Effect of laser and light emitting diode bleaching techniques on micro-leakage of dental composite postoperatively using two different bonding systems (in vitro study)

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Background and objective: Aesthetics is mostly a subjective perception that varies from individual to individual. The main objective of this study was to evaluate and compare the effects of LASER and light emitting diode bleaching techniques on the micro-leakage of composite resin restorations that were bonded with fifth and seventh adhesive bonding generations.
Methods: Standardized cavity preparations were performed on 60 maxillary premolars and samples were divided into three groups according to the two adhesive systems (fifth and seventh) generation. After cavities were restored with two different adhesive systems and restored with composite resin, they were submitted to thermo-cycling procedures. Teeth were divided into six sub-groups according to the bleaching systems (control, in-office bleaching by light emitting diode (LED), LASER-activated in-office bleaching). After the bleaching procedure, teeth were evaluated for marginal leakage. All data were analyzed using the Mann-Whitney U and Kruskal-Wallis tests ($p < 0.05$)
Results: The results of the present study showed that the control group presented lower micro-leakage values compared with the groups treated with bleaching agents. When the scores of micro-leakage of the six subgroups were compared, the differences among the groups were found to be statistically significant ($p < 0.001$). there was no significant difference found between the adhesive systems after treatment with the same bleaching techniques.
Conclusion: Under the conditions of this study, micro-leakage of composite resin restorations differs according to the bleaching techniques used with no significant difference was found between the adhesive systems, and restorations post bleaching procedure was necessitate replacing by the clinician due adverse effects on tooth restoration interface.

Keywords: Bleaching with LED, laser-activated bleaching, bonding generations, composite resin.

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Introduction

The use of bleaching agents to improve the appearance of natural dentition has become a popular procedure, and it is one of the most conservative dental treatments that can improve or enhance the smile and has gained popularity in basic oral care.[1] Currently the demand for tooth whitening has been building for more than a decade as a growing number of public envision and their desire for a white appearing smile. Tooth whitening now represents the most common elective dental procedure, and has been recognized as an effective and safe method to treat discolored teeth, when supervised by a dentist.[2]
Although at-home bleaching has increased dramatically in popularity, in-office bleaching products are still in demand for several reasons. Some patients do not adapt well to an at-home protocol due to the treatment time and because of the bleaching tray.[3] Another contra-indication for home bleaching consists of patients presenting sensitivity who need to be closely monitored for extensive tissue recession or deep, unrestored abfraction lesions.[4]
The mechanism of bleaching by hydrogen peroxide in-office and home bleaching gels con-

tain hydrogen peroxide or its precursor. Hydrogen peroxide bleaching generally proceeds via the perhydroxyl anion (HO2−). Hydrogen peroxide is an oxidizing agent that, as it diffuses into the tooth, dissociates to produce unstable free radicals which are hydroxyl radicals (HO•), perhydroxyl radicals (HOO•), perhydroxyl anions (HOO–), and superoxide anions (OO•–), which will attack organic pigmented molecules in the spaces between the inorganic salts in tooth enamel by attacking double bonds of chromophore molecules within tooth tissues. The change in double-bond conjugation results in smaller, less heavily pigmented constituents, and there will be a shift in the absorption spectrum of chromophore molecules; thus, bleaching of tooth tissues occurs.[5]

Light Amplification by Stimulated Emission of Radiation (LASER) being monochromatic, coherent, and collimated is a differentiated source of energy, when irradiated on a bleaching agent, the chromophores present in the gel absorb the light and thus activate the molecule, thereby improving tooth whitening ability by increasing the thermal energy, thus increasing the effectiveness of the bleaching composition. Few studies showed enhanced bleaching results on using LASER, while other studies showed no significant improvement.[6]

Effect of bleaching agents on the bond interface of restorations to dental substrates is controversial. Most of the current research shows marginal sealing alterations[7,8], and a decrease in bond strength after bleaching .[9,10] Previous studies have compared bond quality between etch-and-rinse and self-etch adhesives subsequent to bleaching.[11] Some of them have advocated the use of etch-and rinse adhesives over self-etching ones subsequent to bleaching.[11,12]

In the 1990s and in the ongoing decade, the fifth generation bonding systems sought to simplified the process of fourth generation adhesion by reducing the clinical steps which results in reduced working time. These are distinguished by being "one step" or "one bottle" system. In addition, an improved way was needed to prevent collagen collapse of demineralized dentin and to minimize if not totally eliminate, postoperative sensitivity.[13,14] So the most common method of simplification is "one bottle system" combined the primer and adhesive into one solution to be applied on enamel and dentin simultaneously with 35 to 37% phosphoric acid for 15–20 s. This single bottle, etch-and-rinse adhesive type shows the same mechanical interlocking with etched dentin occurs by means of resin tags, adhesive lateral branches and hybrid layer formation and shows high bond strength values to dentin with marginal seal in enamel.[15]

The seventh generation bonding systems was introduced in late 1999. The seventh generation or one-bottle self-etching system represents the latest simplification of adhesive systems. With these systems, all the ingredients required for bonding are placed in and delivered from a single bottle.[15,16] This greatly simplifies the bonding protocol as the claim was that could be achieved consistent bond strengths while completely eliminating the errors that could normally be introduced by the dentist or dental assistant who had to mix the separate components with other more complicated systems.[15] Furthermore, once placed and polymerized, they are generally more hydrophilic than two-step self-etching systems; this condition makes them more prone to water sorption, limits the depth of resin infiltration into the tooth and creates some voids.[17]

The present study was conducted to evaluate the micro-leakage of composite resin restorations after using two bonding agents of the fifth and seventh generation on extracted human maxillary premolars, which subjected to in-office bleaching techniques with LASER and light emitting diode.

Methods and Materials

Sixty human maxillary premolars with intact crown were selected for use in this study. The teeth were those that have been freshly extracted for orthodontic reasons, the age between (15-28). An inclusion criterion included vital, non-carious intact crowns. Exclusion criterion included teeth such as cracked areas of enamel, cervical erosion, abfraction, black carious spots or white chalky appearance caries that cannot be seen with naked eye. For suspicious samples X-ray was taken for ensuring the position of pulp horn or internal resorption The teeth were cleaned to remove stains and polished with pumice and rubber cap. The teeth were stored in a bottle of distilled water at room temperature to avoid dehydration, and used within 3 months.

Standardized cavity design preparations were achieved on the buccal surfaces of each tooth. For standardization and accurate positioning of the cavities, one vertical line was drawn from the tips of the buccal cusp to the lowest point of the cervical line, and a horizontal line drawn from mesial side to the distal side at the center of the mid third, the mid distance of this lines represent the center of each cavity. The outline of the cavity was drawn on the tooth surface with a 0.5 blue pen using a pre-designed black sticky celluloid band with a pre-cut hole of 5 x 3 mm which was done on a glass slab and then fixed on the buccal surface. The cavities were made with a diamond straight fissure bur (Kerr, Germany) that were measured previously 2 mm with a periodontal probe from the tip and used with a water-cooled, high-speed turbine and they were 5 mm in mesiodistal length, 3 mm occlusogingival height and 2 mm depth. A new bur was used for each of the eight preparations. No bevels were placed.

After completing the preparations, the teeth were randomly divided into three groups according to the adhesive systems, fifth generation (OptiBond TM S) and seventh generation (OptiBondTM All in One). The adhesive systems used in the study were used in strict accordance with the manufacturers' instructions. Nano-hybrid composite (GC ESSENTIA universal), shade A2 composite, was placed in one increment and cured with quarts-tungsten-halogen light (3M™ Elipar™ DeepCure, USA) for 20 seconds with a standard light at 430-480 nm W/cm2. The output of the curing unit was measured with a curing radiometer every five restorations to ensure light intensity at a constant value. The same operator performed all cavity preparations and restorations.

Group A: which is the control group
A1: 10 samples with 5th generation.
A2: 10 samples with 7th generation.
Group B: all twenty samples restored by applying 5th bonding generation
B1: 10 teeth with 25% H_2O_2 LASER bleach.
B2: 10 teeth with 25% H_2O_2 zoom bleach.
Group C: all twenty samples restored by applying 7th bonding generation
C1: 10 teeth with 25% H_2O_2 LASER bleach.
C2: 10 teeth with 25% H_2O_2 zoom bleach.

All restorations were immediately finished with finishing diamond burs and polished with a graded series of Sof-Lex Extra Thin disks (3M ESPE, St. Paul, MN). The restored specimens were stored in distilled water at 37◦ C for 24 h. The teeth were then submitted to 500 thermo-cycling procedures with temperatures between 5◦ C ± 2◦ C and 55◦ C ± 2◦ C and with a dwelling time of 30 s. Following thermos-cycling, both adhesive system groups were divided into six subgroups (n = 10), according to the bleaching systems used: control (not bleached), LED activated in-office bleaching (25% hydrogen peroxide) and LASER-activated in-office bleaching (25% hydrogen peroxide).

All the subgroup samples were made ready one by one for construction of their bases by using a plastic square cubes and adapting a nylon separator inside the cubes, then heavy body and catalyst of Vinyl Polysiloxane Impression Materials (3M ESPE, USA) was mixed together according to manufacturer's instruction, and pushed in and adapted inside the cube and the samples were inserted from their roots exactly at the center of the cubes, after final check that made for material set samples lastly removed out from cubes with a small spatula.

In control group A1 and A2 subgroups, restorations were not bleached, they were stored in distilled water at 37^{o} C. B1 and C1 subgroups their restorations were undergone bleaching by applying in-office bleaching gel (25% hydrogen peroxide) on buccal surfaces, every 4 samples from both bonding generations. For standardization and accurate results, the bases laid down in such a way that the buccal surface facing the LASER source (simpler doctor smile, USA) from a fixing point of distance (5mm) that was the same for all other samples that was subjected to LASER and the thickness of material was according to manufacturer instruction which was covered the entire restored area. According to manufacturer instruction 5 applications were done each for

30 seconds respectively after completion of each application that was 30 seconds, the bleaching gel was thoroughly washed with water and air spray, and the four remaining applications were done same as the first one, when all the applications were done all the samples washed thoroughly with water and air dried slowly and kept in distilled water.

For B2 and C2 subgroups, bleaching gel applied on the buccal surface that covered the entire restored area and the thickness of the material was according to manufacturer instruction, and the light source of (Zoom White-Speed, USA) applied in a distance of 1.5 cm from the surface and this distance were measured from the buccal surface to the plastic adapter of the device, and fixed since the head of the device can be easily adapted and fixed on the bases that were laid down for making buccal surface facing the light source. According to manufacturer instruction three applications were done each for 15 minutes respectively after completion of each application that was 15 minutes, the bleaching gel was thoroughly washed with water and air spray, and the two remaining applications were done same as the first one, when all the three applications were done all the samples washed thoroughly with water and air dried slowly and kept in distilled water.

After bleaching treatments were completed, the Samples were dried first and each sample was coated with two layers of nail varnish, leaving the buccal surface like a window around the cavity margins. Each subgroup samples were then placed in a glass that contained a microscopical stain of 20 % methylene blue dye (BDH, England) for 24 h at room temperature in such a way that their buccal surfaces and the entire tooth completely sunk in methylene blue. The specimens were then rinsed in tap water and each specimen was sliced longitudinally using a low-speed diamond disk (Isomet Buehler, Ltd., Lake Bluff, IL) with water coolant and evaluated for marginal leakage.

Micro-leakage evaluation. The mainly stained half of the sample was used to evaluate micro-leakage, the evaluation of dye penetration was done by two evaluators at two different times. The degree of dye penetration was then determined under 4X original magnification bucco-palatally with a stereomicroscope (SMZ 800, Nikon, Tokyo, Japan). The scoring method was as follow: (18).

0 = no dye penetration.
1 = dye reaching 1.0 mm in depth.
2 = dye reaching beyond 1 mm in depth.
3 = dye reaching or beyond the axial wall.

Depth of penetration at different levels had been scored to convert the ranking data to quantitative data.

Statistical analysis. Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 22). Non-parametric tests were used to compare the mean ranks of the micro-leakage between the study groups. Kruskal Wallis test was used to compare the mean ranks of three groups, and the Mann Whitney test was used to compare the mean ranks of two groups. A p value of ≤ 0.05 was considered statistically significant.

Results

Data showing the mean rank of micro-leakage of the three groups and Micro-leakage according to bleaching method in each of the bonding groups were shown in Tables 1 and Table 3 by Kruskal Wallis test. Micro-leakage values according to bonding generation in each of the bleaching groups were shown in Table 2. By Mann Whitney test.

When the means of micro-leakage at the

Table 1. Means of micro-leakage of the three study groups.

Bleaching method	N	Mean of micro-leakage (mm)	SD	SE	Median	Mean Rank	P*
Control	20	0.85	0.489	0.109	1	12.63	
LASER	20	2.55	0.605	0.135	3	42.68	< 0.001
LED	20	2.20	0.696	0.156	2	36.20	

enamel margins of the three groups were compared, the differences among the groups were found to be statistically significant (p = 0.001) for LASER applied group. The mean rank of micro-leakage values of the three groups, respectively, from lower to higher, were control (12.63), LED applied in-office bleaching (36.20) and LASER applied in-office bleaching (42.68). The differences between the three groups were found to be statistically significant.

Table 2 results compared the micro-leakage of the 5th bonding generation and the 7th bonding generation in each of the bleaching groups (separately). No significant differences were detected in the mean rank of micro-leakage between the 5th and the 7th generations in the control group (p = 0.177), LASER group (p = 0.313), and in the LED group (p = 0.185). It is evident in the table that, in general, the mean, the median and the mean rank of micro-leakage of the 7th generation was higher than that of the 5th generation but the differences were not significant.

Table 3 results showed that in the 5th generation of boding group, still the LASER group had the highest mean of micro-leakage (2.4), median (2.5), and mean rank (21.75), and the LED group had second highest mean of micro-leakage (2.00), median (2), and mean rank (18.20), and the least mean of micro-leakage (0.70) was related to control group, with a median of (1), and mean rank of (6.55). the differences were significant between the bleaching groups (p < 0.001). The same pattern was evident in the 7th generation group where the mean of micro-leakage of the LASER (2.7), the median (3), and the mean rank (21.5) were the highest, later comes the LED group with mean micro-leakage of (2.40), the median (2.5), with a mean rank of (18.65), lastly the control group with a mean of micro-leakage of (1), a median of (1), and the mean rank (6.35). (p < 0.001).

Table 2. Micro-leakage according to bonding generation in each of the bleaching groups.

Bleaching method	Bonding groups	N	Mean	(±SD)	SE	Median	Mean Rank	P*
Control	5th generation	10	0.70	(0.48)	0.153	1	9.15	0.177
	7th generation	10	1.00	(0.47)	0.149	1	11.85	
LASER	5th generation	10	2.40	(0.69)	0.221	2.5	9.35	0.313
	7th generation	10	2.70	(0.48)	0.153	3	11.65	
LED	5th generation	10	2.00	(0.66)	0.211	2	8.90	0.185
	7th generation	10	2.40	(0.69)	0.221	2.5	12.10	

*By Mann Whitney test.

Table 3: Micro-leakage according to bleaching method in each of the bonding groups.

Bonding (Generation)	Bleaching method	N	Mean	(SD)	SE	Median	Mean Rank	P*
5th	Control	10	0.70	(0.483)	0.153	1	6.55	
	LASER	10	2.40	(0.699)	0.221	2.5	21.75	< 0.001
	LED	10	2.00	(0.667)	0.211	2	18.20	
	Total	30	1.70	(0.952)	0.174	2		
7th	Control	10	1.00	(0.471)	0.149	1	6.35	
	LASER	10	2.70	(0.483)	0.153	3	21.50	< 0.001
	LED	10	2.40	(0.699)	0.221	2.5	18.65	
	Total	30	2.03	(0.928)	0.169	2		

Discussion

This study was done to evaluate and compare the effect of LASER and light emitting diode bleaching techniques on micro-leakage of dental composite post operatively with two different bonding systems which were fifth (etch-and-rinse) bonding system and seventh (self-etch adhesive) bonding system. The same bleaching gel (25% hydrogen peroxide) was applied for both LASER and LED applied bleaching groups.

Bleaching has become an attractive treatment modality for both clinicians and patients due to its excellent clinical effectiveness, easy application, lower cost, and safety. Based on the existing evidence, bleaching agents may cause structural changes on restorative materials that may compromise their physical properties and lead to premature failure.

Most of the studies that dealt with bleaching effects on dental restorative materials involved composite resins as their investigating subjects. Therefore, this category of restorative materials has been widely investigated in general. Depending on earlier studies composite resin has been used with two different adhesive systems in the present study.

Seal breaks occurring at the margin suggests discontinuity between the restoration and the tooth structure following bleaching. This may be due to the bleaching effects on the restoration, the tooth structure or both.[19] Several studies have determined that bleaching results in significantly greater effects on the surface and sub-surface structure of both tooth and restorations, compared to their respective controls.[20,21] Also, previous studies suggested that bleaching effects on micro-leakage depend not only on the applied bleach but also on the tooth substrate and restorative materials[22-24], which was closely related to this study outcome relating the discontinues and surface changes happened that was resulted in seal break and caused different micro-leakage scores.

Descriptive analysis was found that micro-leakage values in control group (A1 subgroup & A2 subgroup), fifth generation applied group (B1 subgroup & B2 subgroup) and seventh generation applied group (C1 subgroup & C2 subgroup) were significantly increased that may be due to the physical changes that might happened during temperature changes between cycles of thermoscycling procedure that was done for 3 groups. In the oral cavity, dental materials are exposed to thermal changes and the difference in the modulus of thermal conductivity of the tooth and restorative materials causes stress at the interface.[25] In a study, thermo-cycling was used to simulate the thermal changes of oral cavity in order to evaluate the effect of bleaching on dental restorations in the laboratory.[26]

The oxidizing effect of the bleaching agents might also be held responsible for the observed alteration of enamel and dentin organic matrix, and residual oxygen present in enamel and dentin after bleaching may be

responsible for the reduced bond strength of restorative materials bonded to enamel and dentin. Additionally, chemical softening of the restorative materials might also occur if the bleaching products have solubility parameters similar to that of the resin matrix.[27]
It is also known that LASERs are used to increase the temperature of a bleaching agent applied to the tooth surface to accelerate the bleaching process[28], Thereby incorrect use of LASER parameters could result in an increase in the tooth temperature, which could cause deleterious effects such as softening of the resin based materials.[29)]
Therefore, the light parameters for clinical applications should be carefully assessed[28]
In this study, impact times and LASER parameters were chosen on the basis of the manufacturer's recommendations. The white speed bleaching device that updated in recent year was different from other versions by minimizing the side effects and the degree of heat production, which in turn lessens the post bleaching problems and, thereby: lessening the micro-leakage scores. Also, in accordance to the results of the present study micro-leakage scores at margins were statistically significant among LASER activated in office bleached, light emitting diode activated in office bleaching and non-bleached restorations.
The results of the present study showed that none of the subgroups of the dentin bonding agents prevented micro-leakage at the restoration- tooth interface, however the seventh bonding generation applied subgroups showed more micro-leakage values than the other fifth bonding generation applied sub groups. None of the adhesive systems studied exhibited perfect sealing at the restoration-tooth interface.
The most extensive penetration of the dye was observed in the samples treated with the self-etch adhesive system in the A2, B2, C2 subgroups. Some authors claimed that the lack of fillers in the self-etch adhesive group, can explain the poor results in terms of micro-leakage. Yazici et al. stated that there is a possibility that the lack of a separate primer may reduce the infiltration depth or the wettability of dentin adhesives, thereby reducing adhesion and sealing capacity.[30]
Moreover, the thickness of the adhesive layer obtained with the filler containing dental bonding systems is higher which improves the ability of the interfaces to maintain adhesion during the critical early stages of polymerization.[31] Etching enamel with non-rinsing conditioners of a PH higher than that of phosphoric acid, remains debatable in the terms of the clinical effectiveness of the conditioners and the durability of the restoration.[32] In previous two studies, the self-etching adhesives did not achieve the same results as the single component adhesives 2nd group (5th generation) using 37% phosphoric acid[30], which was matching the present study results as the self-etching adhesives (7th bonding generation) did not attain the same results that achieved by etch and rinse adhesives (5th bonding generation) in the manner of micro-leakage values.
One of the visual side effects of bleaching on restorative material was alteration in color and that difference in the degree of their change differs depending on the different composite types, different bleaching regimes, and the duration of the procedure. All the mentioned causes resulted in surface alteration that was increased the susceptibility to discoloration, thereby restoration post bleaching procedure was necessitate replacing depending on the results stated by earlier studies. In a study, an increase in the surface micro-hardness was found on the composite resin subjected to highly concentrated carbamide peroxide gels.[33] In another study, similar bleaching-induced surface softening was reported on the silorane-based and traditional types of composite resins (nano-filled and hybrid).[34]
Furthermore, the silorane-based composite resin showed significantly more color alteration compared with traditional composite resins after in-office bleaching treatment (30% CP and 35% HP).[35] Despite the color changes, significant fluorescence changes of composite resins, induced by 20% and 35% hydrogen peroxide, were found to be dependent on the material tested and bleaching therapy, regardless of the peroxide concentration.[36]

Conclusions

The effect of post-restorative bleaching agents on micro-leakage of composite resin restorations differs according to the type of bleaching systems applied. The marginal leakage of resin composite restorations is increased after bleaching with LASER activated bleaching agents. Fifth generation (OptiBond TM S) and seventh generation (OptiBondTM All in One) adhesive systems showed different micro-leakage scores after being treated with the same bleaching gel, and the same bleaching system but the difference was not significant. The effect of bleaching procedure resulted in surface alteration that was increased the susceptibility to micro-leakage, thereby; restorations post bleaching procedure was necessitate replacing by the clinician.

Conflicts of interest

The author reported no conflict of interests.

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