Effects of different concentrations of hydrogen peroxide on the surface roughness of various esthetic restorative materials

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Effects of Different Concentrations of Hydrogen Peroxide on the Surface Roughness of Various Esthetic Restorative Materials

Background: The aim of this in vitro study was to evaluate surface roughness of four different restorative materials during bleaching procedures.

Methods: In this study, the bleaching agents were applied on the low-fusing porcelain (VITA VM9), the heat-pressed glass ceramic (IPS Empress Esthetic), and two types of composites (Clearfil Majesty Esthetic, Clearfil Photo Posterior). A total of 20 disc-shaped specimens were fabricated (with a diameter of 10 mm and a thickness of 2 mm) from each material (n=10). Before the experiment, the samples were steeped in distilled water for 24 hours, and their initial measurements were recorded. The first set of specimens were bleached with 10% hydrogen peroxide (HP) for 1 hour daily, for 10 days. The other set of specimens were bleached with 40 % hydrogen peroxide (HP) bleaching gel for two consecutive applications for 20 minutes each. Surface roughness values were measured prior to and following the bleaching procedures by using a profilometer (Surftest Analyzer 402, Mitutoyo Corporation, Kawasaki, Kanagawa, 213-8533 Japan). Statistical analysis were done on Windows by using SPSS 20.0 programme. Paired-t test was used to analyze the surface roughness values, which were measured before and after bleaching procedure. The independent samples t-test was used to compare the effects of bleaching agents on surface roughness change in each material. Statistical significance criterion was taken as $p<0.05$.

Results: After application of both bleaching agents, surface roughness values of all restorative materials, that were tested, increased significantly ($p<0.05$). However, there were no significant differences between two bleaching methods for restorative materials ($p>0.05$).

Conclusion: Although clinical effects depend on in-vivo conditions, the effects of office bleaching agents should be known and these agents should be applied consciously when restorative materials are present.

KEY WORDS

Tooth bleaching agents, dental porcelain, composite resins

Tooth whitening, either by the removal of extrinsic stains, or bleaching by the reduction of intrinsic colouration, is becoming more popular among patients(1). Using bleaching techniques to improve the esthetics of the natural dentition has become increasingly popular since 1989 (2). Patients' interest in cosmetic dentistry has contributed to the development of new bleaching materials and techniques (3). Bleaching is a relatively non-invasive approach to whitening teeth, that is stained extrinsically or intrinsically. Bleaching techniques may be classified by whether they involve vital or non-vital teeth or whether the procedure is performed in-office or has an at-home component (4,5). While office bleaching is administered by a dentist and staff members using higher concentrations of whitening agents, at-home bleaching is administered by the patient, using lower concentrations of whitening agents in special trays (6, 7).

Current available agents are usually based on 6–20 % and 25– 40 % peroxide gels for home and in-office whitening, respectively. Duration of treatment for home bleaching varies extensively as it depends on the length of time that the patient applies the technique per day (8,9) On the other hand, office bleaching uses higher-concentration solutions applied for a shorter period of time, because these products are capable of producing more peroxide radicals and hence accelerating the process (9,10).

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As the bleaching agents contact the tooth structures for an extended period of time and possibly inadvertently come into contact with dental materials, the effects of whitening products on dental hard tissues and dental materials has attracted much attention in the literature (11). These agents' influence on physical properties and surface morphology of dental materials needs a closer approach. Some authors have reported microstructural changes in restorative materials after bleaching, (9,10) while other studies found only slight changes or no alterations (12,13). However, the interaction between the office solutions and both the teeth and the restorations still raises concern because higher peroxide concentrations could worsen possible harmful effects (14).

Roughness is an important surface property and is described as the overall roughness of a surface. Surface roughness (Ra) is defined according to the measurement techniques, such as the arithmetic mean value of all absolute distances of the roughness profiles from the centerline within a measuring distance (15,16). Materials with roughened surface enhance bacterial adhesion, have a smaller free surface energy, promote plaque adherence, and cause increased staining (1). There are several reports on the effect of home bleaching systems on composites and porcelain, (17-19). However, there is no report in literature regarding the influence of highly concentrated solutions on ceramics.

The purpose of this study was to investigate the effect of % 10 and % 40 hydrogene peroxide bleaching agents on the surface roughness of four clinically various aesthetic restorative materials. The first null hypothesis was that the surface roughness of restorative materials would be affected by bleaching techniques. The second hypothesis was that there were no significant differences between the two bleaching techniques.

MATERIALS AND METHODS

This study tested two bleaching products on four restorative materials. The materials, product names, and manufacturers are listed in Table 1.

A leucite-based core (IPS Empress Esthetic, Ivoclar Vivadent Schaan, Liechtenstein) specimens (10 mm in diameter and 2 mm in thickness) were waxed (BEGO, Bremen, Germany), sprued, and then pressed after investment. All procedures were performed with IPS Empress Esthetic materials. For the fabrication of feldspathic ceramic discs (VITA VM 9, Vita Zahnfabrik Bad Säckingen, Germany), a mold was made using vinyl polysiloxane putty (Virtual, Ivoclar Vivadent Schaan, Liechtenstein) to facilitate the fabrication of the porcelain discs (10 mm in diameter, 2 mm thick). The porcelain was mixed with sculpting liquid and condensed into the mold. Tissue (Selpak, Eczacibasi Holding, Istanbul, Turkey) was used to absorb the excess moisture. After drying, the discs were carefully removed from the mold, placed on a sagger tray, and fired according to the manufacturers' recommendations (950°C) in a porcelain oven (Vita Vacumat 40 T, Vita Zahnfabrik). A total of 40 discs (20 for each porcelain tested) were made. The specimens were then trimmed with a thin, cylindrical diamond bur (D-Z Labor, Drendel and Zweiling GmbH & Co, Berlin, Germany) and were further air particle abraded with 50-μm aluminum-oxide powder. All the ceramic specimen surfaces were then polished with a special polishing kit (Optrafine, Ivoclar, Schaan, Liechtenstein) that had a slow-speed handpiece (NSK, Tokyo, Japan) running at 15,000 rpm.

Holes 10 mm in diameter were drilled in a 2-mm-thick polytetrafluoroethylene plate to form the composite (Clearfil Majesty Esthetic and Clearfil Photo Posterior) specimens. These restorative materials were placed into the mold separately and sandwiched between two glass plates. In accordance with the manufacturer's

Table 1.

Materials Tested

Materials	Product Name	Manufacturer
Nano-filled composite filler	Clearfil Majesty, Esthetic	Kuraray medical 1621 Sakazu, Kurashiki,Okayama 710-0801, Japan
Heavily filled hybrid resin composite	Clearfil Photo, Posterior	Kuraray medical 1621 Sakazu, Kurashiki,Okayama 710-0801, Japan
Feldspathic Porcelain	Vitavm-9	Vita Zahnfabric/Germany
Leucite based core	IPS Empress Esthetic	Ivoclar Vivadent, Schaan,Liechtenstein
Hydrogen peroxide	Opalescence Trèswhite Supreme (10 %)	Ultradent, South Jordan, Utah, USA
Hydrogen peroxide	Opalescence Boost (40 %)	Ultradent, South Jordan, Utah, USA

directions, a curing light (800 mW/cm²) was applied to the top of the filled molds for 40 seconds by use of a light-polymerizing unit (Bluephase, Ivoclar Vivadent Schaan, Liechtenstein). The distance between the light source and the specimen was standardized by the use of a 1-mm glass slide. A total of 40 composite specimens were made for this study. The specimens were polished with medium, fine, and superfine polishing kits (Astrapol, Ivoclar Vivadent Schaan, Liechtenstein) on a slow-speed handpiece (10,000 rpm) according to the manufacturer's directions.

After the finishing procedures, specimens were subjected to ultrasonic treatment (Biosonic UC 50, Coltene Whaledent, Cuyahoga Falls, OH, USA) in distilled water to remove any surface residues. Then they were dried. All specimens were stored in distilled water in screw-top vials (Isolab, Laborgeräte GmbH, Wertheim, Germany) at room temperature for 24 hours before any testing procedure.

A total of 80 specimens were randomly divided into two groups (n=10) according to bleaching procedure. The first group specimens were bleached with a typical in-office whitening procedure (Two consecutive applications of a 40% hydrogen peroxide gel (Opalescence Boost; Ultradent Products, Inc, South Jordan, Utah) for 20 minutes each). Custom bleaching trays were made for each block from a flexible plastic vacuum-formed material (Sof-Tray sheets, Ultradent Products, Inc) that fully covered the block, but left solid pillars of plastic (1 mm in height) to act as spacers. This configuration provided a consistent gel thickness. The bleaching agent, that was used, was removed and replaced by new material during the successive applications. The treated plates were rinsed with water and returned to their individual storage tubs. Second group specimens were bleached with the bleaching protocol simulated a typical home whitening procedure. For this treatment, the flexible vacuum formed material was filled with hydrogen peroxide gel (Opalescence Trèswhite Supreme 10 %; Ultradent Products, Inc) for 1 hour. During bleaching, the block with bleaching tray was placed into an individual, sealed storage container and then placed in a 37°C oven. At the end of the 1-hour bleaching period, the bleaching agent was removed and the block was returned to its water storage container. This process was repeated for 10 consecutive days.

The average surface roughness (Ra, μm) of the treated specimens were measured with the Mitutoyo Surftest–402 Surface Roughness Tester (Surftest 402 Analyzer Mitutoyo Corporation, Tokyo, Japan). Three traces were recorded for each specimen at three different locations (parallel, perpendicular, and oblique). The mean surface roughness value was calculated

Tablo 2.

Surface roughness measurements of the study groups and materials before and after bleaching procedures (Mean ± SD)

			N	Mean	Std. Deviation
Vita	% 40	Before bleaching	10	1,08	,21
		After bleaching	10	1,20	,36
Empress	% 40	Before bleaching	10	,39	,08
		After bleaching	10	,50	,16
Majesty	% 40	Before bleaching	10	,37	,18
		After bleaching	10	,71	,21
Posterior	% 40	Before bleaching	10	,40	,24
		After bleaching	10	,77	,40
Vita	% 10	Before bleaching	10	1,03	,29
		After bleaching	10	1,09	,28
Empress	% 10	Before bleaching	10	,41	,10
		After bleaching	10	,51	,13
Majesty	% 10	Before bleaching	10	,52	,25
		After bleaching	10	,87	,2
Posterior	% 10	Before bleaching	10	,33	,16
		After bleaching	10	,69	,20

by averaging the three measurements. All readings were performed by a single investigator. Roughness values were recorded before and after exposure to the bleaching agents for each specimen.

Data Analysis:

Statistical analysis were performed with SPSS 20.0 (Windows; SPSS Inc, Chicago, IL, USA) for WINDOWS. Paired-t test was used to analyze the surface roughness values which were measured before and after bleaching procedure. The independent samples t-test was used to compare the effects of bleaching agents on surface roughness change in each material. P values less than 0.05 were considered to be statistically significant in all tests ($p < 0.05$).

RESULTS

The mean values and standard deviations of roughness measurements of each study group are presented in Table 2 and Fig. 1-2, respectively. Vita VM9 group, on which % 40 bleaching agent was applied, showed no significant differences after bleaching procedure. Nevertheless, the other groups showed an increased surface roughness value after bleaching procedures ($p<0.05$) (Table 3). The independent t test demonstrated that the change in percentage values of the surface roughness of restorative materials bleached with % 40 hyrogen peroxide were similar to % 10 hyrogen peroxide applications ($p>0.05$).

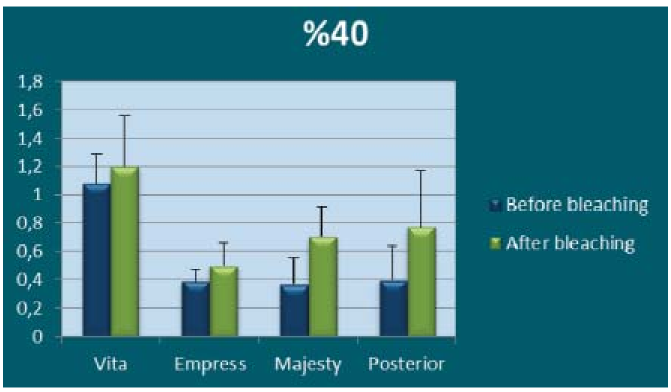

Figure 1.
Surface roughness measurements of the study groups and materials before and after bleaching procedures (% 40 HP).

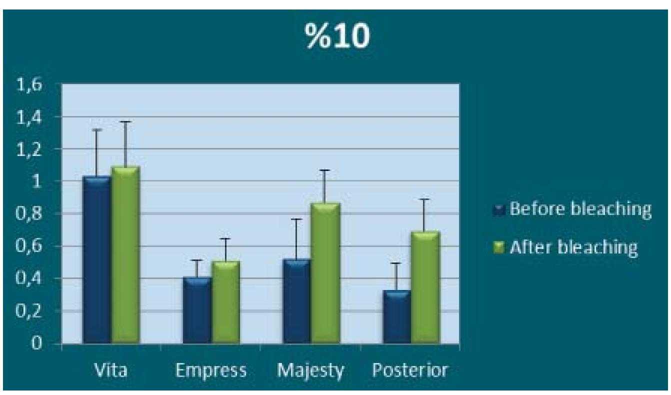

Figure 2.
Surface roughness measurements of the study groups and materials before and after bleaching procedures (% 10 HP).

DISCUSSION

In this in vitro study, surface roughness values of the restorative materials changed after they were exposed to the two bleaching systems, so the null hypothesis that the two bleaching techniques would alter the values of surface roughness was proved. Both of the bleaching techniques demonstrated similar effects on the surface roughness of the restorative materials. Showing that the second hypothesis of this study, that there were no significant differences between the two bleaching techniques, was proved too. Among the materials tested, the change in surface roughness was the highest in the heavily filled hybrid resin composite (Clearfil Photo Posterior).

Clinically surface roughness is an important property that should be investigated, since it can influence both the esthetics and the health (9). Thereby, in this study, the effects of two proprietary bleaching systems, which had different HP concentrations and different regimen of use, on surface roughness of restorative materials were evaluated.

A number of recent articles have studied the impact of bleaching treatment on the physical properties of ceramic restorations. In a recent in vitro study,(9) feldspathic porcelain had a rougher surface after 21 days of exposure to 10 % and 35 % CP. According to the authors, the changes over the porcelain's surface may have been caused by the reduction of silicon dioxide

Table 3.

Paired t test analyses of restorative materials.

		Mean	Std. Deviation	Sig.
Vita	% 40	,12	,21	,1
Empress	% 40	,14	,12	,00
Majesty	% 40	,33	,08	,00
Posterior	% 40	,37	,17	,00
Vita	% 10	,06	,06	,01
Empress	% 10	,09	,09	,00
Majesty	% 10	,34	,13	,00
Posterior	% 10	,36	,10	,00

% 95 confidence interval of the difference

(SiO_2) and potassium peroxide (K_2O_2) molecules. In their study, which is about the effect of bleaching on ceramics, Turker and Biskin(18) revealed that the reduction of the SiO_2 content from feldspathic porcelain surface was between 4.82 % and 4.44 %, which probably contributed to the increased roughness detected. In their study, Zaki and Fahmy (16) distinguished between autoglazed and overglazed ceramic restorations. They showed that an in-office bleaching procedure with 35 % CP followed by an at-home bleaching technique with 15 % CP significantly increased the surface roughness of polished overglazed ceramic restorations. Because the increased ceramic roughness could lead to more plaque retention, bacterial adherence and gingival irritation, the authors suggested protecting these materials with a barrier before bleaching to preserve the integrity of the ceramic surface. The results of this study were in agreement with other previous studies, demonstrating an increase in the surface roughness measurements of all restorative materials tested.

In an other study, surface texture was not effected by the bleaching regimen, as also reported in an SEM investigation by Schemehorn et al.(11), when 6% hydrogen peroxide gel was applied on the feldspathic porcelain. This is probably due to the lower concentration of the bleaching agents used in their study.

A recent study, by Wattanapayungkul and his colleagues(13), demonstrated that treating composite resins with a low peroxide concentration significantly increased their surface roughness. However, because the surface roughness values did not exceed 0.2 μm, which is the critical limit for plaque retention and accumulation, the results were not clinically significant. Another study(9) that evaluated the effect of low and high peroxide concentrations on hybrid and microfilled composite resins came to a similar conclusion. These results support the outcomes of this current study.

Some investigations have been published concerning the effects of different concentrations of carbamide peroxide or hydrogen peroxide used in bleaching procedures (13,16,20,21). These studies demonstrated that when 35 % carbamide peroxide or 35 % hydrogen peroxide were used during in-office bleaching procedures, there were no detrimental effects on the surface roughness of the compomers, resin-modified glass ionomer cements,(13) ceramic restorations (16), and microfilled and hybrid composite resins (20). However, Hafez et al. (21) reported that 35 % or 38 % hydrogen peroxide office bleaching agents significantly increased the surface roughness of the microfilled and microhybrid composites. The results of our research are similar to the findings of a recently published study (21). The filler load is directly related to the surface area that is taken up by filler particles versus resin matrix, as the surface smoothness is generally determined by the largest inorganic particles present within the composite (22). Since roughening was suggested to result from erosion of matrix, the consequent debonding of resin–filler interfaces would lead to dislodgment as to elution of fillers. Thus, the higher the volume and the size of the leached particles, the rougher the resulting surface (9). In this study, nanofilled composite, heavily filled hybrid composite, and 2 ceramic specimens were used in order to be bleached. All restorative materials were polished, and 10 % and 40 % hydrogen peroxide, were used as the bleaching agent. Our results showed that the ceramics and composites tested were not resistant under bleaching systems. The change in surface roughness of different restorative materials after bleaching depends on each material's composition and the amount of time in which the whitening agents were applied.

There are some limitations of the current study design that must be noted. As in many in vitro studies, the oral environment cannot be fully reflected. It would be useful to support the results of this study with another clinical study or with a study that could imitate the oral environment better in order to find out whether the effects of the bleaching agents, used in this study, change when these agents are exposed to saliva.

CONCLUSION

The present study showed that bleaching could affect the surface roughness of restorative materials. Practitioners should make sure that their patients, with dental restorations, are aware of the changes that may occur during whitening, as well as the possibility that their bleached restorations may need to be polished or replaced at the end of the treatment.

Farklı Konsantrasyonlardaki Hidrojen Peroksitin Estetik Restoratif Materyallerin Yüzey Pürüzlülüğü Üzerine Etkileri

Amaç: Bu çalışmanın amacı ağartma prosedürleri boyunca dental restoratif materyallerin yüzey pürüzlülük değişimlerinin incelenmesidir.

Gereç ve Yöntem: Çalışmada ağartma ajanları, bir düşük ısı porseleni (Vita VM9), bir ısı ve basınçla şekillendirilen porselen (IPS Empress esthetic), ve iki tip kompozit materyali (Clearfil Majesty Esthetic, Clearfil Photo Posterior) üzerine uygulanmıştır. Çalışmada kullanılan örnekler 10 mm çapında, 2 mm kalınlığında hazırlanmıştır. Her grup için 10'ar örnek olmak üzere 2 ana grup oluşturulmuştur. Örnekler deneye başlamadan önce 24 saat distile suda bekletilmiş ve başlangıç ölçümleri alınmıştır. % 10 Hidrojen peroksit uygulanan örnekler 10 gün süresince günde 1 saat, %40 hidrojen peroksit uygulanan örnekler ise iki defa 20 dk ağartma ajanına maruz bırakılmıştır. Ölçümler işlem sonrasında tekrarlanmıştır. Yüzey pürüzlülüğü ölçümleri için profilometre cihazı (Surftest Analyzer 402, Mitutoyo Corporation, Kawasaki, Kanagawa, 213-8533 Japan) kullanılmıştır. İstatistiksel analizler SPSS 20.0 paket programı kullanılarak Windows ortamında gerçekleştirildi. Sonuçlar, paired t ve independent samples t istatistiksel analizleri yapılarak değerlendirildi. İstatistiksel anlamlılık düzeyi $p<0.05$ olarak alındı.

Bulgular: Çalışmanın sonucunda; beyazlatma materyali uygulanan tüm gruplar arasında yüzey pürüzlülük değeri değişimleri istatistiksel olarak anlamlı bulunmuştur ($p<0.05$) . Ayrıca iki ağartma prosedürü arasında istatistiksel olarak anlamlı bir fark bulunmamıştır ($p>0.05$) .

Sonuç: Restoratif materyallerin varlığında ağartma ajanlarının etkileri iyi bilinmeli ve uygulama esnasında dikkatli olunmalıdır.

Anahtar Kelimeler: Diş ağartma ajanları, dental porselenler, kompozit rezinler

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