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The effects of vital whitening agents on the surface properties of three different restoration materials.

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Abstract

The aim of this study was to evaluate the effects which can occur on the physical properties of 3 different restorations (amalgam, GIC, composite) with the application of carbamide peroxide whitening. A total of 99 samples were prepared. The samples were randomly separated into 3 groups of 30 with 10 of each of the 3 materials. Each of these groups was examined in a different test device (G1: profilometer, G2: AFM, G3: spectrophotometer). The remaining 9 samples constituted a 4th group for SEM examination. 16% carbamide peroxide was applied at 6 hour intervals for a total of 14 days. A statistically significant increase was determined in the surface roughness (Ra-µm, Ra-nm) and colour change (ΔE) values in all the restorations. The least colour change was observed in composite. In the SEM, no significant surface change was observed in amalgam and composite, whereas micro-cracks were observed to have formed on the GIC surface.

Keywords: Vital whitening, Surface roughness, Colour change, Profilometer, AFM, Spectrophotometer, SEM.

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Introduction

Trauma Nowadays, the increasing desire to look better has increased the importance of the appearance of teeth in human aesthetics. Presence of altered teeth distorting the appearance is a multifactorial pathological condition that differs according to the localization and etiology of the person (natural or iatrogenic, internal or external), which adversely affects the patient's mood-state [1-3]. Discoloured teeth treatments include orthodontic, restorative and prosthetic approaches or combinations of these. The whitening procedure is included within restorative applications and is accepted as a more conservative, simple and cheap method [3,4].This procedure is applied with different methods such as bleaching of vital teeth, home bleaching, office bleaching, power bleaching and over-the counter bleaching methods [5]. Night guard bleaching is a currently popular procedure, which is based on the use of low concentration whitening agents [10%-20% carbamide peroxide (CP) or the equivalent 3.5%-6.5% hydrogen peroxide (HP)] which are placed on plates custom-made for the patient and applied before sleeping. It is recommended that gels containing 10% CP are applied for 8 hours per day and those containing 15%-20% CP for 3-4 hours per day [3].

The effect of a whitening application on dental and surrounding soft tissues is examined with histological and chemical methods. In recent studies, there have been seen to be increased micro-structural changes in the dental hard tissue after the application of vital whitening agents with a high concentration of peroxide. Lengthy whitening treatments are questionable as they could lead to a breakdown of the enamel matrix. Together with mineral loss from the external surface of the tooth, changes occur in the micro-hardness of the enamel [6,7]. In addition to dental tissues, restorations are also affected during whitening treatment. As a result of the research, it has been reported that the materials can cause changes in the surface roughness values (Ra) depending on the period of application of the whitening [8].

The aim of this *in vitro* study was to evaluate the effects of CP whitening agents on the surface characteristics of different restorations which are most likely to be in the mouth, by examination with profilometer, atomic force microscope (AFM), scanning electron microscope (SEM) and spectrophotometry methods.

Materials and Method

To prepare the materials, 99 standard sterile polyethylene tubes, 2.5 mm in length and 10 mm in diameter were used. An artificial saliva solution was used to store the samples. As the whitening agent, 16% CP (Opalescence PF, Ultradent, Germany) was used and the restoration materials were amalgam (Cavex Avalloy, Holland), resin-modified glass ionomer cement (Fuji II LC, GC, Japan) and nanohybrid composite resin (Grandio,Voco, Germany). The polyethylene

tubes into which the samples were to be placed were separated into 3 groups of 33. The materials were prepared according to the manufacturer's instructions and placed in the tubes as Group 1 amalgam, Group 2 GIC and Group 3 composite resin. To obtain a smooth upper surface on the GIC and composite resin samples, microscope glass and clear band were used and polymerisation was applied with an LED light source for 20 seconds.

After 24 hours, all the samples were polished and were removed from the polyethylene tubes. The polished samples were kept in distilled water for 24 hours. From the total 99 samples of completed restorations, 90 were separated randomly into 3 groups of 30, each including 10 amalgam, 10 GIC and 10 composite resin and each of these groups was examined in a different test device (Group 1: profilometer, Group 2: AFM, Group 3: spectophotometer). The remaining 9 samples of 3 of each material constituted a 4th group for SEM examination. The amalgam, GIC and composite resin samples were numbered. All the samples were placed in glass petri dishes to take the first measurements of surface roughness with profilometer (Mahr Perthometer M1/M1, PRN-10, Germany) and AFM (XE-100E, South Korea), colour values with spectrophotometer (Minolta Spectrophotometer CM-2600d, Japan) and surface images with SEM (Quanta FEG 250, Holland).

Group I

In the profilometer device, four measurements were taken of each sample at different angles considering cracks and grooves that could be on the surface of the sample. To reduce the margin of error, all the measurements were taken by a single researcher and the average roughness values (Ra-µm) obtained were recorded.

Group II

With the AFM device, a 3-dimensional (3D) image was obtained at greater resolution. For each sample a measurement of 20 × 20 µm was taken at 0.2 Hz from a single point. Surface images were taken at 256 × 256 pixel resolutions and the data obtained in the analysis of the surface roughness and topography was recorded numerically as Ra-nm.

Group III

All the materials were analysed in respect of colour change with a spectrophotometer device. Colour change values (ΔE) were calculated according to the CIELAB system and were recorded numerically.

Group IV

All the samples were examined with SEM. The surface images obtained for each sample were taken at x 5000 and x 10, 000 magnification and were then photographed.

The data obtained as a result of the measurements taken were recorded. After the first measurements, to be able to mimic the environment of the mouth between whitening sessions, the samples were placed in artificial saliva solution in glass petri dishes covered and stored at 37°C in an incubator. When the samples were removed from the artificial saliva, they were gently dried with pressurised air and this procedure was repeated before each whitening session.

Whitening material containing 16% CP (Opalescence PF, Ultradent and ABD) was used for the whitening procedure. It was applied to all the samples for 6 hours per day for a total period of 14 days. After each 6-hour application of whitening, the samples were washed with distilled water and a soft brush and then placed in the incubator in renewed artificial saliva. This cycle was repeated throughout the 14-day period of the study. At the end of the 14 days, surface roughness and colour measurements were repeated in the same devices and the data were recorded. Statistical analysis was made of the data obtained before and after whitening of all the amalgam, GIC and composite resin samples.

In the statistical evaluation of the study data, IBM SPSS 21.0 for Windows statistics software was used. The measured variables were stated as mean ± standard deviation (SD) and categorical variables as number and percentage (%). Conformity of the data to normal distribution was examined. The data were not seen to meet the parametric test hypotheses. Therefore, the Wilcoxon test was applied in the comparisons of the first and last measured surface roughness values of the material groups. In the comparison of the colour change values of the 3 groups of amalgam, GIC and composite resin, the Kruskal Wallis H-test was applied and for the comparison of paired independent groups, the Mann Whitney U-test. The hypotheses were two-tailed and a value of $p<0.05$ was considered statistically significant.

Results

For all the material groups, the statistical analysis of the data obtained from the surface profilometer and AFM was found to be statistically significant ($p<0.01$) (Figure 1).

A statistically highly significant difference was determined between all the material groups as a result of the analysis of the comparison of the colour change values obtained from the spectrophotometer device before and after whitening ($p<0.001$) (Figure 1). No statistical significance was determined in the paired analysis of the comparison of the colour change values of the amalgam and GIC samples ($p>0.05$).

A statistically highly significant difference was determined in the paired comparison of the ΔE values of the amalgam and composite resin samples with the GIC and composite resin samples ($p<0.001$).

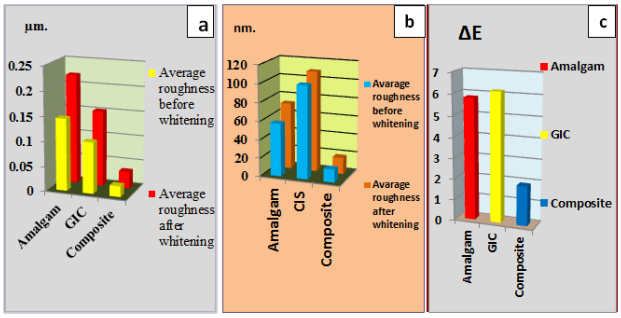

Figure 1. *(a) The average roughness values of the samples before and after bleaching measured by profilometer. (b) The average roughness values of the samples before and after bleaching measured by AFM. (c) The average amount of color shift measured by spectrophotometers after the whitening of all samples.*

Discussion

Home whitening applications are based on the principle of application of a whitening agent by the patient with the aid of a night-guard bleaching plate. In this method, the use of 10%-16% CP gels is recommended for 4-8 hours per day for a period of 2-4 weeks. In the current study, Opalescence PF whitening gel containing 16% CP agent was used for 6 hours per day for 2 weeks [3].

Many studies have shown that restoration materials are affected by HP. A high concentration of HP have been reported to cause chemical deterioration in the composite resin matrix, leading to an excessive increase in the roughness value, reduced surface hardness and oxidative cracks [9-11]. El-Murr et al. emphasised that replacement of glass ionomer and resin-modified glass ionomer cement restorations was necessary after whitening applications [3]. CP and its derivatives cause oxidation, corrosion and dissolution, thereby accelerating deterioration of the amalgam surface and cause mercury expression [12,13].

Research into surface roughness is the primary method used to test the effect of whitening treatment on restorations. Profilometer and AFM are often used in the evaluation of surface roughness. Devices such as SEM (Scanning Electron Microscope), TEM (Transmission Electron Microscope), STM (Scanning Tunneling Microscope) and OFM (Optical Interferometric Microscope) have also been used in studies evaluating surface properties [14,15].

In profilometer examinations, the mean roughness of a surface is defined with the Ra parameter. When the surface roughness has a value of mean>0.2 µm, there is bacteria adhesion and plaque accumulation and a roughness value of >0.3 µm indicates a need for replacement of restorations [16-18]. In the current study, changes in the surface properties of restorations were evaluated with profilometer and the increase in surface roughness of all the materials was found to be statistically significant but not clinically significant. These results are consistent with of Yüzügüllü et al. [19] and partially with the results of Bahannan [20].

AFM is another device used in the analysis of surface roughness and topography. In AFM examinations, 3D images are obtained at higher resolution [16,21]. In the AFM examination of the change in surface roughness values of the restorations in the current study, the roughness values obtained for all the materials were well below the threshold which could be perceived with the naked eye (threshold value: 380-740 nm) and the results were determined to be statistically significant but not clinically significant (Figures 1 and 2).

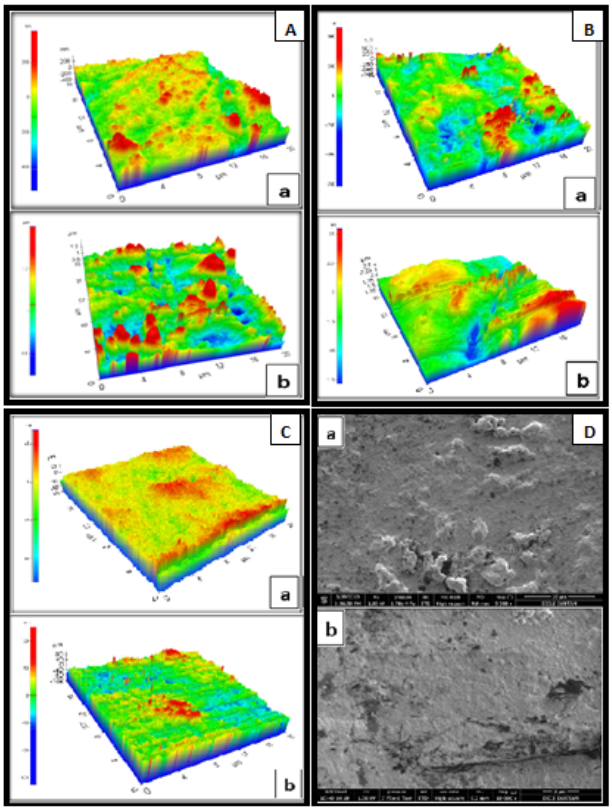

Figure 2. *(A) Amalgams before (a) and after (b) bleaching on AFM image. (B) GICs before (a) and after (b) bleaching on AFM image. (C) Composite resins before (a) and after (b) bleaching on AFM image. (4) Amalgams of before whitening X5000 magnification (a) and after whitening X10000 magnification (b) on SEM image.*

This finding was consistent with the results of Ahn et al. [4].The most rapid method used to image the surface of samples and identify morphological surface changes of restorative materials after whitening, is SEM examination [22]. In the evaluations made with SEM in the current study, 2 images of each sample were taken at x 5000 magnification and at x 10, 000 magnification. A small change was observed to have developed in the amalgam samples but this was not clinically significant (Figure 3). This finding was consistent with the results of Dutra et al. [23]. On the surface of the GIC samples were detected micro-cracks 1-10 µm in width and a clinically significant increase in surface roughness. No significant change was determined to have occurred on the surface on the composite resin samples, which was consistent with the result of study by Al-Ameedee et al. [24].

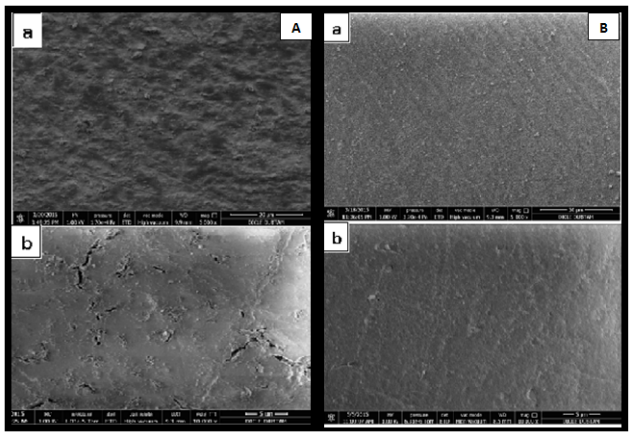

Figure 3. (A) GIC of before whitening X5000 magnification (a) and after whitening X 10000 magnifications (b) on SEM image. (B) Composite resin of before whitening X 5000 magnification (a) and after whitening X 10000 magnification (b) on SEM image.

Spectrophotometry devices are used in evaluation of the amount of colouring in the restorative materials to aid in the measurement of colour permeability, absorption and reflection. In the CIELAB system, values of ΔE<1 cannot be perceived by the human eye. Values of ΔE: 1-2 can be partially differentiated and values in the range of ΔE: 2-3.7 represent clinically perceptible colour differences. The most commonly used scale is the O'Brien clinical colour tolerance table. According to this scale, 0=excellent, 0.5-1=very good, 2-3.5=clinically acceptable and >3.5=incompatible [25-28]. In the current study, a spectrophotometer test device and the O'Brien clinical colour tolerance table were used. A statistically significant difference was determined between the colour changes obtained in the 3 different restoration materials after whitening ($p<0.001$). The colour change values in the amalgam and GIC samples were found to be clinically significant (Figure 1) which was consistent with the findings of Ahn et al. and Rao et al. [4,29]. No clinical significance was determined in the colour change value in the composite resin samples after the whitening procedure. This finding was consistent with the findings of Rao et al. and Alqahtani et al. [29,30].

Conclusion

The results of this study which evaluated the effects of vital whitening agents on the surface properties and colour of three different restoration materials can be summarised as follows:

As a result of the measurements made with profilometer and AFM, an increase in the roughness values was determined in all the restoration materials after the whitening application, but this was clinically insignificant. In the SEM examination, the whitening application was not determined to have caused any significant surface changes in the amalgam and composite resin samples, but micro-cracks were determined in the GIC samples. The results of the colour analysis of the materials made with spectrophotometry showed a difference that was statistically significant ($p<0.001$), but no clinical significance was determined in the colour change value in the composite resin samples, although the colour change values in the amalgam and GIC samples were found to be clinically significant.

The materials used in this study were affected at varying degrees following the application of vital whitening, but nanohybrid composite resin was observed to have been less affected than the other materials. It can be considered that the replacement of composite restorations is not necessary after whitening treatment, whereas there could be a need to change other materials.

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