Journal of Experimental and Clinical Medicine

Experimental Research doi: 10.5835/jecm.omu.31.03.006

Effect of bleaching agents on surface texture of feldspathic ceramic

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ARTICLE INFO

Article History
Received 01 / 04 / 2014
Accepted 09 / 07 / 2014

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Keywords:
Bleaching agents
Carbamide peroxide
Ceramic
Surface roughness

ABSTRACT

The aims of this study were to evaluate the effects of different carbamide peroxide concentrations on surface structure changes of porcelain restorative materials. A total of 50 discs were made and divided into five groups each include 10 specimens. One group served as control and no bleaching agent was applied. Other groups were immersed in the bleaching gels with the concentration of 10% (Group 10), 15% (Group 15), 20% (Group 20), 35% (Group 35) for an average of 8 hours per day. The bleaching procedure was performed over a period of 21 days. The surface roughness values were measured by surface profilometry. Treated ceramic surfaces were examined by scaning electron microscopy (SEM) and atomic force microscopy (AFM). The data were analyzed by analysis of variance and post-hoc Tukey test. The results showed that higher concentration of carbamide peroxide gel effect the surface roughness of test specimens significantly. The highest surface roughness values were obtained in group 35 (0.57 µm±0.19) and showed significantly different from group C (0.24 µm±0.11) which was the lowest surface roughness values. The concentration of the carbamide peroxide bleaching agent used in this study affected the surface roughness of the porcelain test specimens. Ceramic restoration should be protected before any bleaching for preventing negative effects of agent on surface properties.

J. Exp. Clin. Med., 2014; 31:177-181

1. Introduction

Dental bleaching is a conservative alternative to restore the esthetics of either stained or darkened teeth. With careful diagnosis, appropriate treatment planning, and attention to technique, bleaching may represent a more conservative and safe means to lighten discolored teeth. Currently, a broad range of bleaching agents containing varying concentrations of carbamide peroxide (CP) and/or hydrogen peroxide (HP) is available (Perdigao et al., 2004).

After a publicationby Haywood and Heymann, (Haywood, 1992) night-guard bleaching has been a commonly used technique for bleaching. Although at-home bleaching with 10% CP has become a standard technique for teeth whitening, (Haywood and Heymann, 1989; Perdigao et al., 2004) in-office technique has emerged because highly concentrated products can promote faster whitening (Leonard et al., 1998). For the bleaching technique, manufacturers have introduced higher concentrations of CP, such as 15% and 20%, as well as 35% and 38% hydrogen peroxide. The bleaching agents techniques cause oxygen to be released and can cause morphologic alterations in the mineralized structures (Ben-Amar et al., 1995; Zalkind et al., 1996; Barbosa et al., 2008).

CP agent was introduced as an alternative to traditional hydrogen peroxide agent, and its use has become widespread (Haywood, 1992; Wattanapayungkul and Yap, 2003). This agent is very unstable and immediately decomposes to their constituent of primarily hydrogen peroxide and urea and further oxygen, water and carbon dioxide upon contact with tissue and saliva (Haywood, 1992; Sulieman et al., 2004a). Tooth whitening is believed to occur due to changes in the chemical structure of organic substances in tooth, by unstable free radicals that are generated from these compounds (Dahl and Pallesen, 2003), through either an oxidation or a reduction reaction (White et al., 2002; Canay and Cehreli, 2003). However, due to the fact that the bleaching agent is held in intimate contact with the teeth, with potentially associated restorations, it has been speculated that this process could cause negative alterations in oral substrates (Bailey and Swift, 1992; Langsten et al., 2002).

Roughness is an important surface property and is described as the overall roughness of a surface. The roughness of intraoral hard surfaces enhances initial adhesion and retention of oral microorganisms and accelerates maturation of plaque through increasing the area available for adhesion by a factor of 2 to 3. A rough surface may as well abrade opposing tooth or restorative materials (Seghi et al., 1991; Metzler et al., 1999). Thus for optimum esthetics, the surface of dental restorations should be as smooth as possible.

There are several reports on the effect of bleaching agents on the surface properties of restorative materials. Swift and Haywood reported that night-guard vital bleaching techniques have no significant effect on the color or physical properties of porcelain or other ceramic materials, as well as amalgam or gold (Turker and Biskin, 2003). Moraes et al. (2006) reported that there was a significant increase in surface roughness of feldspathic porcelain surface after 21 day immersion in carbamid peroxide. Some authors (Bailey and Swift, 1992; Turker and Biskin, 2002) have reported some changes in restorative materials, while others (Turker and Biskin, 2003; Wattanapayungkul et al., 2004) found no significant alterations. There is an indication that carbamide peroxide reduced the microhardness of feldspathic. For example 10 % carbamide peroxide reduced the microhardness of feldspathic dental porcelain (Turker and Biskin, 2002). However, the studies (Butler et al., 2004; Moraes et al., 2006) found in the literature attempted to evaluate the effecs of different carbamide peroxide concentrations on surface roughness of feldspathic porcelain are limited.

The research hypothesis of this study is that carbamide peroxide with different concentration can affect the surface roughness of ceramic surface. Therefore the aims of this study were to examine the effects of carbamide peroxide with different concentrations on the surface roughness, topography and surface structure of porcelain restorative materials.

2. Experimental procedure

The effect of one commercial at home bleaching agent (Opalesence, Ultradent, South Jordan, Utah, USA) with different concentrations on the surface roughness of feldspathic ceramic was evaluated. The materials, product names, and manufacturers are listed in Table 1. A mold was made using vinyl polysiloxane putty (Coltene Lab-Putty; Coltene/ Whaledent Inc, Cuyahoga Falls, Ohio, USA) to facilitate the fabrication of the porcelain discs (10 mm diameter, 2 mm thick). After each specimen was mixed using the same amount of porcelain and liquid, placed into the mold and compressed with a plastic plunger. The excess moisture was removed by using a tissue (Selpak; Eczacıbaşı Group, Kocaeli, Turkey). After removal from the mold, the specimens were fired in the furnace (Programat P80; Ivoclar-Vivadent, Liechtenstein) according to the manufacturer's directions (Approximately 920-960°C).

Table 1. Materials used

Material	Product Name	Manufacturer
Feldspatic porcelain	VITA	Vita Zahnfabrik, Germany
Carbamide peroxide	Opalesence	Ultradent Products Inc, South Jordan, Utah

The porcelain specimens were polished with a medium-grit diamond bur (Brasseler size 016 #848-11; Brasseler USA, Savannah, Ga) on both sides to remove any irregularities and to create a flat surface. After removal of irregularities, the discs were placed in the porcelain oven and fired to obtain an over glazed surface. A total of 50 discs were prepared and divided into five groups each include 10 specimens in each group. All specimens were stored in screw-top vials (Isolab, Wethe-im, Germany) containing distilled water at room temperature for 24 hours before any test procedure. One group served as control and left untreated. The other groups were immersed in the bleaching gels with the concentration of 10% (Group 10), 15% (Group 15), 20% (Group 20), 35% (Group 35) for an average of 8 hours per day. The bleaching treatment was performed for a period of 21 days by daily application of freshly prepared bleaching gels. At the end of the bleaching treatment, the specimens were removed from bleaching gels and washed under plenty of running distilled water for 30 seconds and placed in fresh distilled water for 16 h until the next day bleaching treatment (Turker and Biskin, 2003). The control group specimens were kept in daily prepared fresh distilled water. Surface roughness measurements were made after the 2 weeks. A stylus profilometer (Veeco Dektak 8) was calibrated using a standart specimens provided by Veeco at the beginning of the measuring session. The specimens were rotated clockwise at random angles on the stage of the profilometer at the beginning of each measurement of 20 total scans to ensure that the entire surface of each specimen was scanned. The roughness value (Ra, μm) of each specimen was evaluated and recorded as the average of the 12 readings by Dektak 32 V8.35 software. All surface measurement tests were performed by the same researcher.

To evaluate the effect of surface treatments methods 5 additional samples were prepared. Four of specimens were treated with the same experimental procedure as described previously. All specimens were coated with gold using a sputter coater and examined under a field emission scanning electron microscope (Philips XL30 scaning electron microscopy (SEM) with energy dispersive spectrometry (EDS) facility) from surface.

The further surface examination was performed by employing an Atomic Force Microscope (atomic force microscopy (AFM), Multimode Nanoscope IV, Digital Instruments, Veeco Metrology group, Santa Barbara, CA, USA) using Si_3N_4 tip in contact mode under atmospheric condition at room temperature. The area of the scan was 10 μm×10 μm and the data recorded with a scan rate of 0.5 Hz. The average surface roughness (Ra) of the untreated and treated ceramics was analyzed using a software (Nanoscope V530R3SR3) and expressed as a numeric value by the same operator. Five measurements from different region of the sample surfaces were performed for each treated and untreated ceramic samples.

The collected experimental data were statistically analy-

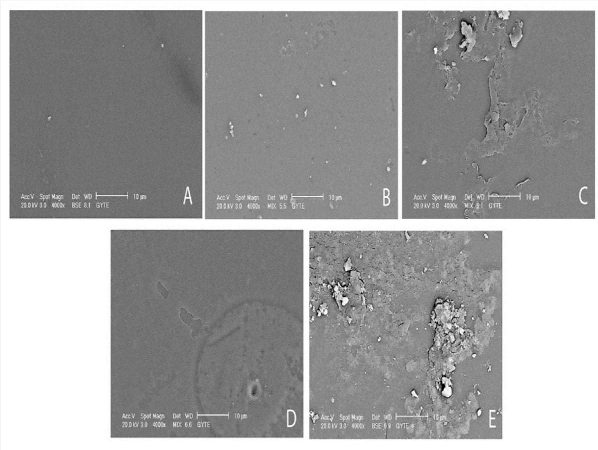

Fig. 1. SEM images of the ceramic surfaces (x 4000); A. Control (No treatment), B. 10% CP, C. 15% CP, D. 20% CP, and E. 35% CP gel was applied

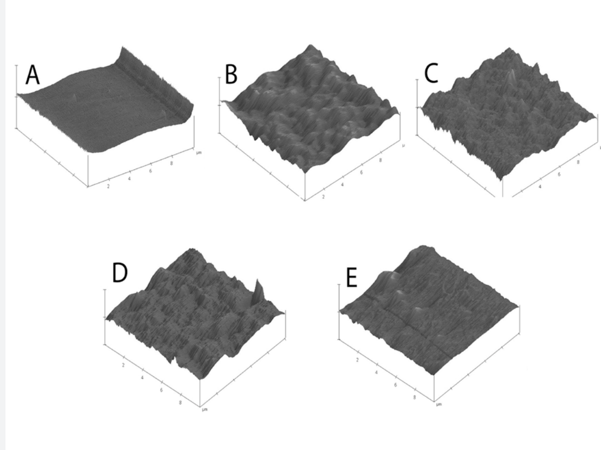

Fig. 2. Typical AFM images of the ceramic surfaces: A. Control (No treatment), B. 10% CP, C. 15% CP, D. 20% CP, and E. 35% CP gel was applied.

zed. The Kolmogorov-Simirnov test showed that the data was of a normal distribution (p>0.05). A homogeneity of variance test was done using Levene's test (p>0.05). Means and standard deviations of bond strengths were calculated and mean values were compared by one-way analysis of variance (ANOVA) (SPSS 12; SPSS Inc., Chicago, Ill), followed by a multiple comparisons' test performed using a Post Hoc Tukey test (α=0.05).

3. Results

The SEM photomicrographs of test specimens were presented in Fig. 1. The figure shows that there were some surface irregularities on the surface of samples of the group 10, 15, 20 and 35 when compared to the control group samples. The treatment has created submicron cavities and pittings and changed the surface structures. Although it is difficult to claim that this change increase linearly with the concentration of bleaching gel, the maximum affect is seen with the application of the highest bleaching gel concentration. Topographical 3D AFM images of the test samples were illustrated in Fig. 2. The treatment has resulted in the formation of some asperities and cavities on the surface of ceramic sample surface and this effect is clearly seen on AFM images. Therefore, the surface of the untreated sample (control) has much smoother appearance compared to the treated sample's surfaces.

The SEM and AFM examination results are parallel from the effect of treatment point of view. The quantified test results of surface roughness with the mean values and standart deviations of the treated and untreated samples are given in Table 2.

The results of one-way ANOVA showed that the relation between bleaching agents concentration and surface roughness of test specimens were significant (P<0.05) (Table 3). The lowest surface roughness values were obtained for the samples in group C (0.24±0.11 μm) and the values for this group were considerably different from all other test groups. The highest surface roughness values were obtained in group 35 (0.57±0.24 μm) while there was no significant difference among the groups of 10.15 and 20.

Table 2. Mean (μm) and standard deviations (SD) of surface roughness values.

Groups	Ra	SD
C	0.24 a	±0.11
10	0.37 b	±0.12
15	0.51 c	±0.17
20	0.52 c	±0.09
35	0.57 c	±0.19

Same letter are not statistically different (p>0.05).

Table 3. Mean (μm) and standard deviations (SD) of surface roughness values.

	Sum of	df squares	Mean square	F	Sig.
Between	1.463	4		18.844	0.000
Groups Within	1.844	95	0.019		
Groups Total	3.308	99			

4. Discussion

Surface topography alteration of feldspathic ceramic due to application of bleaching agents with different concentrations was studied. Our research hypothesis was accepted. In other words, the results of this study showed that increasing the concentration of carbamide peroxide in bleaching agents adversely effects the surface roughness values of feldspathic ceramic restorations.

Interaction between whitening agents and oral structures is of critical importance, and some chemical aspects involved in bleaching could negatively interfere with this. The oxidative process, with its low resulting pH, has been considered as a potential source of adverse effects (Basting et al., 2003; Lewinstein et al., 2004). Surface roughness is defined as relatively finely spaced surface imperfections whose height, width and directions establish a predominant surface pattern (Mohsen, 2010). Surface roughness is a clinically important property that warrants investigation, since it can influence both aesthetics and health (Moraes et al., 2006).

Although there are mixed reports on the effects of bleaching agents with different concentrations and compositions on tooth structure and esthetic restorative materials (Canay and Cehreli, 2003; Schemehorn et al., 2004), few researchers have studied the effect of bleaching on ceramic surfaces (Turker and Biskin, 2003). Recent studies have shown surface effects may occur on existing restorative materials by bleaching agents. Duschner et al. (2004) reported no changes were accured in surface morphology of porcelain exposed to bleaching. This could have been due to the lower concentration of the bleaching agents used in their study. Butler et al. (2004) reported that porcelains might have significant roughening from 10% CP treatment. Turker and Biskin (2003), in a surface spectral analysis study, observed that the SiO2 and K2O2 content for the same feldspathic porcelain tested here, after exposure to CP home agents, was found to be decreased up to 4.82 and 1.89%, respectively, of original content. In addition, in a previous paper, the authors have reported a significant decrease on the hardness of this ceramic material after bleaching (Turker and Biskin 2002). Zaki and Fahmy (2009) reported that significant increase in the roughness of the polished overglazed ceramic after the application of bleaching procedure. As previously mentioned in the literature the surface properties of ceramic restorations have affected from the bleaching procedure. In this in vitro study higher carbamide peroxide concentrations caused increased surface roughness test values. This assumption is in accordance with the findings of other investigators, who have reported that the detrimental effect of bleaching agents is directly proportional to their concentrations (Lewinstein et al., 2004; Sulieman et al., 2004b). This result can be related to the glassy matrix of the ceramic surface affected after the exposure of the higher concentrations of the carbamide peroxide solutions. The glassy matrix of the feldspathic ceramic may be melted after the immersion to carbamide peroxide solution in high concentrations. As a conclusion the increased surface roughness test values can be attributed to this melting process of glassy matrix of the ceramic material. And also in the present study when the surface roughness was evaluated in the concentrations of 10%, 15%, 20% and 35% there were significant differences were found when compared with the control group.

The discrepancies between studies may be explained by the differences in experimental methodologies, bleaching agents compositions applied.

In vitro studies are limited in their attempt to simulate clinical conditions. It was shown that peroxide levels in bleaching products are depleted during use depending on the in vivo situation (McCracken and Haywood, 1996). In this study, the bleaching agents were not diluted or buffered with any water content such as saliva or distilled water buring bleaching treatments (Mujdeci and Gokay, 2006). In this respect, the effect of bleaching products on the surface roughness of ceramic material for in vivo conditions may be different than for in vitro studies. Further studies are needed to investigate the effect of bleaching agents on surface roughness of different ceramic materials.

5. Conclusion

On the basis of these results and within the limitations of this research; carbamide peroxide bleaching agents increased the surface roughness of the feldpatic ceramic material and in the higher concentrations, surface properties of ceramic material can be affected by bleaching agents. Ceramic restoration should be protected before any bleaching for preventing negative effects of agent on surface properties.

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