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Effect of Bleaching Agents on the Colour of Different Aesthetic Restorative Materials

SUMMARY

The aim of this study was to compare the effects of 3 proprietary carbamide peroxide bleaching agents on the colour of 3 dental aesthetic restorative materials. 90 specimens made from feldspathic porcelain, micro-filled composite and light-polymerized modified glass ionomer cement were prepared. Colorimeter was used for colour measurements, and 1-way Anova was used to evaluate the colour measurements ($\alpha<0.05$).

The modified glass ionomer cement group was the only restorative material group that showed significant colour change ($\Delta E>3.3$). No significant difference was found between bleaching agents, and no significant changes in the colour of feldspathic porcelain and micro-filled composite were observed.

Keywords: Bleaching Agents; Aesthetic Restorative Material; Colour

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Introduction

Tooth bleaching was reported in the literature as an aesthetic treatment option as early as 1898[1]. The night-guard bleaching technique has been in routine use since 1989, following the publication of Haywood and Heymann[2]. The night-guard vital bleaching agents are commercially available as various products that have different carbamide peroxide content. The basic clinical technique involves the use of a soft, plastic, night-guard-styled prosthesis[3]. Carbamide peroxide (CP) solutions are very unstable and immediately dissociate into their constituent parts on contact with tissue or saliva. The 10-16% CP solution dissociates into 3-5% hydrogen peroxide and 7-10% urea. The hydrogen peroxide further degrades into oxygen and water, while the urea degrades into ammonia and carbon dioxide[1,3,4]. Treatment times for the night-guard vital bleaching technique vary extensively, and much depends on how much time per day that the patient spends for applying the technique[1].

There are several reports on the effect of bleaching agents on the colour of restorative materials. Swift[5] and Haywood[1] reported that night-guard vital bleaching technique has no significant effect on the colour of porcelain or other ceramic material, as well as amalgam and gold. Monaghan et al[6] reported that Rembrandt Lighten and White and Brite bleaching agents created slight colour changes in the composite resin restorative material. Monaghan et al[7] also observed significant colour differences when the tested composite materials were exposed to the superoxyl bleaching solution after treatment with 37% H_3O_4. Cullen et al[8] found that micro-filled composite colour changes occurred during the bleaching procedure but, bleached composite resins returned to their original colour after a week. Fay et al[9] reported that bleaching agents remove stains from composite and hybrid ionomer. Canay and Çehreli[10] claimed that 10% hydrogen peroxide (HP) was more likely to cause colour change of composites compared with 10% CP.

Aesthetic restorative materials have gained great popularity due to the patient's cosmetic demands. Feldspathic porcelain is one of several porcelains used for Class I and Class II cavities for inlay, onlay and full coverage restorations[11,12]. Micro-filled composite resins are used for Class III and Class IV restorations[13] and modified glass ionomer cement usually for Class V cavities[13,14], both materials being used as an alternative to amalgam and gold restorations.

In the literature, different techniques have been used to evaluate the colour of dental materials. Shade guides[15], visual evaluation[16] or photographs[15,17-19] are useful for colour evaluation; however, these rely on subjective options, which have been shown to be unreliable. The colorimetric instruments, such as colorimeters or spectrophotometers, yield numeric values and better reliability than the others[6,20-22].

The **aim** of this study was to determine the effects of 3 different proprietary carbamide peroxide bleaching agents (Nite-White, Opalescence and Rembrandt) on the colour of 3 dental aesthetic restorative materials: feldspatic porcelain, micro-filled composite and modified glass ionomer.

Material and Methods

3 bleaching products and 3 restorative materials were chosen for this study. The materials, product names, manufacturers, and pH values as measured with a universal indicator (pH=0-14; E Merck, Dormstadt, Germany) are listed in table 1. For the colour measurements, a CR-200 colorimeter (Minolta Co, Ramsey, NJ) was used. Although the manufacturer's instructions for Remrandt Lighten Gel and Opalescence recommend the use of proprietary toothpaste, none were used to eliminate any mechanical abrasive effects[6] so that only the effect of the bleaching agents was investigated.

Table 1. The used materials

Material	Product Name	Manufacturer
Feldspathic porcelain	Duceram	Ducera Dental, Rosbah, Germany
Modified glass ionomer cement	Fuji II LC	GC Corp,Tokyo, Japan,
Composite Resin	3M Silux Plus	3M ESPE, St. Paul, Minn
10% Carbamide peroxide, Carbapol pH=6	Opalesence	Ultradent Products, Inc. South Jordan, Utah
10% Carbamide peroxide pH=6-7	Rembrandt	Den-Mat Corp, Santa Maria, Calif
16% Carbamide peroxide pH=5.5	Nite White	Discus Dental, Inc, Beverly Hills, Calif

To prepare the porcelain specimens, a stainless steel mould consisted of 2 6mm-thick stainless steel plates, held together by welding. Before welding 4 holes, 1 cm in diameter, were drilled in of the plates to obtain flat-bottom specimens. The metal mould was boxed, and silicon duplicating impression material (Flexil Dublicating Silicone, Davis Schottlander & Davis Ltd, Letchworth Herts, United Kingdom) was mixed in accordance with the manufacturer's directions and poured into the boxed mould to duplicate the holes. Refractory material in a powder:liquid ratio of 3:1 was mixed by use of a vacuum mixer (Vop, Botevgrad, Bulgaria) and poured into the silicone mould by use of a vibrator (Vibraboy SL BEGO, Bremen, Germany). When the material had set, the duplicated mould made of investment was removed from the silicon impression. This procedure was repeated until 30 investment moulds were produced.

A calibrated porcelain oven (Programat 90; Ivoclar Vivadent, Schaan, Lichtenstein) was used to fire the porcelain specimens in accordance with the manufacturer's instructions. 30 porcelain specimens were fired on the investment moulds. Investment material was cleaned from the sintered porcelain specimens by air-borne particle abraded with 250µm. aluminium oxide powder (Korax 250, BEGO). The specimens were then trimmed with a thin cylindrical diamond bur (D-Z Labor, Drendel ans Zweilling GmbH & Co, Berlin, Germany) and further air-borne particle abraded by use of 50µm. aluminium-oxide powders. After the self-glazing procedure[23,24] was completed in accordance with the manufacturer's directions, specimens were cleaned in distilled water in an ultrasonic cleaner (Whaledent Biosonic Coltène/ Whaledent Inc, Cuyohoga Falls, Ohio) for 5 minutes.

Holes 1cm in diameter were drilled in a 6mm-thick poytetrafluoroetylene plate to form composite and modified resin glass ionomer cement specimens. These restorative materials were placed into the mould separately and sandwiched between 2 glass plates by use of titanium-coated instruments (Brilliant Esthetic Line Composite Instrument Coltène AG, Altstatten, Switzerland). In accordance with the manufacturer's directions, specimens were polymerized for 40 seconds with a wide-tipped prismatic light-polymerizing unit (3M ESPE, St. Paul, Minn) at 420mW. 30 specimens of each restorative material were prepared. The specimens were polished with medium, fine and superfine Sof-Lex disks (3M ESPE) on a slow-speed handpiece in accordance with the manufacturer's directions and further cleaned in distilled water in an ultrasonic cleaner (Whaledent Biosonic Coltène/ Whaledent Inc) for 5 minutes.

Each restorative material group was divided into 3 bleaching subgroups (n=10). 2 specimens were selected from each of these subgroups to form the control groups. All specimens were stored in distilled water in screw-top vials (Isolab, Wetheim, Germany) at room temperature for 24 hours before any test procedure. The bleaching procedure was performed over a period of 30 days. The specimens were immersed in the bleaching gels for an

average of 8 hours per day. At the end of the bleaching procedure, the treated specimens were removed and washed under running distilled water for 30 seconds and placed in fresh distilled water until the next daily application[4,19,25,26]. The control specimens were kept in distilled water, and the distilled water was changed daily.

The colour measurements were repeated at intervals of 24 and 48 hours, and 1, 2, 3 and 4 weeks (30 days). The specimens were positioned on the calibration plate of CR-200 as a standard background and 3 measurements for each specimen were performed in the same room and lighting. The mean of the readings was calculated. Then, the colour change of the specimens was determined by calculating the ΔE from the L*a*b* values obtained with the colorimeter. A ΔE of more than 1 is clinically noticeable under optimal viewing conditions by trained observers[27]. The following formula was used[27]:

$$\Delta E = [(L_F^* - L_I^*)^2 + (a_F^* - a_I^*)^2 + (b_F^* - a_I^*)^2]^{1/2}$$

In this system, *L** represents lightness, *a** redness-greenness, and *b** yellowness-blueness; the subscript *I* stands for the initial value and the subscript *F* stands for the final value

1-way analysis of variance (ANOVA) was used to evaluate the colour measurements. Significant results were evaluated again with Fisher and Duncan's multiple range test ($\alpha<0.05$).

Results

Mean colour change values and standard deviations for each combination of bleaching and restorative material group are given in table 2.

Statistical comparisons in ΔE were made: (1) with respect to bleaching time within bleaching agent-restorative material combination groups (Tab. 3); (2) between the bleaching agents with respect to time (Tab. 4); and (3) between the bleaching agents for the statistically significant group at t=30 days.

The modified glass ionomer cement group was the only restorative material group that showed significant colour change (ΔE>3.3) with tested bleaching agents. The micro-filled composite group's colour changes were not significant statistically; only Rembrandt bleaching agent created slight colour changes after 3 weeks of immersion (ΔE>1).

Table 2. Mean ΔE values for all the materials tested

	24 Hours- Inıtial		48 Hours-Initial		1 week-Initial		2 weeks-Initial		3 weeks-Initial		4 weeks-Initial	
	Mean *	SD **	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Feld. porcelain												
NiteWhite	0.46	0.21	0.47	0.26	0.44	0.2	0.45	0.22	0.47	0.2	0.45	0.19
Opalescence	0.27	0.12	0.37	0.15	0.37	0.14	0.35	0.55	0.66	0.17	0.34	0.1
Rembrandt	0.33	8.79	0.31	0.11	0.31	9.78	0.3	0.13	0.48	0.15	0.38	0.12
Control	0.39	0.13	0.38	0.12	0.4	0.13	0.39	0.36	0.59	0.16	0.39	0.16
Glass Ionomer												
NiteWhite	2.94	0.56	3.6	0.56	4.7	0.89	5.43	0.93	5.62	0.72	5.4	0.78
Opalescence	2.4	0.92	3	1.18	4.3	0.76	5.52	1.54	6.91	0.81	6.65	0.92
Rembrandt	4.08	1.45	3.81	1.67	5.23	1.56	5.45	1.48	7.97	1.51	8.06	1.57
Control	0.45	0.22	0.69	0.46	1.29	0.91	1.39	0.68	1.35	0.89	1.62	0.7
Microfilled Comp.												
NiteWhite	0.5	0.15	0.63	0.53	0.71	0.24	0.76	0.3	0.74	0.4	0.76	0.45
Opalescence	0.44	0.22	0.49	0.67	0.63	0.37	0.83	0.26	0.87	0.33	0.86	0.43
Rembrandt	0.47	0.18	0.75	0.96	0.88	0.27	0.96	0.18	1.04	0.39	1.04	0.22
Control	0.37	0.11	0.36	0.1	0.36	0.17	0.39	0.11	0.41	0.15	0.39	0.15

*: Mean ΔE value
**: Standard deviation

Table 3. 1-way ANOVA results

Source of variation	Experimental group	df	Sum of Squares	Mean Square	F ratio	Probability
Time	PN	5	5.466667E-03	1.093333E-.03	0.02	1.000
Time	PO	5	5.77/6677E-02	1.154333E-02	0.57	0.720
Time	PR	5	3.741042E-02	7.482084E-03	0.48	0.778
Time	PCon	5	1.86875E-03	3.7375E-04	0.01	1.000
Time	GlN	5	48.91732	9.783464	17.12	0.000
Time	GlO	5	139.9323	27.98645	25.02	0.000
Time	GlR	5	137.2577	27.45155	11.49	0.000
Time	GlCon	5	4.382835	0.8765671	1.62	0.175
Time	CoN	5	0.4086917	8.173833E-02	0.60	0.698
Time	CoO	5	1.478519	0.2957037	1.79	0.136
Time	CoR	5	1.927867	0.3855733	1.82	0.130
Time	CoCon	5	9.810417E-03	1.962083E-03	0.04	0.999

PN: Feldspathic porcelain- NiteWhite
PO: Feldspathic porcelain- Opalescence
PR: Feldspathic porcelain- Rembrandt
PCon: Feldspathic porcelain- Control
GIN: Glass ionomer- Nite White
GIO: Glass ionomer- Opalescence
GIR: Glass ionomer- Rembrandt
GICon: Glass ionomer- Control
CoN: Microfilled composite- Nite White
CoO: Microfilled composite- Opalescence
CoR: Microfilled composite- Rembrandt
CoCon: Microfilled composite- Control

Table 4. Relation between ANOVA result and mean colour value of glass ionomer cement

(values with same letter were not significant statistically)

	24h-i	48 h-i	1 w-i	2 w-i	3 w-i	4 w-i
Nite White	2.9a	3.6b	4.7d	5.4f	5.6	5.4
Opalescence	2.4a	3.04bc	4.3de	5.5fg	6.9h	6.65
Rembrandt	4.08	3.08c	5.2e	5.45g	7.97h	8.06
Control	.45	.68	1.3	1.3.9	1.35	1.62

Discussion

In the literature, with the development of cosmetic dentistry, bleaching techniques have gained a world-wide popularity among dentists as a treatment method. Since the aesthetic demands have increased currently, porcelain inlay and onlay restorations, and glass ionomer restorations in appropriate indications have been used as alternatives to amalgam and composites.

There are several studies on the effects of bleaching agents on the existing restorations. Haywood[1] reported that porcelain, amalgam and gold alloy restorations were not affected by bleaching regarding the colour and composition. It was showed that bleaching solutions moved enamel through dentin and as this effect continued, colour of composite and porcelain restorations might seem lighter[3]. Swift[5] showed that vital bleaching procedure had not a significant influence on the colour and physical properties of porcelain and the other ceramics. In the current study, it was found that bleaching agents had no statistically and clinically significant effect on the colour of porcelain restorations, which was consistent with the findings of Haywood[1] and Swift[5].

There are several reports on the effect of bleaching agents on the colour of composite resins[7-10]. 2 of them used 30% HP and the others used CP as bleaching agents. The authors[8,10] observed significant colour difference with the use of 30% HP as a bleaching agent, and they claimed that HP bleaching agents caused more colour change of composite compared with 10% CP. Monaghan et al[7] and Cullen et al[8] notified that bleaching agents, including CP, create slight colour changes with the composite resin restorative materials; these changes were no different than exposure to water and bleached composite resins resume their colour after a week. Tested composite restorative material group's colour changes occurred only with Rembrandt bleaching agent, with a concentration of 10%, after the third week ($\Delta E>1$). Unfortunately, it was not clinically significant. The result of this study is similar to those of Monaghan et al[7] and Cullen et al[8]. Unfortunately, in the presented study, Nite-White, with a concentration of 16% and Opalescence, with a concentration of 10%, did not cause any colour difference. Turker and Biskin[28], reported a decrease of silica and silicon content (4.03%) on the surface of the micro-filled resins after treatment with 10% Rembrandt bleaching agents. This diminution suggested that Rembrandt bleaching agent caused erosion on the surface of composite matrix so, the slight colour changes of the Rembrandt bleaching agents could be related with this surface alterations.

In the presented study, statistically and clinically significant changes were found in the colour of glass ionomer restorative material treated with bleaching agents tested. There are no colour studies for modified glass ionomer cement to compare to the results of this study. Nevertheless, this study found no significant differences in colour between any of the bleaching agents; the colour of the modified glass ionomer cement continued to increase during the period of bleaching procedure. Further studies are needed to determine the mechanism of colour change in aesthetics restorative materials when exposed to the bleaching agents, which was not a part of this investigation.

Conclusion

This *in vitro* study suggests that the bleaching procedure had no colour changing effect on feldspathic porcelain and micro-filled composite restorations. Colour changes for the modified glass ionomer cement continued during bleaching procedure.

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