
<td>10% CP</td>
<td>44.2 ± 4.6</td>
<td>0.0353</td>
</tr>
<tr>
<td>20% CP</td>
<td>41.1 ± 1.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>35% CP</td>
<td>40.7 ± 6.8</td>
<td>0.0060</td>
</tr>
<tr>
<td>Duceram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>193.9 ± 32.9</td>
<td></td>
</tr>
<tr>
<td>10% CP</td>
<td>191.2 ± 21.1</td>
<td>0.07865</td>
</tr>
<tr>
<td>20% CP</td>
<td>177.2 ± 21.4</td>
<td>0.1041</td>
</tr>
<tr>
<td>35% CP</td>
<td>176.6 ± 35.3</td>
<td>0.2066</td>
</tr>
</tbody>
</table>

restorative materials is an important consideration when bleaching is performed. Restorative materials tested must withstand degradation in the presence of different chemicals with variable pH levels. In the present study, two at-home bleaching materials (Opalescence, 10% CP and 20% CP) and an in-office bleaching material (Opalescence, 35% CP) were used.

The hypothesis of the current study was rejected, since the bleaching systems with 20% CP and 35% CP have affected the tested restorative materials. It significantly increased the roughness after 21 days for all restorative materials (Table 3). The mechanism of how bleaching regimens affect restorative material is not clear, but presumably this may be due to break down of CP into hydrogen peroxide and urea in aqueous solution, with hydrogen peroxide being the active bleaching agent, which may penetrate the surface of restorative materials. No significant differences in roughness were observed after bleaching with 10% CP comparing with 20% CP and 35% CP. It was claimed that the difference between at-home and in-office bleaching on tooth colored restorative materials related to the action of active bleaching agent. Wattanapayungkul et al. reported that treating composite resins with a low peroxide concentration (10% and 15% carbamide peroxide) significantly increased their surface roughness after 8 weeks. They claimed that repolishing or replacement of tooth-colored restorations may be required after bleaching procedures.

The results of the current study support those of Zavanelli et al., who reported that no alterations were observed on ceramic surfaces treated with 10% or 15% carbamide peroxide for 21 days. Although optimal bleaching time was not defined and may be extended to longer treatment periods in patients with severe discoloration, 21 day bleaching was done to simulate the night guard bleaching treatment, as most patients achieve the best results within this period. In a published review, it was stated that 35% CP affected the surface roughness of dental ceramics. Moraes and his colleagues, who evaluated the effect of high peroxide concentrations (35%) came to a similar conclusion. Since exposing those restorative materials to such chemicals exhibits increased roughness, therefore, bleaching with high concentration should be done carefully and should be avoided on the restorations.

It is known that hardness is related to a materials' strength, proportional limit, and its ability to abrade or to be abraded by opposing dental structures' materials. Therefore any chemical softening resulting from bleaching might have implications on the durability of restorations. In the current study, no surface microhardness changes were observed in all tested 10% CP groups. Turker et al. also reported that using 10% CP or 16% CP did not affect the microhardness of the restorative materials.

On the other hand, we found that the microhardness of nano composite resin and resin modified glass ionomer were reduced significantly with 20% and 35% CP. Our results in contrast with the results of others. They claimed that no significant difference was observed in tested composite materials when bleached with the highest concentrations. The variations in data could be due to the susceptibility of some tooth colored restorative materials and the difference in pH values among the bleaching agents. Regarding the microhardness of resin-modified glass ionomer, Taher noticed an average decrease in surface hardness for both at-home and in-office groups (15% CP, 35% HP) after 15 days.
decrease of surface hardness of modified glass ionomer was referred to the porosities and filler particle.

In the present study, there was no statistical significant difference in the microhardness of ceramic specimens. Polydoroua et al. found that 38% hydrogen peroxide did not affect the microhardness of ceramic restorations 30 days after the end of bleaching, in contrast with the findings of others who found that 10–16% CP applied for 8 h daily were able to significantly decrease surface hardness of feldspathic porcelain material.

One of the limitations of this study is that volume loss from the restorative material surface was not estimated. The other limitation is that an energy-dispersive X-ray microanalysis of ceramic surfaces was not determined. Furthermore, only one type of composite, resin-modified glass ionomer, and ceramic were tested.

5. Conclusion

Within the limitation of this study, the following conclusions can be withdrawn:

1. The impact of bleaching agents on surface roughness could be considered concentration dependent.
2. The surface roughness of tested restorative materials increased with 20% and 35% CP.
3. The microhardness of feldspathic was not affected by different concentrations of CP.
4. The microhardness of nano composite resin and resin modified glass ionomer were reduced significantly with 20% and 35% CP.

Conflict of interest

No conflict of interest is declared for this work.

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