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Effect of Light-activated Bleaching on the Microleakage of Class V Tooth-colored Restorations

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Clinical Relevance

There is no need to replace appropriate resin composite, compomer and hybrid glass ionomer restorations following plasma arc light-activated tooth bleaching.

SUMMARY

Objective: In-office bleaching procedures utilizing highly concentrated 30%-35% hydrogen peroxide solutions or hydrogen peroxide releasing agents are used for tooth whitening. Some recommend that, to enhance the whitening process, light-activation of the bleaching agent should be performed. The current study evaluated the effect of plasma arc bleaching on the microleakage of Class V restorations restored with resin composite, compomer and resin-modified glass ionomer (RMGI).

Materials and Methods: The buccal surfaces of 72 freshly extracted premolars were prepared with Class V cavities (4 x 2.5 x 1.5 mm) extended 1 mm apical to the CEJ. The prepared teeth were randomly divided into six groups. The cavities were restored with Single Bond and Z100 resin composite (Groups 1 and 2), Prompt L-Pop and F2000 compomer (Groups 3 and 4) and Vitremer RMGI (Groups 5 and 6), respectively. They were then thermocycled for 500 cycles. The samples from Groups 1, 3 and 5 were incubated at 37°C and 100% humidity. Groups 2, 4 and 6 were bleached using in-office bleaching gel and the plasma arc bleaching unit, then incubated. All samples were sealed with nail varnish and immersed in 2% basic fuschin for 24 hours. The restorations were sectioned longitudinally and

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microleakage was evaluated using a scale ranging from 0 to 3. The data were analyzed using the Kruskal-Wallis test (α=0.05).

Results: No statistically significant differences between study groups were observed in both the enamel and dentinal margins (*p*>0.05).

Conclusion: Plasma arc bleaching did not significantly affect the microleakage of existing tooth-colored restorations restored with Z100 resin composite, F2000 compomer and Vitremer RMGI.

INTRODUCTION

In-office vital bleaching using highly concentrated bleaching agents can be used successfully to whiten discolored vital teeth.[1-2] In-office vital bleaching is an appropriate alternative to home-bleaching when rapid treatment is desired or in the case of a lack of patient compliance using a "boost" therapy that might be continued using home-bleaching procedures.[2] Many studies have reported that tooth bleaching is safe in terms of potential risks to dental hard tissues.[3] The side effects of bleaching are often classified into three categories: problems involving the pulp chamber (tooth hypersensitivity), oral and periodontal tissue reactions (gingival irritation) and the possibility of systemic reactions.[1] After bleaching therapy, replacement of the restorations on visible surfaces is often suggested to the patient due to the mismatch of the restoration and tooth color.[4] However, when bleaching is performed, the following situations should be considered, since the effect of bleaching agent on restorations and their margins will be more of a concern: when existing restorations are of a good quality and are not placed in visible areas, when the patient seeks bleaching after the placement of needed restorations or if the existing restorations are temporarily or permanently replaced due to their aging, caries and inefficacy.

According to the literature, peroxide is capable of penetrating into sound enamel and dentinal structures; it has also been reported to influence the pulp chamber at different concentrations.[5] Benetti and others found that the higher the concentration of peroxide during bleaching, the greater the amount observed in the pulp.[6] Bowels and others claimed that increasing the temperature of the bleaching agent elevated the peroxide penetration into the pulp; the higher the temperature, the more that penetration occurred.[7] The release of hydroxyl-radicals from peroxide is accelerated by an increase in temperature, with the rate of decomposition increasing 2.2 times per each 10°C temperature rise. This is called thermocatalysis, which might create an increase in the efficacy of the bleaching agents.[2] In two studies by Gökay and others, they reported that, during external bleaching with 30% hydrogen peroxide or 10%-35% carbamide peroxide gel, higher levels of hydrogen peroxide penetrated into the pulp chamber in teeth with restorations.[8-9]

In addition, the possibility of hypersensitivity in vital teeth that have been restored is higher than in intact teeth during bleaching therapy.[10-13] Some researchers believe that the bleaching agents can penetrate through unsealed or susceptible dental margins of restorations.[4]

The investigation of dye penetration through restorations and their margins has been performed in previous research both before and after bleaching.[14-24] Controversy continues regarding the influence of pre- and postoperative external and internal bleaching on the microleakage of composite restorations. Some previous studies have reported a negative influence of bleaching on the marginal integrity of existing or new restorations.[14,16,18,20-21]

Light-activated bleaching uses highly concentrated hydrogen peroxide. The light source can be plasma arc lamps, light emitting diodes, argon laser, metal halide lamps or xenon discharge lamps.[2]

Recent studies show contradictory findings on the efficiency of light-activated tooth whitening procedures.[24-30] Tavares and others reported that tooth color changes were significantly more effective with the application of the plasma arc unit in a clinical examination.[25] In contrast, Papathanassiou and others and Hein and others did not find any significant difference between various light sources, including the plasma arc, when used for bleaching.[26-27]

However, it is still not clear whether light-activated bleaching using different light sources and highly concentrated peroxides affects the marginal seal of restorations and if there is a need for replacement of the affected restorations. Therefore, the purpose of the current study was to examine the effect of highly concentrated hydrogen peroxide in power bleaching using a plasma arc unit on the marginal microleakage of Class V restorations performed with a resin composite (Z100, 3M ESPE, St Paul, MN, USA), a compomer (F2000, 3M ESPE) and a resin-modified glass ionomer (Vitremer, 3M ESPE).

METHODS AND MATERIALS

In order to conduct this *in vitro* study, 72 freshly extracted sound human premolars were stored in 0.2% thymol solution for two months prior to the study. Following the cleaning of all teeth with a brush and pumice/water slurry, Class V cavities 4 mm mesiodistally, 2.5 mm occlusogingivally and 1.5 mm in depth, with a 1 mm extension apical to the CEJ, were prepared using diamond fissure burs in the buccal surfaces of all teeth. The samples were divided into three groups of 24 each. Following the manufacturer's instructions (3M ESPE), the restorations were prepared through the application of Single Bond adhesive and Z100 resin composite, Prompt L-Pop adhesive, F2000 compomer, and Vitremer RMGI (Table 1). Next, specimens from all the groups were thermocycled between 5°C and 55°C for 500 cycles (Mp Based, KARA 1000, Tehran, Iran) with a 30-second dwell time and a 15-second transfer time. Each set of 24 samples was then randomly divided into two groups of 12 and labeled as Groups 1 to 6. The restorations in the first (1 & 2), second (3 & 4) and third (5 & 6) pairings included resin composite, compomer and RMGI, respectively.

Table 1: *Materials Used in This Study and Mode of Their Applications According to the Manufacturer's Instructions (3M ESPE)*

Materials	Manufacturer's Instructions
Single Bond & Z100 resin composite	Etch for 15 seconds. Rinse with water spray for 10 seconds leaving the tooth moist. Apply two consecutive coats of the adhesive with a fully saturated brush tip. Dry gently for 2 to 5 seconds. Light cure for 10 seconds. Apply resin composite. Light cure for 40 seconds.
Prompt L-Pop & F2000 compomer	Mix Prompt L-Pop disposable adhesive. Apply for 15 seconds. Air blow gently. Apply the brush tip rotationally again for 3 seconds. Air blow. Light cure for 10 seconds. Apply F2000 compomer restorative material. Light cure for 40 seconds.
Vitremer RMGI	Apply Vitremer primer for 30 seconds. Air dry for 15 seconds. Light cure for 20 seconds. Mix the Vitremer powder and liquid in a 2.5/1 ratio for 45 seconds. Apply the paste. Light cure for 40 seconds. Apply finishing gloss. Light cure for 20 seconds.

Table 2: *Microleakage Distribution in Enamel Margins in the Study Groups*

Groups \ Scoring	0	1	2	3	Total
1. Resin Composite	12 100%	0 0%	0 0%	0 0%	12 100%
2. Bleached Resin Composite	10 83.4%	1 8.3%	0 0%	1 8.3%	12 100%
3. Compomer	11 91.7%	1 8.3%	0 0%	0 0%	12 100%
4. Bleached Compomer	8 66.6%	4 33.4%	0 0%	0 0%	12 100%
5. RMGI	7 58.3%	5 41.7%	0 0%	0 0%	12 100%
6. Bleached RMGI	7 58.4%	3 25%	2 16.6%	0 0%	12 100%

Groups 1, 3 and 5 were considered as the control groups, which were left unbleached. They were incubated at 37°C and 100% humidity (Behdad, 01 154, Tehran, Iran). Groups 2, 4 and 6 were separately fixed on silicon putty that was previously adjusted with the arc of plasma arc unit. Then, powder photoactivator and hydrogen peroxide solution vials of Everbrite in-office tooth whitening kit (Everbrite, Dentamerica, City of Industry, CA, USA) were mixed. The mixture was placed on the surface and margins of the restorations using a syringe. A plasma arc unit (Litex 685, Dentamerica) was placed 10 mm from the teeth and set on the bleaching program. This program performed 15 bleaching cycles in 10 minutes. Each cycle consisted of a 30-second light-activation period and a 10-second resting period. Thus, each group had four cycles and a total of 40 minutes bleaching. The bleaching gel was then suctioned and the teeth were washed and stored at 37°C in distilled water for 24 hours. The apices of all samples were then sealed using sticky wax, and the tooth surfaces were covered with two coats of nail varnish except for the restorations and 1 mm from the margins. Each group was immersed in a 2% basic fuschin solution and incubated at 37°C for 24 hours. Every tooth was then cut longitudinally in a buccolingual direction using a cutting machine (Dentarapid, Krupp Dental, 759 DR 2, Hilzingen, Germany) and diamond disk (Komet, 942 200, GmbH, Lemgo, Germany). Microleakage in the occlusal and gingival margins was examined under 32x magnification using an optical stereomicroscope (MBC-10, N9116734, St Petersburg, Russia). The following standard scoring system was applied: 0 = no microleakage, 1 = penetration up to one third of the cavity depth, 2 = penetration between one-third and up to two-thirds of the cavity depth, 3 = penetration into more than two-thirds of the cavity depth and up to the axial wall or towards the pulp. The obtained data were analyzed using an SPSS software program and statistically analyzed using the Kruskal-Wallis test (α=0.05).

RESULTS

Tables 2 and 3 summarize the obtained microleakage scores of the six studied groups. The Kruskal-Wallis test did not show any significant difference regarding the integrity of the dentin and enamel margins of the six groups for both conditions of bleaching and non-bleaching ($p>0.05$).

DISCUSSION

Since it appears that light or heat-activated bleaching often causes the production and absorption of heat energy into the material or tooth tissue and pulpal irritation was also shown in some research,[2] the current study was done to examine the effect of plasma arc

Table 3: *Microleakage Distribution in Dentinal Margins in the Study Groups*

Groups \ Scoring	0	1	2	3	Total
1. Resin Composite	10 83.4%	1 8.3%	0 0%	1 8.3%	12 100%
2. Bleached Resin Composite	5 45.4%	3 27.3%	2 18.2%	1 9.1%	11 100%
3. Compomer	10 83.3%	2 16.7%	0 0%	0 0%	12 100%
4. Bleached Compomer	7 58.3%	5 41.7%	0 0%	0 0%	12 100%
5. RMGI	6 50%	6 50%	0 0%	0 0%	12 100%
6. Bleached RMGI	8 66.6%	2 16.7%	2 16.7%	0 0%	12 100%

bleaching on the marginal integrity of bonded restorations.

According to the results of this study, microleakage in the enamel margins of the cavity was less than in the dentinal margins for all three materials tested. This is in accordance with previous research.[16,21]

According to the results of the current study, there is no significant difference between light-activated bleached and non-bleached restorations (Tables 2 and 3). It appears that, if there is an efficient bond between dental structure and restorative material, the margins would be safe from the absorption of peroxide and these margins would not turn into a potential pathway facilitating the accumulation of microorganisms and penetration of bacterial toxins. In addition, it seems that the type of bonding agent and an appropriate bond in the cavity margins, including enamel and dentinal margins, are likely to protect the restoration and its margins from the risk of peroxide penetration.

In the current study, Prompt L-Pop adhesive (3M ESPE) was used for Groups 3 and 4 (compomer restorations) (3M ESPE). According to the manufacturer, the application of adhesives prior to the application of F2000 compomer causes significant changes in bond strength and marginal integrity.[32] Previously, Owen and others reported the microleakage of composite bleached restorations to be higher with Aelitefil/Allbond resin composite than in another resin composite (Helioprogress/Heliobond), a compomer (Dyract AP) and an RMGI (Fuji II LC).[22] In the above mentioned study, light was not used for bleaching.

Some researchers believe that the effect of bleaching agents on restorative materials results from their pH, as products with pH<5.5 have been reported to have more effects on restorative materials.[2] It is said that, in such systems, the role of a catalyst or booster that is mixed with the H_2O_2 gel increases the pH of the mixed gel, thus increasing the peroxide decomposition rate and release of active radicals.[2] According to research, the use of light in the range that makes its use possible in the oral cavity does not increase the speed of H_2O_2 decomposition.[2,27] When light is projected onto a bleaching product, such as a bleaching gel, a small fraction is absorbed and the inherent energy converted into heat. Most likely, this is the main mechanism of action for all light-activated bleaching procedures.[2] In order to increase light absorption and, as a result, heat conversion, some bleaching products are mixed with specific colorants, for example, carotene. The orange-red color of carotene increases the absorption of blue light. In order to increase the absorption of red and infrared light, small particles of silica in the nanometer or micrometer scale may be added to give these products a bluish appearance.[2] In the current study, the applied gel did not contain carotene pigments and it had a bright color. The gel probably had silica particles included in the nanometer scale, which could absorb some fraction of light. Furthermore, the pH of the product before and after being mixed with photoactivator was not mentioned on the package or on the manufacturer's website.

The information regarding dental pulp temperature increase,[2] restoration microleakage[4] and dental or restoration surface alterations following bleaching[4] indicates a rapid and effective absorption of peroxide with the temperature rise of the agent or tooth tissue. Understanding and evaluating light-activated tooth bleaching and its effect on the integrity of restoration margins mandates a thorough knowledge on the light absorption features of dental structures, restorations and the bleaching product. According to the existing data, light- or heat-activated bleaching has the potential to increase pulpal stimulation, although it is still not clear whether it has any advantage regarding the acceleration of the process. Moreover, it appears that the current results require further investigation. Since the basic principles and advantages of such therapies are still not clear, the occurrence of side effects, including microleakage in bonded restorations, should not be overlooked in future studies. In addition, the results may not be applicable to clinical conditions. There is a need to conduct vast clinical investigations with different conditions, including various light sources and bleaching agent applications to determine whether the same results would be found *in vivo* as were found *in vitro* in the current study.

CONCLUSIONS

Under the conditions of this study, plasma arc light-activated bleaching did not significantly affect the marginal integrity of composite, compomer and resin-modified glass ionomer restorations. Further knowledge of the behavior of light absorption in dental structures and restoration margins would contribute to a thorough risk assessment regarding light-activated tooth bleaching.

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