Effect of home bleaching agents on the texture and surface roughness of glass ionomer and compomer restorative materials

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الغرض من هذه الدراسة المخبرية هو استبيان تأثير مبيضات الأسنان على خشونة وملمس سطح بعض مواد حشي الأســـنان. تمت هذه الدراســـة على ٢٤ عينه من مادة الأيونومر الزجاجي ومادة الكومبومر مقسمه الى ٨ عينات في كل مجموعة.

تم استعمال المبيض بيرل دروب وناتشورال هوايت على هذه العينات. تم فحص نسخه من العينات في المجهر الإليكتروني وتم أيضا قياس خشونة السطح.

أو ضحت الدراسة ان خشونة وملمس السطح يتغير باستعمال المبيضات وأن تأثير البيرل دروب أقل من تأثيرناتشورال هوايت على سطح الحشوات المستعمله.

Surface roughness of restorative materials contributes to plaque adhesion and surface discoloration of esthetic restorations. The purpose of this in vitro investigation was to measure the effect of home-use bleaching agents on surface texture and roughness of a conventional glass ionomer (Ketac-Fil) and a compomer (Dyract® AP) restorative material. Twenty-four flat cylindrical specimens of each material were prepared using Teflon molds. Specimens of each material were divided into three groups of 8 each. Groups 1 and 2 served as controls (no bleaching agents). Groups 3 and 4 were treated with 3 applications of Pearl Drops® on Ketac-Fil and Dyract® AP respectively. Groups 5 and 6 were treated with 3 applications of Natural White® on Ketac-Fil and Dyract® AP respectively. Before testing surface roughness, an impression was taken of each specimen to form a replica. All replicas were then prepared for SEM examination. Surface roughness (Ra value) was evaluated using a surface roughness analyzer. Statistical analysis was done using a non-parametric one-way analysis of variance (Kruskal-Wallis test) with a Tukey's post hoc test. Results showed highly significant differences among the six groups (α<0.0001). Group 4 (Pearl Drops® applied to Dyract® AP) demonstrated the lowest Ra value compared with all other groups (α<0.001). Group 5 (Natural White® applied to Ketac-Fil) demonstrated the highest Ra value compared with all other groups (α<0.0001). Dyract® AP was significantly smoother than Ketac-Fil for all treatments with α<0.0001. SEM evaluation revealed different degrees of surface texture. It was concluded that Dyract® AP and Ketac-Fil showed significant differences in surface roughness and texture before and after application of Pearl Drops® and Natural White® home-use bleaching agents.

Introduction

The home bleaching technique was formally introduced to the dental profession by Haywood and Heymann in 1989.[1] Since then, the use of patient-administered bleaching agents has become increasingly popular for whitening stained teeth. Recent surveys reported that more than 90% of general practice dentists offer dentist-prescribed home bleaching services.[2,3] Surprisingly, only 40% of the responding dentists had bleached their own teeth.[2] It has also been reported that 92% of North American dental schools teach tooth-whitening procedures.[4] In contrast, curriculum time and safety concerns were reasons for not teaching the procedures in 8 percent of the schools.[4]

Several investigators have studied the effects of home bleaching on oral tissues and restorative materials.[5-15] In vitro studies of home bleaching agents have reported different effects on enamel and dentin of extracted human teeth.[5-8] Several studies have also evaluated the effects of the home bleaching products on restorative materials and their bond strength to tooth tissues.[9-15] Home bleaching products may adversely affect the bond strength of restorative materials clinically. In addition, bleaching agents may affect adherence of certain cariogenic microorganisms to the bleached restorative materials.[16-18]

As home bleaching is rapidly gaining popularity with patients and dentists to whiten natural teeth, more research is needed to evaluate the effects of the agents on oral tissues and restorative materials. Therefore, the purpose of this in vitro investigation was to study the effect of home-use bleaching agents on surface texture and roughness of a conventional glass ionomer (Ketac-Fil) and a compomer (Dyract® AP) restorative material.

Materials and Methods

A glass ionomer, Ketac-Fil (ESPE) and a compomer, Dyract® AP (Dentsply De Trey), were selected and used in this study. Twenty-four flat cylindrical specimens of each material were prepared using cylindrical Teflon molds (10 mm diameter x 2 mm thickness). Each material was mixed and placed in the Teflon molds according to the manufacturer's instructions. Specimens of each material were divided into three groups of 8 each. Table 1 shows the distribution of the groups and their surface treatment. Groups 1 and 2 served

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as controls (no home-use whitening agents were applied). Groups 3 and 4 were subjected to 3 applications of Pearl Drops® (Carter-Wallace Ltd., Folkestone, Kent, England) while groups 5 and 6 were subjected to 3 applications of Natural White® (Natural White, Inc., Tonawanda, N.Y., 14150, USA). The manufacturer's instructions were followed for each application. Some of the components of Pearl Drops® are Aqua, Aroma, Polysorbate 20, Aluminium Hydroxide, Dicalcium Phosphate Dihydrate, and Sodium Monofluorophosphate. Also, some of the components of Natural White® are Aqua, Aroma, Hydrated Silica, Dicalcium Phosphate, Sodium Lauryl Sulphate, and Sodium Monofluorophosphate.

Before testing surface roughness, an impression was taken for each specimen using polyvinylsiloxane (President, Colten/Whaledent, Inc.). The specimens were removed from the impressions after 30 minutes and were left for one hour to degas the impressions before making replicas. Subsequently, epoxy replicas of the specimens were prepared in the impressions using 2-Ton epoxy (Devcan Corporation, Danvers, MA 01923) and allowed to set for 48 hours. If artifacts were discovered in either the impressions or replicas, another impression or replica was made. All replicas were then prepared for SEM examination and sputter coated. Careful examination of replicas was performed using a scanning electron microscope (Jeol, JSM-T330A, Jeol Ltd., Tokyo, Japan) at an operating magnification ranging from 15x to 2000x and accelerating voltage of 25kV. Micrographs of representative areas were taken at 500x to compare the surface texture characteristics of all groups.

Surface roughness was evaluated for all specimens using a surface roughness analyzer (Perthen, Perthometer/ Perthograph, Mahr, D3000 Hannover 1 Postfach 4720, Germany). A typical profile and the average surface roughness (Ra) value of each specimen were recorded. The Ra measurement is a mathematical mean of the departure of the roughness profile from a mean line calculated by the machine. Statistical analysis was conducted using non-parametric one-way analysis of variance (Kruskal-Wallis test) with a Tukey post hoc test.

Table 1. Materials and surface treatment used in the present study.

Group number	Material	Surface treatment
1	Ketac-Fil	Control-no treatment
2	Dyract®AP	Control-no treatment
3	Ketac-Fil	Pearl Drops®
4	Dyract®AP	Pearl Drops®
5	Ketac-Fil	Natural White®
6	Dyract®AP	Natural White®

Results

The mean, standard deviation, and range of the arithmetic roughness value (Ra) of all groups are presented in Table 2. There were significant differences among the six groups (α<0.0001). Tukey's multiple range test showed a significant difference (α<0.0001) for Ra values between group 1 (control-Ketac-Fil) and all other groups except group 3 (α=0.980). A significant difference (α<0.0001) for Ra values between group 2 (control - Dyract® AP) and all other groups except group 6 (α=1.000) was also found. All other groups showed significant differences (α<0.0001) for Ra values among themselves. Group 4 (Dyract® AP and Pearl Drops® application) demonstrated the lowest Ra value compared with all other groups (α<0.001). Group 5 (Ketac-Fil and Natural White(application) demonstrated the highest Ra value compared with all other groups (α<0.0001). A significantly (α<0.0001) lower surface roughness was found between Dyract® AP and Ketac-Fil when the control, Pearl Drops,® and Natural White® treatments were compared. Representative findings of surface roughness for all materials are presented in Fig. 1.

Table 2. Mean surface roughness (Ra*), standard deviation (SD), and range for all groups.

Group number	N	Mean	SD	Range
1	8	0.695	0.037	0.65-0.76
2	8	0.391	0.031	0.35-0.44
3	8	0.668	0.035	0.61-0.71
4	8	0.214	0.027	0.17-0.25
5	8	1.080	0.175	0.95-1.40
6	8	0.390	0.029	0.35-0.43

*In micrometers

SEM examination of all groups before and after bleaching revealed a distinct difference between the two restorative materials (Figs. 2-7). In addition, SEM examination of the specimens after

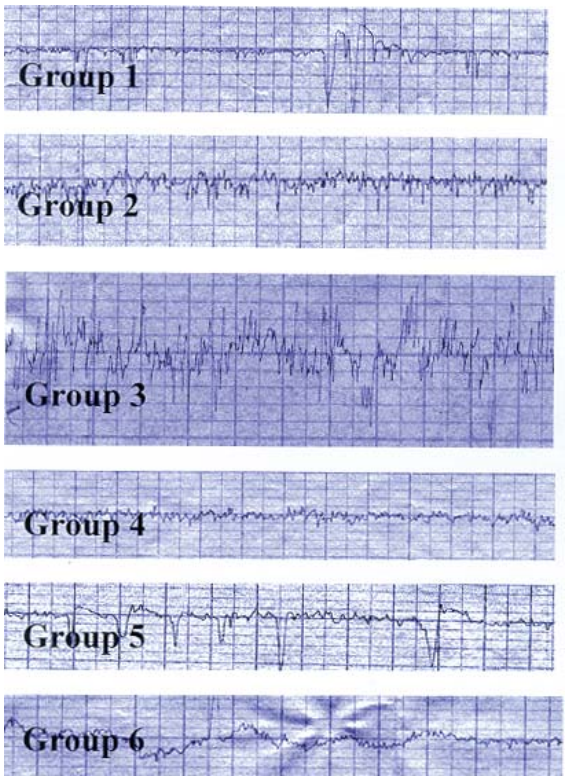

Fig. 1. Surface roughness tracing for all groups.

Fig. 2. Scanning electron micrograph of Ketac-Fil control, no treatment, group 1 (500x).

3 treatments with a bleaching agent compared to the specimens prior to bleaching showed surface texture changes. Before bleaching, the replica surfaces of Ketac-Fil appeared granular with cracks (Fig. 2) while the Dyract® AP surface was relatively smooth with some marks and pits of varying sizes (Fig. 3). Compared to control specimens, treatment with Pearl Drops® showed that Ketac-Fil appeared more granular with cracks (Fig. 4) while Dyract® AP appeared smoother (Fig. 5). Treatment

Fig. 3. Scanning electron micrograph of Dyract® AP control, no treatment, group 2 (500x).

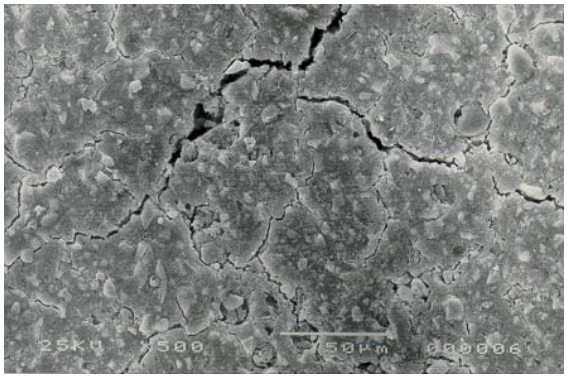

Fig. 4. Scanning electron micrograph of group 3, Pearl Drops® applied to Ketac-Fil (500x).

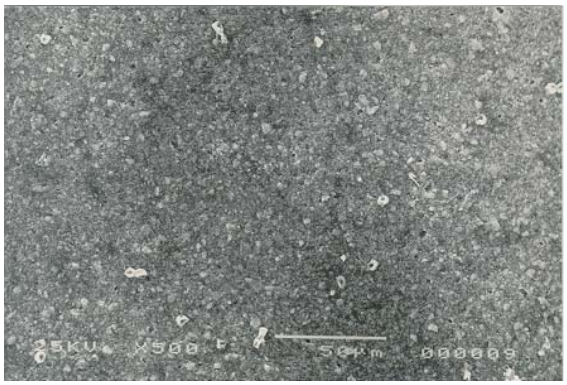

Fig. 5. Scanning electron micrograph of group 4, Pearl Drops® applied to Dyract® AP (500x).

with Natural White,® compared to control specimens, showed that Ketac-Fil appeared more granular with cracks, pits and defects of irregular pattern (Fig. 6) while Dyract® AP appeared smoother with few pits (Fig. 7). Examination and assessment of replicas for all materials did not always confirm the data obtained from surface roughness analysis.

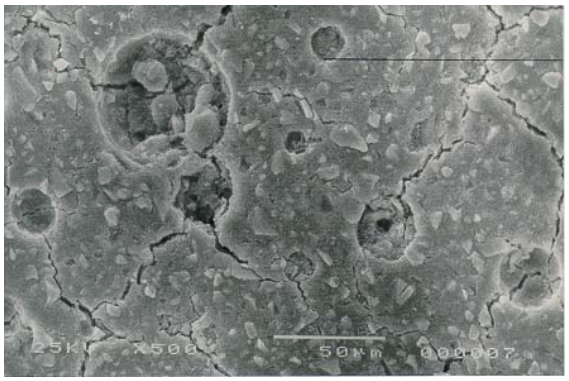

Fig. 6. Scanning electron micrograph of group 5, Natural White® applied to Ketac-Fil (500x).

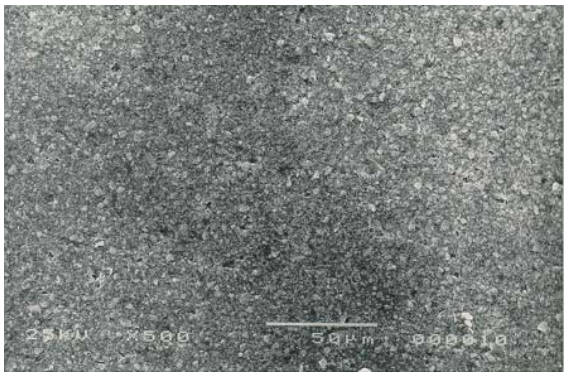

Fig. 7. Scanning electron micrograph of group 6, Natural White® applied to Dyract® AP (500x).

Discussion

This study showed a significant difference of surface roughness between Ketac-Fil and Dyract® AP before and after using three applications of two home bleaching agents. These differences in the roughness among materials could be related to their different compositions and setting behaviors.[19] Other studies have also evaluated the effects of home bleaching products on restorative materials and their bond strength to tooth tissues.[9-15] Bailey and Swift evaluated the effect of three bleaching products on the microhardness and surface texture of hybrid and microfilled composite resins and reported cracking of the microfilled specimens and slight roughening of the hybrid composite resin while microhardness tests indicated that the treated composite resins became somewhat softer.[20] Another study indicated that luting agents, such as glass ionomer and zinc phosphate cement, dissolve readily in 10% carbamide peroxide gels.[21] The concentrations of the ingredients of either Pearl Drops® or Natural White® used in this study were not disclosed by the manufacturers. However, the Natural White® contains hydrogen peroxide. The accepted theory for the bleaching effect of hydrogen peroxide solutions is that these solutions act as oxidizing agents of pigments located in the enamel and dentin. Oxidation is thought to cause the bleaching action by lightening the interprismatic organic matter and possibly removing some of it. In addition, the viscosity of the various bleaching materials affects the etching action differently.[18] Natural White® contains a viscose gel.

It has been suggested that surface texture can be evaluated qualitatively or quantitatively.[18] In this study, SEM was used for qualitative evaluation and surface roughness was used for quantitative evaluation. The profilometric measurements reflected changes of surface roughness of the two restorative materials that were unavailable from SEM photomicrographs evaluation. In this study, lower surface roughness was recorded for Pearl Drops® in all groups compared to Natural White®. Also, Dyract® AP and Pearl Drops® (Group 4) demonstrated the lowest Ra value compared with all other groups which may reflect a tendency of smoothing the surface of bleached restorative material.

SEM showed evidence that the surface texture of the two restorative materials changed following three treatments of the bleaching agents. The evaluation revealed surface features that were not always detected using surface roughness analysis. SEM examination of the specimens revealed the micromorphology of the surfaces of these materials and demonstrated the characteristic features of their surfaces. Comparison of the surface texture among these materials using SEM micrographs showed some differences. However generally, Dyract® AP showed smoother surface texture compared to Ketac-Fil. Although this *in vitro* study showed surface texture changes following application of the bleaching agents, these results should be viewed with caution, since in clinical situations *(in vivo)* such changes may be different due to the presence of saliva and the oral environment, which were not taken into account in the present model system. The pH bleaching agent may be related to surface texture alterations.[18,22] In the present study, pH was not determined for the bleaching agents.

Considering definitions of surface roughness and texture used in this study, surface roughness analysis may not reliably quantify the surface characteristics of the restorative materials. A

qualitative evaluation of surface texture may be indicated, also.

Conclusions

It is concluded from this investigation that:

1. Dyract® AP and Ketac-Fil showed significant differences in surface roughness before and after application of Pearl Drops® and Natural White® home-use bleaching agents.
2. Dyract® AP with Pearl Drops® treatment demonstrated the lowest Ra value compared with all other groups.
3. Ketac-Fil with Natural White® treatment demonstrated the highest Ra value compared with all other groups.
4. A significantly lower surface roughness existed between Dyract® AP and Ketac-Fil for control, Pearl Drops®, and Natural White® groups.
5. Detectable changes in surface texture of Dyract® AP and Ketac-Fil are evident following repeated applications of Pearl Drops® and Natural White® home-use bleaching agents. Different patterns of change are observed.

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