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Effects of In-Office Bleaching Products on Surface Finish of Tooth-Colored Restorations

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Clinical Relevance

In-office bleaching systems that employ strong oxidizing agents are not detrimental to the surface finish of tooth-colored restorative materials.

SUMMARY

A number of "high power" in-office bleaching products have recently been re-introduced into the market. The use of such strong oxidizing agents has raised questions as to possible adverse effects on tooth structure and restorative materials. This study evaluated the effects of 35% carbamide peroxide (Opalescence Quick) and 35% hydrogen peroxide (Opalescence Xtra) on the surface finish of four tooth-colored restorative materials (Spectrum TPH, Dyract AP, Reactmer and Fuji II LC). Twenty-seven matrix-finished specimens of each material were fabricated, stored in distilled water at 37°C for seven days and randomly divided into three groups. Specimens in Group 1 were stored in distilled water at 37°C (control). Specimens in Groups 2 and 3 were treated with 35% carbamide peroxide and 35% hydrogen peroxide, respectively. A total of three 30-minute bleaching sessions were conducted at one-week intervals. Storage medium during the hiatus period was distilled water at 37°C. Surface roughness measurements were carried out using profilometry after each bleaching session. Data was analyzed using ANOVA/Scheffe's test at a 0.05 significance level. No significant difference in surface roughness was observed between the bleached and the control groups for all materials. In-office bleaching products are not detrimental to the surface finish of composites, compomers, giomers and resin-modified glass ionomer cements.

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INTRODUCTION

Over the last decade, home vital tooth bleaching has attracted the interest of patients and dentists due to its high success rates, ease of use and media publicity. This procedure utilizes low concentrations of hydrogen peroxide (3% to 7%) or carbamide peroxide (10% to 20%). Recently, new in-office bleaching products that utilize high concentrations of hydrogen peroxide or carbamide peroxide have been re-introduced. The latter procedure, which involves 30% to 35% carbamide peroxide or hydrogen peroxide, is totally under the dentist's control and has the potential for bleaching quickly in situations in which it is effective. High concentrations of hydrogen peroxide have been reported to cause surface roughening of teeth and etching-like patterns (Flaitz &

Hicks, 1996; Shannon & others, 1993; Zalkind & others, 1996).

The effects of such strong oxidizing agents on the physico-mechanical properties of restorative materials have, however, not been widely studied. Surface roughness of restorations is one clinically important physical property that warrants investigation. The surface finish of restorations influences aesthetics and oral health, as the presence of irregularities may influence appearance, plaque retention, surface discoloration and gingival irritation (Weitman & Eames, 1975; Dunkin & Chambers, 1983; Chan, Fuller & Hormati, 1980; Shintani & others 1985). Studies have shown that using home bleaching systems increases the surface roughness of some composite restoratives (Cooley & Burger, 1991; Bailey & Swift, 1992). Mor & others (1998) found that 10% carbamide peroxide and 10% hydrogen peroxide caused a significant increase in surface adherence of *S mutans* and *S sobrinus*, while a decrease in adherence of *Actimimyce viscosus* was found after treatment with 10% hydrogen peroxide. Little is known about the effects of in-office bleaching systems on the surface finish of composites, compomers, giomers or PRG composites and resin-modified glass ionomer cements. Giomer is a new category of hybrid aesthetic restorative material that employs the use of pre-reacted glass ionomer (PRG) technology (Yap & Mok, 2002). Unlike compomers, the fluoroalumino silicate glass is reacted with polyacrylic acid prior to inclusion into the resin matrix. The bonding and handling is similar to compomers. The manufacturer's claims include fluoride release and recharge, smooth surface finish, excellent aesthetics and clinical stability.

This study evaluated the effects of in-office bleaching systems on the surface finish of different tooth-colored restorative materials. The surface roughness of the different materials was also compared.

METHODS AND MATERIALS

Four tooth-colored restorative materials and two commercial bleaching agents were selected for this study. The restorative materials included a composite resin (Spectrum Dentsply/Detrey, Konstanz, Germany), a compomer (Dyract AP, Dentsply/Detrey, Konstanz, Germany), a giomer (Reactmer, Shofu Inc, Kyoto, Japan) and a resin modified glass ionomer (Fuji II LC Capsule, GC Corporation, Tokyo, Japan). The bleaching agents were 35% carbamide peroxide (Opalescence Quick, Ultradent Products, Inc, UT 84095, USA) and 35% hydrogen peroxide (Opalescence Xtra, Ultradent).

The restorative materials were placed in the rectangular recesses (4 mm long x 3 mm wide x 2 mm deep) of customized acrylic molds and covered with acetate matrix strips (Hawe-Neos Dental, Bioggio, Switzerland) to achieve the smoothest surface finish (Bauer & Caputo, 1983; Pratten & Johnson, 1988; Yap, Lye & Sau, 1997) and to avoid problems of operator-induced variables during finishing and polishing. A glass slide was placed over the molds and pressure was applied to extrude excess material. The restoratives were light polymerized according to manufacturers' cure times with a Poly LUX II light cure unit (KaVo Dental, Warthausen, Germany). Mean intensity of the light source (597 ± 10 mW/cm^2) was determined with a radiometer (CureRite, EFOS INC, Ontario, Canada) prior to starting the experiment. Cure times were as follows: Spectrum–20 seconds; Dyract–40 seconds; Reactmer–30 seconds and Fuji II LC–20 seconds. The specimens were stored in distilled water at 37°C for seven days and randomly divided into three groups. Specimens in Group 1 were not exposed to any bleaching systems and served as the control group. Group 2 specimens were bleached with 35% carbamide peroxide (Opalescence Quick) for 30 minutes without any light activation or reapplication of bleaching gel. Group 3 specimens were bleached with 35% hydrogen peroxide (Opalescence Xtra) for 15 minutes with 20 seconds light activation. After 15 minutes, the gel was washed away, fresh gel was reapplied and the aforementioned treatment was repeated. The combination of the two cycles resulted in a total bleaching time of 30 minutes (Table 1). After bleaching, the specimens were washed and surface roughness measurements (R_a) were taken at the center of the specimens using a profilometer (Surftest SV-400; Mitutoyo, Kanagawa, Japan). The average surface roughness, R_a values is the arithmetric average height of roughness component irregularities from the mean line measured within the sampling length. Smaller R_a values indicate smoother surfaces. Four sampling lengths of 0.25 mm were used, giving a total evaluation length of 1 mm. The specimens were bleached for another two sessions at one-week intervals. Storage medium for all groups during the hiatus period was distilled water at 37°C. All statistical analysis was carried out at significance level 0.05. Multiple

Table 1: *Summary of Treatment Groups*

Groups	Bleaching Agents	Treatment Time	Light Activation	Reapplication of Gel
Group 1 (Control)	No treatment with bleaching agents	Not Applicable	Not Applicable	Not Applicable
Group 2	35% Carbamide Peroxide (Opalescence Quick)	30 minutes	No	No
Group 3	35% Hydrogen Peroxide (Opalescence Xtra)	30 minutes	Yes	Every 15 minutes

Table 2: *Mean Ra Values [10^{-2}] of Four Materials After the Various Bleaching Sessions (standard deviations in parenthesis)*

Materials	Spectrum TPH			Dyract AP			Reactmer			Fuji II LC		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Session 1	**5.00** (1.58)	5.22 (2.22)	4.78 (1.09)	5.57 (1.58)	6.00 (1.94)	6.11 (2.09)	8.44 (1.88)	7.22 (1.64)	8.89 (3.86)	10.89 (1.83)	10.11 (2.26)	10.89 (2.09)
Session 2	4.56 (0.5)	5.00 (0.70)	5.00 (1.50)	7.78 (2.54)	6.44 (1.81)	7.00 (2.17)	7.56 (2.92)	9.44 (4.44)	10.33 (3.00)	9.33 (2.45)	11.44 (2.04)	8.89 (1.27)
Session 3	4.78 (1.09)	5.00 (1.41)	4.56 (0.76)	8.22 (1.79)	6.22 (1.48)	6.44 (1.67)	8.78 (2.81)	8.37 (2.24)	9.33 (3.76)	9.11 (1.36)	9.67 (1.12)	8.33 (1.41)

Note: At all treatment sessions, there is no significant difference between Group 1, 2 and 3 for all materials.

Table 3: *Comparison of Ra Values Between Materials at the Various Treatment Sessions*

		Differences
Session 1	**Group 1**	Spectrum, Dyract < Reactmer < Fuji II LC
	Group 2	Spectrum, Dyract, Reactmer < Fuji II LC
	Group 3	Spectrum < Reactmer, Fuji II LC Dyract < Fuji II LC
Session 2	**Group 1**	Spectrum < Dyract, Fuji II LC
	Group 2	Spectrum, Dyract < Reactmer, Fuji II LC
	Group 3	Spectrum < Reactmer, Fuji II LC
Session 3	**Group 1**	Spectrum < Dyract, Reactmer, Fuji II LC
	Group 2	Spectrum < Reactmer, Fuji II LC Dyract < Fuji II LC
	Group 3	Spectrum < Reactmer, Fuji II LC Dyract < Reactmer

**Results of one-way ANOVA/Scheffe' test at significance level 0.05.*
< indicates statistically significant difference.

analysis of variance (ANOVA) was used to determine the interaction among various variables. One-way ANOVA and Scheffe's post-hoc test were used to establish the effects of bleaching systems on individual materials and to compare the surface roughness of the various materials after bleaching.

RESULTS

The mean Ra values of four materials after the various bleaching sessions are shown in Table 2, while Table 3 shows the results of statistical analysis comparing materials.

Multiple analysis of variance showed no significant interaction between materials, treatment groups and sessions. At all treatment sessions, no significant difference in surface roughness was observed between the control and the bleached groups for all materials. The use of in-office bleaching systems was therefore not detrimental to the surface finish of the tooth-colored restorative materials evaluated. Significant differences in surface roughness were, however, observed between materials. Differences between materials varied somewhat depending on the treatment session. For all treatment sessions and groups, Spectrum was significantly smoother than Fuji II LC. After the third treatment session, Spectrum was significantly smoother than Dyract, Reactmer and Fuji II LC for the control group. No significant difference was observed among the latter three materials. For the bleached groups, Spectrum was only significantly smoother than Reactmer and Fuji II LC. No significant difference in surface roughness was observed between Spectrum and Dyract. Ra values obtained with Dyract were significantly lower than Fuji II LC for Group 2 and Reactmer for Group 3.

DISCUSSION

Vital tooth bleaching using high concentrations of hydrogen peroxide was described as early as the 1900s (Henderson, 1910; Fisher, 1911; Ames, 1937). The procedures were both complicated and time-consuming; furthermore, gingival irritation was relatively frequent. The new in-office bleaching products being marketed also utilize high concentrations of carbamide peroxide or hydrogen peroxide. The delivery systems are, however, more friendly and the consistency more workable. The concentration of hydrogen peroxide and the pH of bleaching products is important to clinicians as they may have adverse effects on both tooth structure and restorations. Price, Sedarous & Hiltz (2000) measured the pH of 26 tooth-whitening products available in the market. They found that home bleaching products have a pH range from 5.66 to 7.35. The pH range of in-office bleaching systems was lower and ranged from 3.67 to 6.53. Among the systems evaluated, Opalescence Xtra had the lowest mean pH (3.67) and Opalescence Quick had the highest mean (6.53). These two bleaching systems were thus selected for the current study. With the exception of conventional glass ionomer cements, the materials selected represent the entire continuum of tooth-colored restorative materials currently available.

Surface alterations to resin composites and glass ionomer cements after exposure to bleaching agents have been reported (Bailey & Swift, 1992; Lee, Grimuado & Shen, 1999; Kilimitzoglou & Wolff, 2000; Turker & Biskin, 2000). The products used in these studies were "at-home" systems and over-the-counter bleaching products. Roughening was suggested to result from loss of matrix rather than filler particles (Bailey & Swift, 1992). Other studies (Burgess & others, 1991; Souyias, Hoelscher & Neme, 2000) have, however, demonstrated no significant increase in surface roughness. The apparent discrepancies may be explained, in part, by the differences in experimental methodologies and bleaching agents used. While some researchers have adopted clinically relevant protocols, others have employed continuous exposure of restorative materials to bleaching agents over stipulated time periods. The frequency of change of bleaching agents may also contribute to the disparity in results.

The contact time between bleaching products and teeth/restorations for home vital bleaching is much longer than that for in-office vital bleaching. In this study, three sessions of 30-minute bleaching treatment with one-week intervals were employed to simulate clinical conditions. At all treatment sessions, no significant difference in surface roughness was observed between the control and bleached groups for all materials. Using Opalescence Quick and Xtra are, therefore, not detrimental to the surface finish of the composite, compomer, giomer and resin-modified glass ionomer cements evaluated clinically. It is important to note that results may be material dependent, as some restorative materials are pH sensitive. For example, the surface finish of "smart" composites, such as Ariston pHc (Vivadent, Schann, Liechtenstein) that use a low oral pH to increase fluoride release (Combe & Douglas, 1998), may be affected by the low pH of some hydrogen peroxide-based bleaching systems. For all treatment sessions and groups, the composite (Spectrum) was significantly smoother than the resin-modified glass ionomer cement (Fuji II LC). This can be explained by the differences in microstructure. The mean particle size of Spectrum is under 1 µm, while that of Fuji II LC is 4.8 µm. Treatment with strong oxidizing agents appeared to stabilize the surface of the compomer evaluated. For the control group, a gradual increase in roughness was observed for Dyract specimens. The Ra values of bleached Dyract specimens, however, remained relatively stable over the experimental period. The aforementioned accounts of the significantly smoother surface of Dyract as compared to Reactmer/Fuji II LC for the bleached groups after three weeks storage in water at 37°C. Compomers are known to uptake water and expand (Yap & others, 2000). Water uptake is necessary for establishing an acid-based reaction and fluoride release (Yap, Khor & Foo, 1999). Water uptake may result in stress corrosion and complete or partial debonding of fillers leading to increased surface roughness (Söderholm, 1983). The exact mechanism for the stabilization effect of in-office bleaching agents is not known and warrants further investigation.

Although in-office bleaching systems are not detrimental to the surface finish of tooth-colored restoratives, care should still be taken when bleaching teeth with restorations. Hydrogen peroxide was found to have higher levels of penetration into the pulp chamber in restored teeth compared to sound teeth (Gokay, Tuncbilek, & Ertan, 2000). The mechanical properties and, durability of tooth-colored restoratives may also be affected by in-office bleaching agents. Dentists should, therefore, limit treatment time to as short as possible since extended bleaching treatment with such high concentrations of peroxide along with low pH may cause some alterations to both tooth structure and restorations.

CONCLUSIONS

1. The use of in-office bleaching systems that employ strong oxidizing agents is not detrimental to the surface finish of composite, compomer, giomer and resin-modified glass ionomer cements evaluated.
2. The surface finish of the composite Spectrum was significantly better than the resin-modified glass ionomer regardless of bleaching treatment.

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