EFFECT OF TWO DIFFERENT BLEACHING CONCENTRATIONS ON MICROLEAKAGE AND MICROHARDNESS OF TOOTH-COLORED RESTORATIONS (AN IN VITRO STUDY)

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ABSTRACT

INTRODUCTION: Bleaching may exert some negative effects on existing resin restorations.
OBJECTIVES: To evaluate the effect of bleaching with 14% and 40% hydrogen peroxide on microleakage and microhardness of different tooth-colored restorations.
MATERIALS AND METHODS: MICROLEAKAGE TEST: Class V cavities were prepared on labial surfaces of 60 extracted human upper central incisor teeth. The teeth were divided into 2 groups: Group I: restored with FiltekZ350XT composite, Group II: restored with Fuji II LC resin-modified glass ionomer. The teeth were thermocycled, each group was subdivided into 3 subgroups: subgroup A: was not bleached and served as control, subgroup B: bleached with 14% hydrogen peroxide gel and subgroup C: bleached with 40% hydrogen peroxide gel. The teeth were immersed in dye, sectioned, and dye penetration was scored at the incisal and cervical walls under stereomicroscope. Data were analyzed using Repeated Measures ANOVA, Wilcoxon and Mann-Whitney tests.
MICROHARDNESS TEST: 20 specimens (2mm thickness and 10mm diameter) were prepared from Filtek Z350XT composite, and Fuji II LC RMGI. Specimens were subjected to thermocycling, after which the microhardness of each specimen was measured before bleaching. Specimens were subdivided in to 2 subgroups, and bleached with 14%, 40% hydrogen peroxide gels. After bleaching, microhardness of each specimen was measured again. Data were analyzed using independent sample t-test and paired t-test.
RESULTS: For microleakage test; statistical analysis showed no significant differences in microleakage of the tested composite and RMGI subgroups for incisal or cervical margins. For microhardness; the results showed significant increase in mean microhardness for the composite and RMGI subgroups bleached with 14% hydrogen peroxide, whereas, composite and RMGI subgroups bleached with 40% hydrogen peroxide showed significant decrease in mean microhardness.
CONCLUSION: Bleaching did not have an effect on microleakage of Filtek Z350XT composite and Fuji II LC RMGI restorations, while they affected the microhardness of these restorations.
KEYWORDS: Dental bleaching, microleakage, microhardness, tooth-colored restorations.

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INTRODUCTION

Tooth color is one of the important parameters in achieving aesthetics of the teeth; it can be improved by a number of methods and approaches; one of which is bleaching. Bleaching is the process of removing or whitening the color of teeth through the application of a chemical agent to oxidize the organic pigmentations on the teeth (1, 2).

For vital bleaching, there are different materials and techniques used; hydrogen peroxide and carbamide peroxide are considered as the most common materials which can be used either in "in-office" or "at-home" bleaching procedures. The mechanism by which teeth are bleached is currently not fully understood (3).

Evidence points towards the initial diffusion of peroxide into and through the enamel to reach the enamel-dentin junction and dentin regions, where a number of different active oxygen radicals can be formed depending on reaction conditions (4).

These free radicals react with the high molecular weight, complex organic molecules that are responsible for the color of the stains, breaking them into less complex molecules with lower molecular weight that reflect less light resulting in reduction or elimination of this discoloration. However, this reaction is non-specific and may cause undesirable effects on teeth and restorative materials. So the demand for having more esthetic teeth and restorations has led several studies to be done in the field of tooth bleaching and its effects on the properties of the teeth and the quality of restorations (5).

Some scientific investigations showed that bleaching slightly increased the surface roughness of the restorations, which in turn can affect the sealing ability of these restorations (6) and increase microleakage.

Whereas, other investigations showed that bleaching had no influence on microleakage of restorations (7).

Other studies investigating the effect of bleaching agents on microhardness of restorative materials have reported conflicting results (8, 9). These results indicate an increase, decrease, or no change in the surface hardness of restorations after treatment with bleaching gels.

Based on this, the purpose of this study was to evaluate the effects of two types of hydrogen peroxide bleaching agents with two different concentrations on the microleakage and microhardness of different tooth-colored restorations.

MATERIALS AND METHODS

Materials used in the study

The type, composition and manufacturer of the used restorative materials and bleaching agents are shown in (Table 1).

Table 1: Composition of the materials used in this study.

Material	Type	Composition	Manufacturer
Filtek Z350XT.	Nano-filled Composite resin.	**Matrix:** Bis-GMA, UDMA, TEGDMA, Bis-EMA. **Filler:** non-agglomerated/non-aggregated silica filler (particle size 20 nm), non-agglomerated/non-aggregated zirconia filler (particle size 4-11 nm), aggregated zirconia/silica cluster filler (cluster particle size 0.6-10 µm). **Filler content:** 78.5% by weight (63.3% by volume).	3M – ESPE Dental Products, St Paul, MN, USA.
Single Bond Universal Adhesive.	Self etching adhesive bonding agent.	MDP Phosphate Monomer, Dimethacrylate resins, HEMA, Vitrebond™ Copolymer, Filler, Ethanol, Water, Silane, Initiators.	3M – ESPE Dental Products, St Paul, MN, USA.
Fuji II LC.	Light cured resin-modified glass ionomer.	**Powder:** Fuloro-Alumino silicate glass. **Liquid:** distilled water (20-30% by WT), Polyacrylic acid (20-30% by WT), 2-Hydroxy-ethylmethacrylate (30-35% by WT), Urethanedimethacrylate (<10% by WT), Camphorqunone (<1% by WT).	GC corporation, Tokyo, Japan.
DayWhite.	14% hydrogen peroxide gel.	14% hydrogen peroxide, ACP, potassium nitrate, mint flavor.	Philips Zoom, Discus Dental, LLC, Los Angeles, CA 90094, USA.
Opalescence Boost.	40% hydrogen peroxide gel.	40% hydrogen peroxide, 1.1% fluoride, 3% potassium nitrate, flavoring.	Ultradent products inc., South Jordan, UT84095, USA.

Methods

Microleakage

Sixty freshly extracted human upper central incisor teeth were collected from the out-patient clinic of oral surgery department, Faculty of Dentistry, Alexandria University. Teeth were scaled, polished, and disinfected in a 0.5% Chloramine T solution for one week (10) and stored for maximum 2 weeks in artificial saliva which was changed daily until ready to use (11).

Cavity preparation

Standardized rectangular Class V cavities (3mm mesio-distal length, 2mm inciso-cervical width, and 1.5mm depth) were prepared on the labial surface of all teeth. The gingival margin was placed 1mm incisal to the cemento-enamel junction. To standardize the cavity dimensions, a tofflemire metal band with a window of 3 x 2mm was held around each tooth by a tofflemire retainer, and a permanent marker was used to mark the cavity outline. In order to standardize the cavity depth, a rubber stopper was mounted on the bur on pre-measured length of 1.5mm, and depth was confirmed using a periodontal probe. The cavities were prepared using 0.8 plain fissure bur (Komet Dental Burs, Rock Hill, USA) mounted on a high speed handpiece with copious water cooling. The bur was replaced by a new one after every 4 cavities (12).

Specimens grouping and restoration procedures

The teeth were randomly divided into 2 groups of 30 teeth each (n=30) according to the type of restorative material used:

Group I: The teeth were restored with Filtek Z350XT using Single bond Universal bonding agent.

The cavities were first treated with Single bond Universal using the self etching technique; the surfaces of the cavity was gently brushed with Single bond Universal adhesive for 20 seconds, a moisture-free air source was used to deliver a gentle burst of air to the adhesive for 5 seconds, then the adhesive was light cured for 20 seconds using LED light curing unit (Elipar^{TM}S10 / 3M–ESPE, St Paul, MN, USA) with light intensity of 1200 mW/cm^2.

The adhesive was applied in 2 coats; the first coat of the bonding agent was applied and light cured, then the second coat was applied and light cured. The cavities were then restored with Filtek Z350XT composite resin.

The composite was placed in 2 increments (13); the first increment covered the entire incisal wall down to gingivo-pulpal line angle and was cured for 40 seconds. The second increment filled the remainder of the cavity; this increment was adapted with a transparent Mylar matrix and was also cured for 40 seconds.

Group II: The teeth were restored with Fuji II LC, resin-modified glass ionomer.

Fuji II LC capsules were activated, and mixed with an amalgamator (TAC 200/S, LINEA TAC, Montegrosso D'asti AT, Italy) for 10 seconds. The capsule was then placed in the metal GC capsule applier (GC Corporation, Tokyo, Japan) and directly delivered to the cavity, keeping the tip of the capsule close to the cavity floor and gradually withdraws the tip as the cavity was filled in one bulk technique. After filling the cavity, a transparent Mylar strip was used to adapt the restoration and then the restoration was light cured for 20 seconds.

Restorations of both groups were finished with Sof-Lex (3M-ESPE, St Paul, MN, USA) contouring and polishing discs. All the teeth were then stored in artificial saliva at 37°C and 100% humidity in the incubator for 24 hours. After 24 hours, all teeth were thermocycled for 500 cycles between 5°c and 55°c with dwell time of 30 seconds for each and a transfer time of 10 seconds.

Bleaching procedures

Each group was subdivided into 3 subgroups of 10 specimens each (n=10):

Subgroup A: The teeth were not bleached to serve as a control subgroup and were stored in artificial saliva at 37°C for 14 days which was changed daily to minimize the effect of the monomer, which leaches into the storage medium over time.

Subgroup B: The teeth were bleached with 14% hydrogen peroxide gel (DayWhite). For each tooth, bleaching gel was painted using a disposable brush on the labial surface for 30 minutes twice daily for 14 days, after each active treatment session, each tooth was rinsed for standardized time of 1 minute under running water to remove the bleaching agent, then stored in artificial saliva, which was also changed daily, for the next bleaching session.

Subgroup C: The teeth were bleached with 40% hydrogen peroxide gel (Opalescence Boost). For each tooth, bleaching gel was painted on the labial for 20 minutes for 3 successive sessions, between each session the teeth were rinsed for standardized time of 1 minute under running water to remove the bleaching material, and then the next session was done until the 3 bleaching sessions were finished.

Microleakage testing

After finishing the bleaching procedures, the teeth were coated with two coats of nail varnish leaving a 1mm window around the restoration and the apex of each tooth was sealed with sticky wax. All the teeth were then immersed in 0.5% basic fuchsin (SDFCL, Mumbai, INDIA) dye solution for 24 hours at room temperature. After 24 hours, the teeth were removed from the dye solution, rinsed under running water to remove excess of the dye and the teeth were allowed to dry.

The root of each tooth was sectioned from the middle third of the root; the teeth were sectioned longitudinally in a labio-palatal direction through the center of the restorations using a water cooled diamond coated disc (Metkon micracut 150, Osmangazi/Bursa, Turkey). The teeth sections were evaluated under stereomicroscope (Olympus B061, Japan) at 50X magnification to determine the degree of dye penetration at the incisal and cervical margins of the restoration. The severity of leakage was evaluated using an arbitrary 6-points leakage scale (14) as follows (Figure 1):

0 = no leakage.

1 = leakage up to depth of 0.5mm on the incisal or cervical walls.

2 = leakage up to half of the incisal or cervical walls (0.5mm<leakage depth<1mm).

3 = leakage over half of the incisal or cervical walls (1mm<leakage depth<1.5mm).

4 = subtotal leakage on the whole of the incisal or cervical walls (leakage depth = 1.5mm).

5 = total leakage partly or entirely over the pulpal wall of the cavity
(leakage depth>1.5mm).

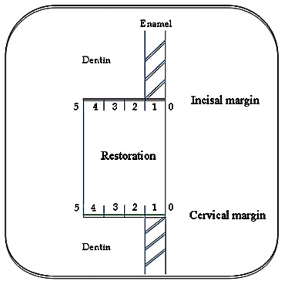

Figure 1: Dye penetration scoring criteria.

Statistical analysis was performed using Repeated Measures ANOVA test to compare leakage between the three studied subgroups of each group, Wilcoxon test to compare leakage between the incisal and cervical margins within each subgroup, and Mann-Whitney test to compare leakage between composite and RMGI subgroups bleached with 14% hydrogen peroxide, and between composite and RMGI subgroups bleached with 40% hydrogen peroxide. Significance of the obtained results was judged at the 5% level ($p \leq 0.05$).

Microhardness

A total of 20 disc-shaped specimens of the tested restorative materials (2mm in thickness and 10mm in diameter) were prepared using a Teflon mold (15), 10 specimens of each restorative material

Group I: prepared from Filtek Z350XT resin composite (n=10).

Group II: prepared from Fuji II LC resin-modified glass ionomer (n=10).

The molds were slightly over filled with the restorative materials, then covered with a Mylar strip and pressed with a glass slab with hand pressure for 30 seconds to remove voids and excess material and form parallel planar surfaces. Each restorative material was light cured according to the manufacturer's instructions using LED light curing unit (Elipar™S10 / 3M–ESPE, St Paul, MN, USA) with light intensity of 1200 mW/cm^2. All specimens were then stored in distilled water for 7 days (16) at 37°C to ensure complete polymerisation. After 7 days, the specimens were polished with medium, fine, and super fine Sof-Lex discs and further cleaned in distilled water in an ultrasonic cleaner for 2 minutes to remove any surface debris. After 24 hours, the specimens were thermo-cycled for 500 cycles between 5°c and 55°c with dwell time of 30 seconds for each and a transfer time of 10 seconds.

Pre-bleaching microhardness testing Microhardness was measured using Vickers microhardness tester (Wolpert Wilson instruments™, USA), 3 indentations were made at different points on the top surface of each specimen using 100 gram load and a 20 seconds loading time. A mean value for each specimen was obtained from these 3 measurements and used as a baseline measurement.

Bleaching procedures

Each group was further subdivided into 2 subgroups of 5 specimens each:

Subgroup A: bleached with 14% hydrogen peroxide gel (DayWhite). Bleaching agent was painted using a disposable brush on the top surface for 30 minutes twice daily every 12 hours for 14 days. After each active treatment period, the specimens were rinsed for a standardized time of

1 minute under running water to remove the bleaching material, and then stored in distilled water for the next bleaching session. The distilled water was changed daily to minimize the effect of the monomer which leaches into the storage medium overtime.

Subgroup B: bleached with 40% hydrogen peroxide gel (Opalescence Boost). Bleaching agent was painted on the top surface for 20 minutes for 3 successive sessions, between each session the specimens were rinsed for a standardized time of 1 minute for each under running water to remove the bleaching material, and then the next session was done until the 3 bleaching sessions were finished.

Post-bleaching microhardness testing

After finishing the bleaching sessions, all the specimens were again subjected to microhardness testing. Three readings were taken from the top surface of each specimen and a mean values were obtained.

Data were statistically analyzed using paired t-test to compare mean hardness number for each subgroup before and after bleaching, and independent sample t-test to compare mean hardness number between subgroups for each group, between composite and RMGI subgroups bleached with 14% hydrogen peroxide, and between composite and RMGI subgroups bleached with 40% hydrogen peroxide. Significance of the obtained results was judged at the 5% level ($p \leq 0.05$).

RESULTS

For microleakage test; mean of scores of dye penetration at incisal and cervical margins for both composite (Filtek Z350XT) and resin-modified glass ionomer (RMGI) (Fuji II LC) subgroups are presented in (Table 2), and graphically in (Figure 2).

Repeated Measures ANOVA test showed no significant differences in mean leakage between the three tested subgroups for composite, and RMGI restorations ($p > 0.05$).

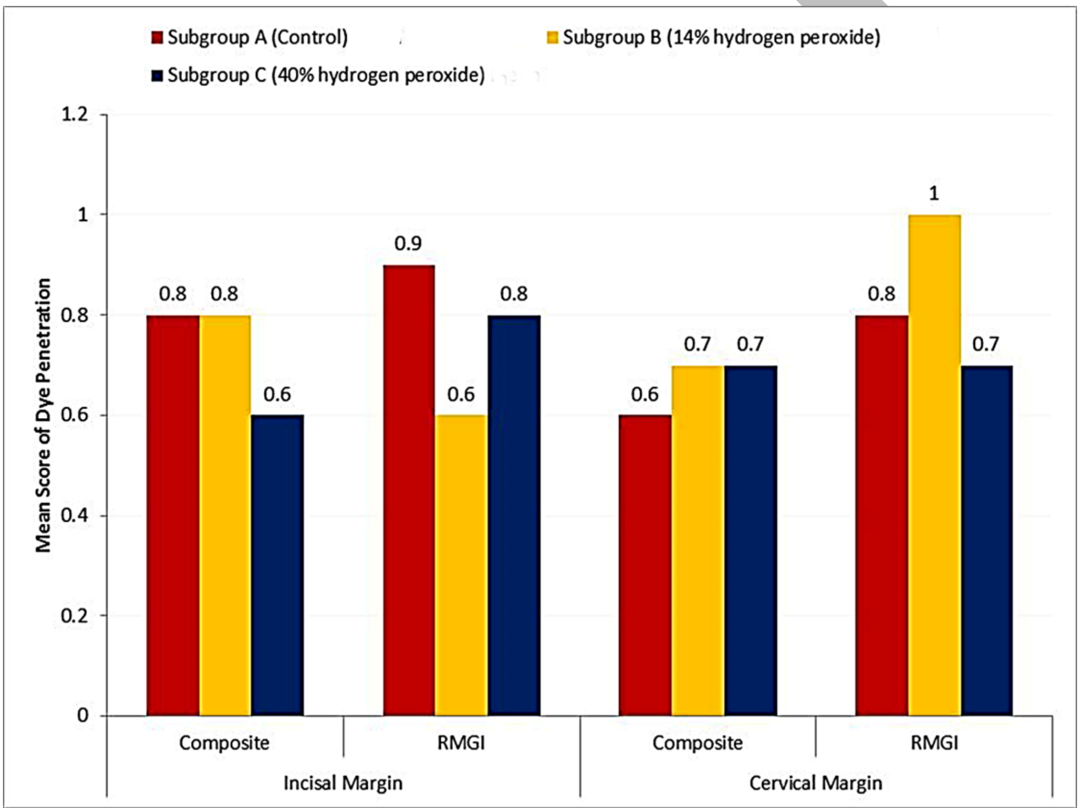

Figure 2: Mean scores of dye penetration at incisal and cervical margins of the three subgroups of composite and resin modified glass ionomer (RMGI) groups.

Wilcoxon test showed no significant differences in mean leakage between the incisal and cervical margins within each bleached subgroup for composite and RMGI restorations ($p > 0.05$).

Mann-Whitney test also showed no significant differences in mean leakage between composite and RMGI subgroups bleached with 14% hydrogen at the incisal or the cervical margins. For composite and RMGI subgroups bleached with 40% hydrogen peroxide also showed no significant differences in mean leakage at the incisal or the cervical margins ($p > 0.05$).

For microhardness test; mean Vickers hardness numbers (VHN) for composite and RMGI subgroups before, and after bleaching are presented in (Table 3), and graphically in (Figure 3).

Paired t-test (t_p) showed significant increase in mean Vickers hardness number (VHN) for composite and RMGI subgroups bleached with 14% hydrogen peroxide, whereas the test showed significant decrease in (VHN) for composite and RMGI subgroups bleached with 40 % hydrogen peroxide ($p <. 0.05$).

Independent sample t-test (t) showed significant differences in mean Vickers hardness number (VHN) between subgroups bleached with 14% hydrogen peroxide and subgroups bleached with 40% hydrogen peroxide for composite and RMGI restorations ($p <. 0.05$). The test also showed significant differences in (VHN) between composite and RMGI subgroups bleached with 14%

hydrogen peroxide, and between composite and RMGI subgroups bleached with 40% hydrogen peroxide (p<. 0.05).

Table 2: Mean and standard deviations (SD) of scores of dye penetration at incisal and cervical margins for composite and resin-modified glass ionomer (RMGI) subgroups.

Margin	Group	Subgroup						P
		Subgroup A (Control)		Subgroup B (14% Hydrogen peroxide)		Subgroup C (40% Hydrogen peroxide)		
		Mean	SD	Mean	SD	Mean	SD	
Incisal Margin	Composite	0.8	0.42	0.8	0.42	0.6	0.52	0.517
	RMGI	0.9	0.32	0.6	0.52	0.8	0.42	0.865
Cervical Margin	Composite	0.6	0.52	0.7	0.48	0.7	0.48	0.283
	RMGI	0.8	0.42	1.00	0.00	0.7	0.48	0.197

P: Repeated Measures ANOVA

Table 3: Mean and standard deviation (SD) of Vickers hardness number (VHN) of composite and resin-modified glass ionomer subgroups before and after bleaching.

Group	Subgroup	Phase				P
		Pre-bleaching		Post-bleaching		
		Mean	SD	Mean	SD	
Composite	**Subgroup IA** (14% Hydrogen peroxide)	97.4	10.9	105.9	5.6	0.014*
	Subgroup IB (40% Hydrogen peroxide)	101.2	11.9	86.1	9.9	0.001*
RMGI	**Subgroup IIA** (14% Hydrogen peroxide)	67.5	10.8	76.9	7.3	0.009*
	Subgroup IIB (40% Hydrogen peroxide)	69.4	8.8	53.9	3.9	0.001*

P: Paired t-test * P < 0.05 (significant)

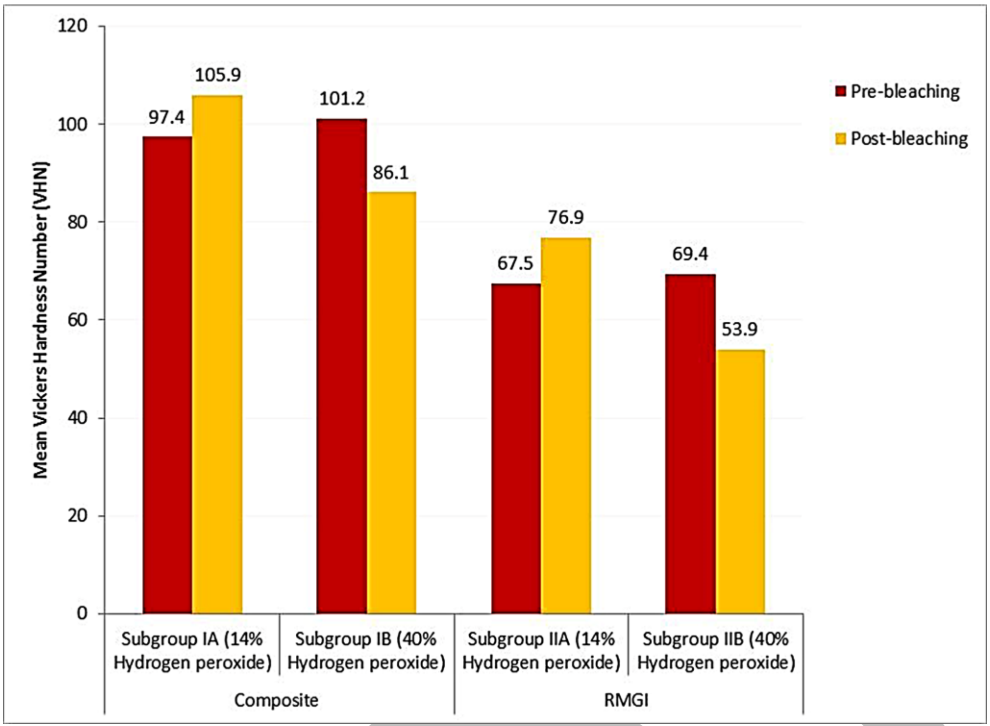

Figure 3: Mean Vickers hardness number (VHN) of composite resin and resin modified glass ionomer (RMGI) subgroups before and after bleaching.

DISCUSSION

Bleaching, in recent years, has become a popular treatment to remove surface stains and restore esthetics. Numerous bleaching agents have been used, including hydrogen peroxide which is considered as one of the best bleaching agents; therefore, the clinician should be aware of the effects of these agents on tooth structure and restorative materials.

Thermocycling has been used in the present study to simulate thermal changes occurs in the oral cavity in order to evaluate the effect of bleaching on dental restorations in the mouth and artificially age the specimens. According to a study done by Brown et al. (17) ten cycles of thermocycling on a specimen is equivalent to placing in the oral conditions for a day. Thus, 500 cycles of thermocycling applied in this present study is equivalent to putting the specimen inside the patient's mouth for 50 days.

Marginal sealing is known to influence the longevity of dental restorations. The most common method of assessing the sealing efficiency and the quality of adhesion in dental restorations is by microleakage evaluation.

The results of the present study showed that the two concentrations of hydrogen peroxide (14% and 40%) used did not have an adverse effect on the marginal seal of the tested composite (Filtek Z350XT) and RMGI (Fuji II LC) restorations at the incisal nor at the cervical margins. These results were in agreement with Klukowska et al. (18) who found that bleaching with 14%, and 38% hydrogen peroxide and 20% carbamide peroxide had no influence on microleakage of the tested microhybrid composite resin (Filtek Z250). Another study done by Khoroushi and Fardashtaki (19) showed that plasma arc (light-activated) bleaching did not significantly affect the microleakage of existing hybrid composite (Z100), compomer (F2000) and RMGI (Vitremer) restorations tested. A study by Sartori et al. (20) showed that bleaching with 10% carbamide peroxide and 35% hydrogen peroxide had no effect on microleakage of the tested microhybrid composite (Filtek Z250) at the adhesive interface in enamel or dentin. Hashemikamangar et al. (21) also found no significant differences in microleakage between the control and bleached (30% hydrogen peroxide) subgroups of the tested silorane-based composite resin (Filtek P90) and methacrylate-based composite resins (Filtek Z250, and Filtek Z350XT).

Conversely, the results of our present study were in contrast with researches done by Crim (22), Owens et al. (23), Ulukapi et al. (24), Jacob and Kumar (25) and Moosavi et al. (26) which indicated that bleaching was an effective factor on the sealing ability of restorations as microleakage increased after the use of different concentrations of hydrogen peroxide or carbamide peroxide. These previous studies explained the increase in microleakage of restorations after bleaching by the presence of residual peroxides from the bleaching agents which in turns increase microleakage as they could interfere with resin attachment to the tooth. In addition, when in contact with resin restorations, bleaching agents may cause an increase in surface roughness and porosity (27) and cause surface changes, according to Sarrett et al. (28) these changes occur because of the organic matrix which makes the resin more susceptible to chemical reactions. The conflicting results between our present study and these previous studies may be contributed to the differences in compositions of the tested restorative materials and bleaching products, different PH value of bleaching agents, different testing methodologies and different simulating clinical conditions.

The results also showed that there were no significant differences either between the incisal and cervical margins of the bleached subgroups for composite and RMGI groups, or between the composite and RMGI subgroups bleached with the same bleaching agent. These results were in contrast with Moosavi et al. (26) who found that postoperative bleaching with 15% carbamide peroxide could increase microleakage in the dentinal margins of composite (Filtek P60) and enamel margins of RMGI (Fuji II LC) restorations. This may be due to the differences between our present study and this previous study in the teeth selected for the test with different enamel thickness and the cavity design; in our study extracted human upper central incisors were used and Class V cavities were prepared on the teeth with cervical margins located 1mm incisal to the cement-enamel junction; thus all cavities were prepared on the crown of the teeth and the incisal and cervical margins were in enamel. While in Moosavi's study, extracted human third molars were used and Class V cavities were prepared with the cervical margins located 1mm cervical to the cement-enamel junction, where half of the cavities was prepared on the crown and the other half was on the root, so the incisal margins were in enamel while the cervical margins were in dentin which gave significant difference in microleakage between the two margins in the final results for the tested restorative materials.

Microhardness is one of the most important mechanical properties of restorative dental materials, and it is defined as the resistance of a material to surface indentation or penetration (29).

In the present study, it was found that bleaching with 14% hydrogen peroxide increased the surface hardness of composite and resin-modified glass ionomer (RMGI) specimens, while bleaching with 40% hydrogen peroxide decreased the surface hardness of composite and RMGI specimens. This can be explained by the fact that the penetration depth of the bleaching agents into the restorative materials depends on the concentration of these bleaching agents, which in turns affects the dissolution effects of these bleaching agents on the restorative materials (30), therefore, in case of bleaching Filtek Z350XT composite specimens with 14% hydrogen peroxide, the increase in mean hardness number (VHN) could be attributed to the composition of the tested nano-composite resin, having an organic matrix with considerably low surface hardness value into which were dispersed inorganic filler particles with higher surface hardness value (31).

With bleaching procedures, the bleaching agent may erode only the superficial softer matrix phase leaving the filler particles protruding. Accordingly, the Vickers' diamond indenter may hit the filler particles rather than the organic matrix resulting in higher surface hardness records (2).

In case of Fuji II LC RMCI specimens this increase in mean hardness number may be due to protrusion and localization of the silica core at the surface after the superficial erosion of the glass ionomer by the bleaching agent (32).

These results are in agreement with the study done by Cooley and Burger (33) which reported a significant increase in the mean microhardness of microfilled, hybrid, and macrofilled tested composite resins after bleaching with four types of 10% carbamide peroxide gels. Another study done by Türker and Biskin (32) found an increase in microhardness of light-cured modified glass ionomer (Fuji II LC) after bleaching with 10% and 16% carbamide peroxide, and for the tested microfilled composite resin (Silux Plus), there was an increase in microhardness after bleaching with 16% carbamide peroxide (Nite-White), while there were a decrease in microhardness after bleaching with two 10% carbamide peroxide gels (Opalescence and Rembrandt).

However, the results of our present study were in contrast with Campos et al. (34) who observed a decrease in microhardness of resin-modified glass ionomer (Vitremer), and compomer (Dyract AP) after treatment with 10% and 15% carbamide peroxide, whereas, these bleaching agents did not alter microhardness of the tested composite resins; Charisma (microhybrid composite) and Durafill VS (microfilled composite). Another study done by Mujdeci and Gokay (35) showed that bleaching materials used in the study (10% carbamide peroxide and 14% hydrogen peroxide) did not affect the microhardness of the tested nanohybrid composite resin (Grandio), a compomer (Dyract eXtra), and a glass ionomer cement (Ionofil Molar AC) restorative materials. These differences between our study and these previous studies may be due to the use of different restorative materials and bleaching agents with different concentrations which may act in different manner and different experimental testing procedures.

On the other hand, in the current study when Filtek Z350XT composite and Fuji II LC RMGI specimens were bleached with 40% hydrogen peroxide, there was a decrease in the mean hardness number (VHN), this may be due to penetration of the bleaching agent in the restorative materials and forming free radicals, these free radicals in turn may impact the resin-filler interface causing a filler-matrix debonding, and filler loss from the surface (16).

Another explanation for this decrease in hardness was the fact that the free radical released by the bleaching agent may eventually combine to form molecular oxygen and water, some aspects of this chemical process might accelerate the hydrolytic degradation leading to surface dissolution and lowering surface hardness (36). Also peroxides have been claimed to induce oxidation cleavage of polymer chains resulting in decrease in microhardness of composite restorations (37).

These results are in agreement with Taher (38) who found an average decrease in surface hardness of composite resin (Point-4), ormocer (Admira), compomer (Dyract AP), and resin-modified glass ionomer (Fuji II LC) restorative materials after bleaching with 35% hydrogen peroxide. Another study done by Bahannan (39) showed that the microhardness of nano composite resin (Filtek Supreme) and resin modified glass ionomer (Fuji II LC) specimens were significantly decreased after bleaching with 20% and 35% carbamide peroxide.

However, the results of our present study are in contrast with a study done by Polydorou et al. (40) who found that bleaching with 38% hydrogen peroxide did not reduce the microhardness of hybrid composite (Tetric Ceram), flowable composite (Tetric Flow), microhybrid composite (Enamel Plus HFO), nanohybrid composite (Filtek Supreme), ormocer (Definite) restorative materials.

The results of the present study also showed significant differences between the composite and RMGI subgroups bleached with the same bleaching material, this could be due to the difference in composition of the tested restorative materials. Filtek Z350XT composite resin composed of resin matrix of Bisphenol A glycol dimethacrylate (Bis-GMA), Urethane dimethacrylate (UDMA), Triethylene glycol dimethacrylate (TEGDMA) and Bisphenol A ethoxylated dimethacrylate (Bis-EMA) into which was dispersed inorganic silica and zirconia fillers with filler content of 78.5% by weight. Whereas Fuji II LC resin-modified glass ionomer composed of Fuloro-Alumino silicate glass, Polyacrylic acid (20-30% by Weight), 2-Hydroxy-ethylmethacrylate (30-35% by Weight) and Urethane dimethacrylate (<10% by Weight). Although these two restorative materials were affected in the same way by the tested bleaching agents where 14% hydrogen peroxide increased their hardness and 40% hydrogen peroxide decreased it, these differences in their compositions affect their mechanical properties giving different results in hardness values of each restorative material after bleaching.

CONCLUSION

The results indicated that bleaching agents 14% and 40% hydrogen peroxide used did not cause adverse effects on the microleakage of Filtek Z350XT composite bonded with Single Bond Universal and Fuji II LC RMGI restorations, whereas in terms of microhardness, bleaching with 14% hydrogen peroxide increased the microhardness of Filtek Z350XT composite and Fuji II LC RMGI specimens, while bleaching with 40% hydrogen peroxide decreased the hardness of composite and RMGI specimens.

STATEMENT OF CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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