

Research Article

The Effect of Home-Bleaching Agents on Surface Roughness of Restorative Materials

Dionysopoulos D*, Koliniotou-Koumpia E, Gerasimou P and Papadopoulos C

Department of Operative Dentistry, School of Dentistry, Aristotle University of Thessaloniki, Greece

***Corresponding author**

Dimitrios Dionysopoulos, Department of Operative Dentistry, School of Dentistry University of Thessaloniki, Aristotle, Greece, Tel: +30-231-099-9579; Fax: +302310999599; Email: ddiondent@gmail.com

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Abstract

Aim: The purpose of this study was to evaluate the effect of two home-bleaching agents (10 and 20% carbamide peroxide) on the surface roughness of four tooth-colored restorative materials over time.

Methods: Four tooth-colored restorative materials, a compomer (Compoglass F - Ivoclar-Vivadent) and three composite resins (Filtek Z250 - 3M ESPE, Filtek Supreme XT - 3M ESPE, Grandio - Voco) were tested in this study. Two commercial home bleaching agents (Opalescence - Ultradent Products Inc.) 10% and 20% carbamide peroxide were selected. Thirty cylindrical specimen of each restorative material were fabricated, randomly divided into 3 groups and treated as follows: Group A stored in distilled water, Group B bleached with 10% carbamide peroxide seven hours/day and Group C bleached with 20% carbamide peroxide seven hours/day. All treatment was conducted at 37°C and fresh gel applied and rinsed off daily for six weeks. For the bleached groups the specimens were stored in distilled water at 37°C during the hiatus periods. Surface roughness measurements (Ra, μm) were made after 24h and repeated every week of exposure for six weeks using a profilometer. Data were analyzed using ANOVA and Tukey's test at a level of significance of $\alpha=0.05$.

Results: Specimens from control groups showed no significant alteration during all test periods while for exposure to 10% carbamide peroxide only compomer presented significant increase in surface roughness after 6 weeks ($p<0.05$). For 20% carbamide peroxide surface roughness mean values were significantly increased after six weeks for all restorative materials ($p<0.05$).

Conclusions: The effect of bleaching on surface roughness of restorative materials was material and time depended. Bleaching procedures should not be carried out when tooth-colored restorations are presented. Otherwise, the restorations may need to be repeated.

INTRODUCTION

The use of tooth-whitening agents to improve the appearance of natural dentition has become a popular procedure. Tooth-bleaching may be performed at a dental office or at home by the patient himself [1]. There are a number of techniques that have been described in the literature for the bleaching of teeth. These methods utilize different bleaching agents, concentrations, times of application, product format, application mode and light activation [2]. Contemporary bleaching agents are typically either hydrogen peroxide (HP) or carbamide peroxide (CP). In-office bleaching generally uses relatively high levels of bleaching agents (25-35% HP or 35% CP) for shorter time periods while home-bleaching products typically contain low levels of whitening agent (3-6% HP or 10-16% CP). Ten percent CP has been used extensively within the dental profession for the purpose of home-bleaching teeth [3]. Carbamide peroxide (CP)

agent was introduced as an alternative to traditional hydrogen peroxide (H_2O_2), and its use has become widespread. Carbamide peroxide - $[\text{CO}(\text{NH}_2)_2]\text{H}_2\text{O}_2$ - is very unstable and immediately breaks down into its constituent parts on contact with tissue and saliva, dissociating primarily into H_2O_2 and urea (NH_2CONH_2) and further into oxygen (O_2), water (H_2O) and carbon dioxide (CO_2) [4].

Tooth whitening is believed to occur due to changes in chemical structure of its organic substances, by unstable free radicals that are generated from these compounds, through either oxidation or reduction reaction [1,5]. Hydrogen peroxide is capable of oxidizing a wide range of colored organic and inorganic compounds, causing decolorization and hence bleaching of the substrate [2].

Surface roughness of the restorations is important, as it plays

a major role in the formation of biofilms and bacterial adhesion [6] that may lead to gingival inflammation [7]. Furthermore, surface restorations not only results in optimal aesthetics such as extrinsic staining [8] but also provide for acceptable health of soft tissues and marginal integrity of the restorative interface [9].

The effect of bleaching agents on the properties of the restorative materials is important. Several studies have evaluated its effect both on the mechanical and physical properties of restoratives [10]. However, investigations on surface roughness of restoratives after bleaching treatment have shown contradictory results. The opposing results may be attributed to the diverse bleaching protocols and materials tested.

The purpose of this study was to evaluate the effect of two home-bleaching agents (10 and 20% CP) on the surface roughness of three composite resins and a compomer during 6-week experimental period.

The first null hypothesis of the study was that there were no significant differences in surface roughness among the restorative materials tested after bleaching. The second null hypothesis was that there were no significant differences in surface roughness between the experimental groups treated with different bleaching agents.

MATERIALS AND METHODS

Four tooth-colored restorative materials (Filtek Supreme XT, Filtek Z250, Grandio, Compoglass F) and two commercial home bleaching agents (Opalescence - 10% and 20% CP) were investigated in this study (Table 1). Thirty cylindrical specimens of each material (6 mm in diameter and 3 mm in height) were made using Teflon molds. The molds were slightly over-filled with material, covered on each side with matrix strips (Have-Neos Dental, Bioggio, Switzerland) and placed between 2 microscope glass slides (1 mm thick); pressure applied to extrude the excess material. The specimens were light-cured for 40 sec from both sides of the mold with a QTH light-curing unit (Elipar 2500, 3M ESPE, St. Paul, MN, USA) at 1300 mW/cm². The intensity of the light-curing unit was checked using a photometric tester (Hilux, Curing Light Meter, Benlioglu Dental Inc., Turkey). After 24 h, polishing was performed with medium, fine and superfine aluminum oxide discs (Sof-Lex, 3M ESPE, St. Paul, MN, USA). The specimens were stored in distilled water at 37°C for 4 weeks prior to the start of the experiment.

The specimens were randomly divided into 3 groups of 10. In Group 1 (control group) the specimens were stored in distilled water at 37°C. Groups 2 and 3 were treated with 10% and 20% CP bleaching agents respectively, for 7 h per day. Treatment was conducted at 37°C and fresh gel was applied and rinsed off daily for 6 weeks, according to manufacturer's instructions. Baseline surface roughness measurements were made 24 h before the first exposure and repeated every 7 days for 6 weeks. To minimize the effect of operator variability, bleaching procedures were carried out by the same researcher. The bleached specimens rinsed, cleansed in an ultrasonic cleaner for 3 min, allowed to dry and kept in 100% humidity for 24 h, before measuring the surface roughness.

The average surface roughness (Ra, μm) of each specimen

Table 1: The materials used in this study.

MATERIAL	TYPE	COMPOSITION	MANUFACTURER
Filtek Z250	Microhybrid composite resin	Bis-GMA, Bis-EMA, TEGDMA, zirconia, silica (0.01-3.5μm, 60vol%)	3M ESPE, St Paul, MN, USA
Filtek Supreme XT	Nanofilled composite resin	Bis-GMA, Bis-PMA, DUDMA, TEGDMA, zirconia, silica (60vol%) nanoclusters (0.6-1.4μm) nanofil silica (20nm)	3M ESPE, St Paul, MN, USA
Grandio	Nanohybrid composite resin	Bis-GMA, DUDMA, TEGDMA, Fillers: 87% Glass ceramic (1μm) Silica (20-60nm)	Voco, Cuxhaven, Germany
Compoglass F	Compomer	UDMA, DCDMA, Bis-PMA, TEGDMA, YbF ₃ , BaAlFSiO ₄ glass	Ivoclar Vivadent, Schaan, Liechtenstein
Opalescence	Home-bleaching agent	10% carbamide peroxide, carbopol > 1.5%, glycerin, flavoring	Ultradent, South Jordan, UT, USA
Opalescence	Home-bleaching agent	20% carbamide peroxide, carbopol > 1.5%, glycerin, flavoring	Ultradent, South Jordan, UT, USA

was measured using a surface profilometer (Mitutoyo SJ 201, Kanagawa, Japan). Readings were taken at the centre of each specimen and 5 sampling lengths of 0.8 mm were used, giving a total evaluation length 4 mm with a standard cut-off of 0.8 mm, a transverse length of 0.8 mm and a stylus speed of 0.25 mm/sec. The Ra of a specimen was defined as the arithmetic average height of roughness component irregularities from the mean line measured within the sampling length. Five profilometer tracings were made at the centre of each specimen and the numerical average was determined for each group.

Two-way ANOVA was used to determine significant interactions between materials and bleaching methods. One-way ANOVA and Tukey's HSD test were used to compare the mean surface roughness between materials for each treatment group. The statistical significance was pre-set at $\alpha = 0.05$.

RESULTS

The mean Ra values of the restorative materials tested at 6-week period are shown in (Table 2) and (Figures 1 and 2). Table 3 shows the statistical significant differences after 6 weeks of bleaching treatment. The results showed that Compoglass F exhibited higher Ra values than composite resins 1 week after the beginning of the treatments ($p > 0.05$), while the three composite resins did not show significant differences in Ra values during all the experimental period, regardless bleaching treatment ($p > 0.05$). The restorative materials did not present significantly higher Ra values during bleaching with 10% CP ($p > 0.05$), except Compoglass F, which exhibited significantly increased surface roughness from week 2 until the end of the procedure ($p < 0.05$). At week 1 only Compoglass F specimens treated with 20% CP

Table 2: Mean surface roughness values (Ra, μm) and standard deviations of restorative materials evaluated at each week.

Group 1 : Water								
Restorative material	Week	0	1	2	3	4	5	6
Filtek Z250		0.09 (0.02) ^{Aa}	0.09 (0.01) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}
Filtek Supreme XT		0.08 (0.02) ^{Aa}	0.08 (0.01) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.01) ^{Aa}	0.09 (0.02) ^{Aa}	0.08 (0.02) ^{Aa}
Grandio		0.08 (0.01) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.01) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.01) ^{Aa}	0.09 (0.02) ^{Aa}
Compoglass F		0.11 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}	0.12 (0.02) ^{Aa}	0.12 (0.02) ^{Aa}
Group 2 : 10% CP								
Restorative material	Week	0	1	2	3	4	5	6
Filtek Z250		0.10 (0.01) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}
Filtek Supreme XT		0.09 (0.02) ^{Aa}	0.09 (0.01) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}	0.12 (0.02) ^{Aa}
Grandio		0.08 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.09 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}
Compoglass F		0.11 (0.02) ^{Aa}	0.13 (0.03) ^{Ab}	0.14 (0.03) ^{Bb}	0.16 (0.03) ^{Bb}	0.18 (0.04) ^{Bb}	0.21 (0.03) ^{Bb}	0.24 (0.05) ^{Bb}
Group 3 : 20% CP								
Restorative material	Week	0	1	2	3	4	5	6
Filtek Z250		0.10 (0.01) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.11 (0.03) ^{Aa}	0.12 (0.02) ^{Aa}	0.13 (0.02) ^{Ba}	0.15 (0.03) ^{Ba}
Filtek Supreme XT		0.09 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}	0.13 (0.02) ^{Aa}	0.15 (0.02) ^{Ba}	0.16 (0.03) ^{Ba}
Grandio		0.08 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.10 (0.02) ^{Aa}	0.11 (0.02) ^{Aa}	0.12 (0.03) ^{Aa}	0.13 (0.02) ^{Ba}	0.14 (0.03) ^{Ba}
Compoglass F		0.11 (0.02) ^{Aa}	0.16 (0.03) ^{Bb}	0.21 (0.05) ^{Bb}	0.28 (0.06) ^{Bb}	0.32 (0.07) ^{Bb}	0.38 (0.07) ^{Bb}	0.47 (0.09) ^{Bb}

*Means in a line followed by different capital letters indicate statistical significant difference ($p < 0.05$) compared with baseline measurements (Week 0).

*Means in a column followed by different small letters indicate statistical significant difference ($p > 0.05$) between restorative materials.

showed significantly higher surface roughness compared to baseline measurements while the composite resins showed significantly higher values at week 5 ($p < 0.05$). At the end of the bleaching procedure with 20% CP all the specimens of the materials bleached, presented significantly higher Ra values than the control group ($p < 0.05$).

DISCUSSION

The results obtained from this *in vitro* study demand rejection of the first null hypothesis that there were no significant differences in surface roughness among the restorative materials tested after bleaching. This is in agreement with previous studies, which investigated the effect of home-bleaching agents on surface roughness of various restorative materials [11-15].

Regarding composite resins, bleaching agents may

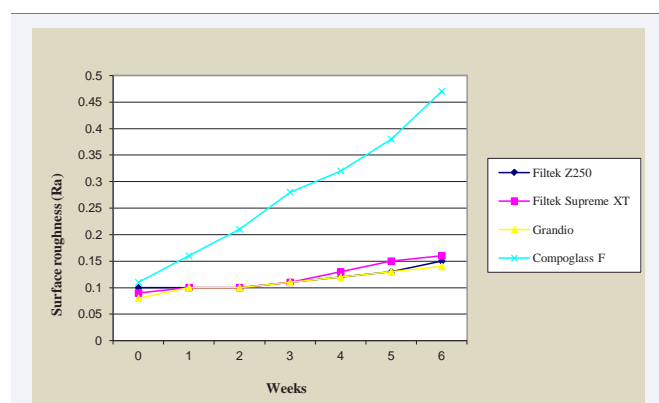


Figure 2 Surface roughness (Ra, μm) of the restorative materials bleached with 20% CP for each week.

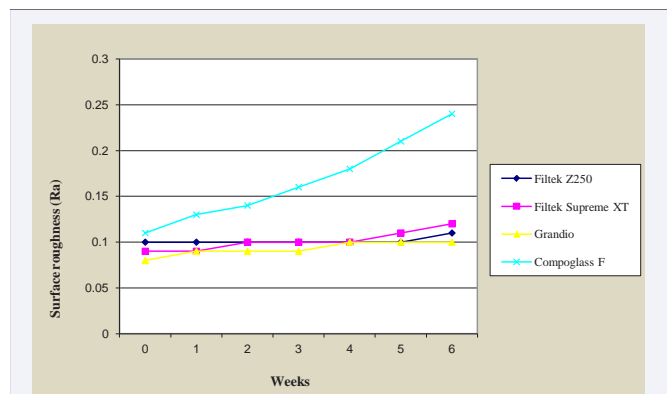


Figure 1 Surface roughness (Ra, μm) of the restorative materials bleached with 10% CP for each week.

Table 3: Comparison of surface roughness among experimental groups after six weeks of treatment.

Restorative material	Significance at week 6
Filtek Z250	20% CP > 10% CP = distilled water
Filtek Supreme XT	20% CP > 10% CP > distilled water
Grandio	20% CP > 10% CP = distilled water
Compoglass F	20% CP > 10% CP > distilled water

> indicate higher significant value ($p < 0.05$)

= indicate no significant difference ($p > 0.05$)

influence mainly resin matrix [16], whereas inorganic fillers are probably not affected even in a very low pH environment [17]. Nevertheless, other studies have reported no alteration in surface roughness of micro hybrid composite resins after exposure to home-bleaching agents [12]. In the present study, micro hybrid

composite specimens presented significantly rougher surfaces after 5 weeks of exposure to 20% CP bleaching agent. It has been assumed that the filler load is related to the surface roughness of the restorative materials [7]. The increased surface roughness may be attributed to erosion of resin matrix from free radicals of peroxide which leads to debonding of resin-filler interfaces and to dislodgment and elution of fillers. Consequently, the higher the volume and the size of leached particles of the materials, the rougher the resulting surface. In the current study, different filler load and size among microhybrid (Filtek Z250), nanohybrid (Grandio) and nanofilled (Filtek Supreme XT) composite resins did not affect surface roughness.

Compoglass F showed a dramatic increase in Ra values over time, while the composite resins were not affected by bleaching procedure until week 4 when bleached with 20% CP. The increase in surface roughness of Compoglass F (compomer) after bleaching might be attributed to the resin matrix and fillers of the material being different from the composite resins tested. Water uptake and expansion has been reported in compomers that may result in stress corrosion and complete or partial debonding of fillers leading to cracking and increased surface roughness [15]. Furthermore, the resin matrix of compomers may be more susceptible to hydrolysis and oxidation. Clinical studies demonstrated that surface roughness of compomers was significantly increased when exposed to bleaching agents [18]. SEM evaluations have showed cracks [15,19], chemical alterations and surface dissolution [13] in the restorations after their exposure to 10% and 15% CP.

The use of a higher concentration of CP resulted in greater surface roughness of the restorative materials investigated. As a result, the second null hypothesis that there were no significant differences in surface roughness between the experimental groups treated with different bleaching agents is rejected. This is in agreement with other reports, which investigated the effect of concentration of bleaching agents on surface roughness [3,13].

Some studies found no significant increase in composite surface roughness after exposure to home-bleaching agents [15,21,22], but other reported roughening and cracking when evaluated under scanning electron microscopy (SEM) [12-14,16,23]. The results of this study showed that the effect of bleaching agents on the surface roughness of restorative materials is material and time depended.

Treatment times for home-bleaching vary extensively and depend on the length of time per day that the patient spends on applying the technique. There are many *in vitro* studies simulating clinical situation as closely as possible, which used home-bleaching agents within 2-4 week experimental period with application intervals of 4-8 h per day [10]. In the present study the duration of bleaching procedure was 6 weeks and the application time was 7 h per day.

It has been reported that for surface roughness below 0.2 μm no significant effect on plaque accumulation and composition was found [24]. This led to the suggestion of a 0.2 μm "threshold Ra" where any decrease in surface roughness below this level causes no further reduction in plaque accumulation. In this study all bleached specimens presented Ra values less than 0.2 μm

except specimens of Compoglass F. These results suggest that Compoglass F should be replaced or re-polished after bleaching.

Profilometers used for *in vitro* investigations, provide limited two-dimensional information, but an arithmetic average roughness can be calculated [25]. Therefore, the complex structure of a surface cannot be fully characterized by use of only surface roughness measurements. However, in combination with SEM analysis and optical profilometer, more valid predictions of clinical performance can be made [7]. Further investigations, in particular clinical studies, would be necessary to clarify the effect of bleaching agents on physical and mechanical properties of restorative materials.

CONCLUSIONS

1. The effect of bleaching on surface roughness of tooth-colored materials is material and time depended.
2. Surface roughness of Compoglass F reach a critical threshold value of 0.2 μm after 2 weeks of bleaching with 20% CP and after 5 weeks using 10% CP.
3. There is no significant difference in change of surface roughness according to the type of composite resin, whether nanofilled, nanohybrid or microhybrid.

CLINICAL SIGNIFICANCE

This *in vitro* study suggests that compomer restorations should be placed after bleaching procedures, because the bleaching process appears to alter the surface properties of these materials.

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