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Araştırma/ Research Article

OZON VE LAZER İLE AKTİVE EDİLEN BEYAZLATMA METODLARINI TAKİBEN ETKİNLİK VE POSTOPERATİF HASSASİYETİN DEĞERLENDİRİLMESİ[≠]

EVALUATION OF EFFECTIVENESS AND POSTOPERATIVE SENSITIVITY FOLLOWING OZONE AND LASER ACTIVATED BLEACHING METHODS[≠]

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ABSTRACT

Aim: Bleaching of discolored teeth is one of the important issues of aesthetic dentistry. For this purpose, peroxides have been used for many years. Ozone is a contemporary bleaching method used as a substitute for hydrogen peroxide because of undesired side effects of peroxides. The aim of this in vivo study is to compare different bleaching methods including hydrogen peroxide (HP), laser activated hydrogen peroxides and ozone.
Materials and methods: A hundred patients were divided into 5 groups (n=20) for this study. Group 1: Bleaching with ozone. Group 2: Chemical bleaching with 40% HP gel. Group 3: Chemical bleaching with 35% HP gel. Group 4: Bleaching with 40% HP gel + diode laser activation. Group 5: Bleaching with 35% HP gel + diode laser activation. Color of the teeth before, immediately after bleaching and 2 weeks later the treatment were evaluated with the *CIE L*a*b*system.* Hypersensitivity was assessed with a *Visual Analogue Scale.* Differences between the groups were statistically analyzed.
Results: Immediately after treatment color changes among the groups were statisticall similar ($p > 0.05$) while at 2 weeks recall color change of Group 1 was significantly less than the other groups ($p < 0.05$). In terms of hypersensitivity, Group 1 represented significantly less values compared to the other groups ($p < 0.05$) while other groups were statistically similar ($p > 0.05$).
Conclusions: HP is superior to ozone in bleaching effectiveness. Ozone is safer in hypersensitivity. Activation with diode laser reduced the time but did not affect bleaching effectivenes**s.**
Key words: Hydrogen peroxide, hypersensitivity, laser, ozone, bleaching

ÖZ

Amaç: Renklenmiş dişlerin beyazlatılması, estetik diş hekimliğinin önemli konularından biridir. Bu amaçla, uzun yıllardır, peroksitler kullanılagelmiştir. Ozon ise peroksitlerin istenmeyen yan etkilerini taşımayan güncel bir beyazlatma yöntemidir. Bu *in vivo* çalışmanın amacı; hidrojen peroksit (HP), lazer aktivasyonlu HP ve ozon içeren beyazlatma yöntemlerinin karşılaştırılmasıdır.
Gereç ve Yöntem: Bu çalışma için yüz hasta 5 gruba ayrıldı (n = 20). Grup 1: Ozon ile beyazlat- ma; Grup 2: % 40 HP jel ile kimyasal beyazlatma; Grup 3: %35 HP jel ile kimyasal beyazlatma; Grup 4: %40 HP jel + diyot lazer aktivasyonu ile beyazlat- ma; Grup 5: %35 HP jel + diyot lazer aktivasyonu. Beyazlatma tedavi öncesi, sonrası ve 2 hafta sonrasında diş renkleri *CIE L*a*b* sistemi* ile değer- lendirildi. Hipersensitivite, Görsel Analog Skala ile değerlendirildi. Gruplar arasındaki farklılıklar istatistiksel olarak analiz edildi.
Bulgular: Tedavi hemen sonra gruplar arasındaki renk değişimleri istatistiksel olarak benzer ($p > 0.05$) iken, 2 hafta sonra grup 1'deki renk değişimi diğer gruplara göre anlamlı derecede düşüktü ($p<0.05$). Hipersensitivite açısından ise grup 1 diğer gruplara göre anlamlı derecede düşük değerler gösterirken ($p < 0.05$) diğer gruplar istatistiksel olarak benzerdi ($p > 0.05$).
Sonuç: Ozon ile yapılan beyazlatma tedavisi, hipersensitivite açısından daha güvenli bulunurken; beyazlatma etkinliği açısından hidrojen peroksit daha üstün bulundu. 980 nm diyot lazer ile aktivasyon tedavi süresini kısalttı ancak beyazlatma etkinliğine etki etmedi.
Anahtar kelimeler: Hidrojen peroksit, hipersensitivite, lazer, ozon, beyazlatma

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INTRODUCTION

With the advances in restorative dentistry, all kinds of esthetic problems can be easily solved. The color changes can be treated with chemical bleaching methods which are considered as more conservative approaches compared to restorative procedures. [1] The action of mechanism of bleaching agents is oxidizing discoloring molecules in deep layers of dentine and enamel, thus distructing chromogens. Free oxygen radicals disintegrates double carbon links and converts them into single-linked non-discoloring molecules. [2] Hydrogen Peroxide (HP) is the most widely used bleaching agent especially in office form. It is generally used in high concentrations (35-40%) to provide short-term bleaching affects (nearly 1 hour). [3] Futhermore, activation of this agent with heat, light and lasers at different wavelengths are gaining popularity to achieve faster and more effective bleaching result. [4] Lasers are able to catalyze bleaching reaction by enhancing the formation of free oxygen radicals and by providing deeper penetration. [5] However, it should be noted that during activation with lasers, selecting the precise parameters is crucial to prevent pulpal heat increase. In recent years, using ozone gas (O_3) became an alternative technique to conventional bleaching methods. For this purpose, ozone sytems are capable of slow O_3 releasing to the external surface of enamel thus providing bleaching. [6]

Studies dealing with color changes after either bleaching or restorative procedures generally utilized the *Commission Internationale de l'Eclairage (CIE) L*a*b* system* including three axises of the color. The first axis of this system is the L-axis which represents the range between dark (score 0) and light (score 100) while the a-axis and b-axis represent the range between red-green and blue-yellow, respectively. [7]

The aim of this study is to compare the bleaching efficiency of HP alone, HP activated with diode laser and ozone application by using the *CIE L*a*b*system*.

MATERIALS AND METHODS

The present study was approved by the "Ethical Committee of Gaziantep University" (20022014/82) and conducted in full accordance with the World Medical Association Declaration of Helsinki. Written informed constent was obtained from each participant. The study included 100 subjects ranging between 18-56 years old representing our department with the request for bleaching.

The inclusion criteria were;

- All anterior teeth should be vital and free of any restoration.
- All anterior teeth should be free of crowded alignment,
- Color of the teeth should be A_3 or darker according to measurement of the spectrophotometer.

The exclusion criteries were:

- Patients with any periodontal and systemic diseases or pregnancy,
- Severe discolorations such as tetracycline and fluorosis.

Determination of tooth color

Teeth color were measured with a spectrophotometry device (VITA Easyshade Advance, Zahnfabrik H.Rauter, Bad Säckingen, Germany) and recorded. Measurements were performed by touching the tip of the device to the center of the buccal surface at 3 time intervals including before, just after and 2 weeks following the treatment. The device was calibrated before each use according to the manufacturer's instructions. At each measurement, L^*, a^* and b^* values were recorded and the resultant color change between 2 measurements (ΔE) was calculated with the formula of

$\Delta E^*=[(\Delta L)^2 +(\Delta a)^2 +(\Delta b)^2]^{1/2}$ = where $\Delta L^*=L_{final} - L_{initial}$; $\Delta a^*=a_{final} - a_{initial}$; and $\Delta b^*=b_{final} - b_{initial}$.

The subjects were randomly divided into 5 Groups each including 20 patients. Similar groups in terms of gender, age and initial tooth color were formed. All steps of the procedures (flowchart) was represented in Figure 1.

The content of bleaching agents used and bleaching steps for each group were summarized in Tables 1 and 2, respectively.

Bleaching procedures according to the groups were performed as follows;

Group 1: Cast models were obtained for each patient's maxilla and mandibula, custom trays were made from thermoplastic material (Easy-Vac Gasket, 3A MEDES, Gyeonggi-do, Korea) (Figure 2). The hose pipe of the ozone releasing machine (Ozonytron XP-OZ MIO international, Munich, Germany) was attached to the custom tray and ozone was applied to the external surfaces of teeth by using a special setting for bleaching (600.000 ppm) (Figure 3). Ozone was applied to each arch for 15 minutes×2.

Table 1. Contents of the bleaching agents and pH values.

Materials	Composition	pH
Opalescence BOOST bleaching gel	40% HP, potassium nitrate and sodium fluoride	7.52
Whiteness HP BLUE CALCIUM-bleaching gel	35% HP, thickeners, inert blue pigment, neutralizing agent, calcium gluconate, glycol, and deionized water	9.2

Table 2. Bleaching protocol of each group.

Groups	Materials	Concentration	Number of Sessions	Duration of each application	Light activation source
Group 1	Ozon with Ozonytron XP-OZ	600.000 ppm	2	2x15 min per arch	-
Group 2	Opalescence BOOST bleaching gel	40% HP	2	3x15 min	-
Group 3	Whiteness HP BLUE CALCIUM-bleaching gel	35% HP	2	3x15 min	-
Group 4	Opalescence BOOST bleaching gel	40% HP	2	3x10 min	Diode laser (980 nm)
Group 5	Whiteness HP BLUE CALCIUM bleaching gel	35% HP	2	3x10 min	Diode laser (980 nm)

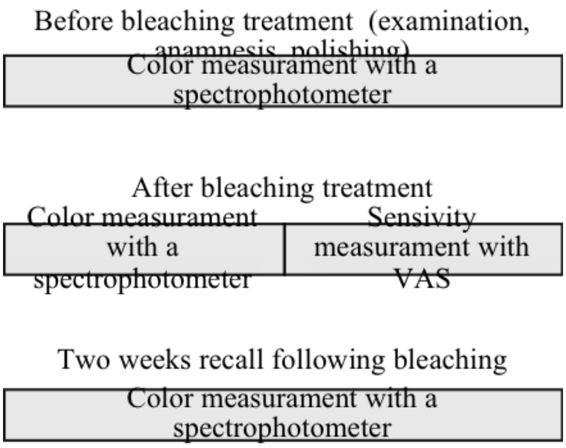

Figure 1 Flow chart. VAS ; Visual Analogue Scale


Figure 2. Custom trays and cast models.


Figure 3. Positioning of custom trays for both archs.

Group 2: The 40 % HP containing bleaching gel (Opalescence BOOST Whitening System, ULTRADENT, South Jordan, Utah, USA) was applied according to the manufacturer's instructions. In order to provide isolation and protect soft tissues, a lip retractor (OptiView, Lip and cheek retractor, Kerr Dental, Orange, CA, USA) and suction were used. A gingival barrier (OPAL DAM green, Ultradent, South Jordan, Utah, USA) was applied to the gingival margin to protect the gingival tissues and polymerized with a LED light source (VALO® Cordless, ULTRADENT, South Jordan, Utah, USA). The bleaching material in the double syringe was mixed according to the manufacturer's instructions and applied to the buccal surfaces of the teeth at a thickness of 1 mm. The gel was kept on teeth for 15 minutes and cleansed with air-water spray until all remnants were removed. This step was repeated three times.

Group 3: All steps for this Group is the same as in group 2 with one exception that is 35 % HP containing bleaching gel (Whiteness HP BLUE CALCIUM- FGM, Joinville, Brazil) was used by mixing the content of two different syringes. A layer with a thickness of 1 mm from the agent was applied to the buccal surfaces and waited for 45 minutes as in the previous group.

Groups 4 and 5: The steps of these Groups were similar to Groups 2 and 3 respectively. However, in Groups 4 and 5, laser activation with a 980 nm diode laser was used (Gigaa Dental Laser Cheese, Wuhan, China). Activation with laser in Groups 4 and 5 was performed as follows; the relevant bleaching gel (40 % HP for Group 4 and 35 % HP for Group 5) was applied on the external surfaces of the teeth in 1 mm thickness and kept for 10 minutes. At the first and fifth minutes, laser activation with an output power of 4 watts for 20 seconds for each quadrant was achieved by using a special bleaching handpiece at a distance of 5 mm. Then all gel were cleansed with air-water spray and this was repeated three times.

The procedures in all groups were repeated at a second appointment 1 week later.

Evaluation of tooth sensitivity after bleaching procedure

The patients' sensitivity following bleaching was measured by using an air syringe and recorded with a *Visual Analogue Scale (VAS)* scored within a range of 10 points (0: no pain; 10: severe pain).

Statistical analysis

Prior to statistical analysis, the normality of the data were analyzed with the Shaphiro Wilk test. The Kruskal–Wallis and All Pair Wise tests *were* used for *the analysis of* more than two independent groups when data do *not* follow a *normal distribution. The* Willcoxen test was used for two dependent groups which do not follow normal distrubitution. When comparing more than two independent of normal distrubituon a two-way repeated measures ANOVA and LSD test was used. Due to non-normal distribution of the data, statistical analysis was performed utilizing the Friedman and all pairwise tests. Standard deviation (±) for normal *distribution* data and median [25-75%] for non-normal *distribution* data were given as descriptive statistics. Significance was set to < 0.05. Analysis was performed using SPSS 19 program (IBM SPSS Statistics 19, SPSS inc., an IBM Co., Armonk, New York, USA).

RESULTS

1*. L* values*

The *L** values for all groups at three time intervals were represented in Table 3. For all groups, the differences between L_1* (pre-treatment) and L_2* (post-treatment) were statistically significant ($p < 0.05$), while the differences between L_2* (post-treatment) and L_3* (2 weeks recall) were not statistically significant ($p > 0.05$).

2. *a* values*

Median *a** values were represented in Table 4. In groups 1 and 4, the difference between a_1* and a_2* was statistically significant ($p < 0.001$) while the difference between a_2* and a_3* was insignificant ($p > 0.05$). In groups 2, 3 and 5, the differences between both a_1* - a_2* and a_2* – a_3* were statistically significant ($p < 0.05$).

Table 3. Mean L* values ± standard deviation (SD)

Groups	L_1*	L_2*	L_3*
Group 1	83 ± 3.89^a	86.8± 5.1^b	86.1± 4.7^b
Group 2	79.3±3.31^a	83.2± 3.2^b	83.9± 2.7^b
Group 3	80.4±3.43^a	83.9± 3.7^b	85.8± 5.5^b
Group 4	79.3±3.77^a	83.9± 3.7^b	84.5±4.0^b
Group 5	81.6±3.17^a	85.2± 3.3^b	86.7± 3.3^b

L_1= Pre-treatment, L_2*= Post-treatment, L_3*= 2 weeks recall*
Different superscripts represent statistically different groups.

Table 4. Median *a** values [25%-75%]

Groups	a_1*[25%75%]	a_2* [25%-75%]	a_3*[25%75%]
Group 1	1.74[(1.3)- (4.17)]^a	-0.4 [(-1.17)- (-0.39)]^b	-0,64[(-0.97)- (-0.12)]^b
Group 2	1.8 [(2.2)- (3.12)]^a	0.5 [(0.42)- (1)]^b	-0,89 [(-1.6)- (-0.24)]^c
Group 3	0.98 [(1.6)- (2.9)]^a	-0.29 [(-0.85)- (-0.79)]^b	-1,24 [(-1.6)- (-0.74)]^c
Group 4	1.34 [(1.8)- (2.7)]^a	-0.25 [(-0.8)- (-0.83)]^b	-0,53 [(-1.3)- (-0.12)]^b
Group 5	0.9 [(1.5)- (2.0)]^a	-0.99 [(-1.62- (-0.16)]^b	-1,6 [(-2.1)- (-0.77)]^c

a_1= Pre-treatment, a_2*= Post-treatment, a_3*= 2 weeks recall*
Different superscripts represent statistically different groups.

3. *b* values*

Mean *b** values and standard deviation were represented in Table 5. The differences between both b_1* - b_2* and b_2* - b_3* were statistically significant for all groups ($p < 0.001$).

Table 5. Mean *b** values ± standard deviation (SD**)**

Groups	b_1*	b_2*	b_3*
Group 1	29 ±3.69 ^{a}	24.3± 3.65 ^{b}	21.7± 4.17^c
Group 2	29.6 ±3.09 ^{a}	23.5± 3.86 ^{b}	19.8 ±4.8 ^{c}
Group 3	29.3± 5.57 ^{a}	24.1± 5.54 ^{b}	20.4± 5.46^c
Group 4	29.6± 3.28^a	22.3± 3.84^b	19.4± 3.96 ^{c}
Group 5	28.2± 2.74^a	21.3± 3.5 ^{b}	18± 2.62 ^{c}

b_1= Pre-treatment, b2*= Post-treatment, b_3*= 2 weeks recall*
Different superscripts represent statistically different groups.

4. *ΔE* values*

Inter- and intra-group comparison of *ΔE** values was represented in Table 6.

For inter-Groups comparison, ΔE_1* values (the difference between initial and final colors) were statistically similar ($p > 0.05$) while ΔE_2* values (the difference between initial and 2-weeks recall) were statistically less for group 1 compared to the other groups ($p < 0.05$).

For intra-group comparison, ΔE_2* values (the difference between initial and 2-weeks recall) is significantly higher than ΔE_1* values (the difference between initial and final colors) for all groups.

5. *VAS evaluation*

VAS scores were represented in Table 7. Following the bleaching agents, group 1 represented significantly less hypersensitivity compared to the other groups ($p < 0.001$) while the other groups were statistically similar ($p > 0.05$).

Table 6. Mean $\Delta E*$ values ± standard deviation (SD)

Groups	ΔE_1*	ΔE_2*
Group 1	8.7± 4.16 [a1]	10.3± 3.08 [a2]
Group 2	7.9± 2.74 [a1]	11.7± 32 [b2]
Group 3	7.3± 2.04 [a1]	11.7± 2.67 [b2]
Group 4	9.5± 2.45 [a1]	12.3± 2.05 [b2]
Group 5	9.2± 3.06 [a1]	12.6± 2.74 [b2]

ΔE_1= the difference between initial and final colors ΔE_2*= the difference between initial and 2-weeks recall*
Different superscript letters represent inter-Group differences (coloumm)
Different superscript number represent intra-Group differences (linear).

Table 7. Median VAS values [25%-75%]

Groups	VAS scores
Group 1	0± [0-0] [a]
Group 2	4± [2-4] [b]
Group 3	2± [0.5-8] [b]
Group 4	4± [2-4] [b]
Group 5	2± [0-4] [b]

Different superscripts represents statistically different groups.

DISCUSSION

HP is the most widely used bleaching agent. [8] In order to increase the efficiency of this agent, several activation methods including heat, light and lasers such as argon, CO2, KTP, Er:YAG, Nd:YAG and diode lasers have been used. [4, 9] Previous studies [5, 10, 11] revealed that activation methods increased the efficiency of HP and reduced the time required for bleaching. On the contrary, other studies [12-14] stated that activation methods accelerates the bleaching reaction but do not provide increased degree of whitening. Polydorou et al. [7] reported that activation of HP with 980 nm diode laser did not increase the efficiency of the agent and did not provide more esthetic results. The results of the present study are in accordance with the studies which state 980 nm diode laser activation decreased the treatment duration but did not provide further whitening. We assume that this result is presumably related with the action of mechanism of a diode laser on HP. A diode laser acts thermally which induces the action of free oxygen radicals rather than enhancing lasers affect. [15] However, studies on KTP laser (532 nm wavelength) stated that this type of laser acts photothermally, disintegrates chromogen molecules and by this way provides both additional bleaching and saves time. [16, 17] But it should be noted that its cost-effectiveness is questionable because KTP lasers are devices that are highly expensive compared to diode laser systems.

The wavelength of a laser is an important parameter for its efficiency. Among the diode laser wavelength options, the 980 nm wavelength is absorbed by water more than others. Absorption of laser energy by a water-containing bleaching gel is higher for a 980 nm diode laser compared to other wavelengths. [18] For this reason, a 980 nm wavelength diode laser was included in the present study.

Color changes in the present study were evaluated with the formula: $\Delta Ef\text{-}i=[(\Delta L)^2+(\Delta a)^2+(\Delta b)^2]^{1/2}=[(Lf-Li)^2+(af-ai)^2+(bf-bi)^2]^{1/2}$. This system determines the *L*, a** and *b** axises of color which is also referred to *CIE L*a*b* color system* [2]. *ΔE* means the color change between 2 measurements.

*L** axis represents darkness-brightness of an object while *a** and *b** represent red-green and yellow-blue, respectively. These axises of color were not included in many previous studies.[19,4] However, evaluating color changes by using *L*, a** and *b** axises provides detailed comparison of color changes. For this reason, color changes among the groups of the present study was performed with the mentioned formula including all of the *L*, a** and *b** axises.

Ishikawa-Nagai et al. [20] stated that *b** value is the most important axis during the evaluation of color changes while *L** and *a** values are the second and third, respectively. As a general rule, it is expected that if whitening occurs, *L** values should increase, *a** and *b** values should decrease. In accordance with the above statements, in the present study, *L** values increased while *a** and *b** values decreased.

Furthermore, it is evident that the most obvious change was determined in *b** values.

The efficiency of bleaching agents is directly proportional with both concentration (generally 35-40% for HP), pH and light. [21, 22] Optimum pH for HP containing agent is stated as 9 in the study of Torres et al.[23]. This may explain why 40 % HP containing agent with pH of 7.52 in the present study was not superior to 35 % HP containing agent with pH of 9.2 in both chemical and laser activated groups.

Another bleaching method is ozone either alone or in combination with HP. In this technique, the oxidizing capacity of ozone destructs chromogen molecules and serves as an effective and safe bleaching method. [6] Previous studies [24, 25] evaluated the bleaching efficiency of ozone, HP and combined use of them and found that ozone alone resulted in the least whitening in accordance with our results, particularly ΔE_2. We assume that this result is related with the less penetration of free oxygen radicals compared to HP which releases hydroxyl radicals and leads to a high pH. Increase in pH means the increase in the bleaching efficiency of the agent. [26] In other words, the results of the present study revealed that at the initial visit, ozone provided similar degree of whitening with HP. However, at the next visit, its prolonged whitening was less than HP. We assume that this is related to relative reactivity of free radicals of HP.

In the study of Al-Omiri et al.[25], it was reported that ozone does not irritate soft tissue while HP is a strong irritant and requires precise gingival isolation. Thus, clinicians can interpret that patients for whom high-level whitening is not necessary and/or proper isolation is impossible, bleaching with ozone may be preferred.

Hypersensitivity is the most frequent adverse effect of vital bleaching. [27] Previous studies [28,29] reported different frequencies for hypersensitivity following bleaching. The degree of hypersensitivity changes from moderate to severe, depending on the type of bleaching technique.[30] Both the concentration and application duration are directly proportional to the severity of hypersensitivity.[28] However, other studies [11,31] reported that high concentration bleaching agents do not result in more hypersentivity compared to low-concentrations. This is in accordance with the findings of the present study. All groups including HP represented similar VAS values while ozone was superior to HP in terms of hypersensitivity. In the light of those previous studies and the present study, we assume that the potassium nitrate content of 40% concentrated HP gel may have compensated the high concentration of this agent because calcium gluconate in 35% concentrated gel may have lower capability of reducing dentinal hypersensitivity. [31, 32] This may be researched in a further study. Furthermore, according to the results of the present study, laser activation seems to have neither positive nor negative effects on hypersensitivity in accordance with the study of Bernardon et al. [33]. Tooth sensitivity has been correlated with the heat generated by light irradiation. [15] In the current study, the use of a laser did not influence the intensity of sensitivity reported.

In the ozone group, no subject represented hypersensitivity. This may presumably be related with the use of no chemical agent in this group. Another explanation may be the different free radicals. HO_2 radicals are stronger than oxygen radicals.[34] Thus, we assume that the reactivity of the free radicals released during the bleaching reaction may have affected the post-operative hypersensitivity.

Within the limitations of the present study, ozone is less effective than HP but it is safer in hypersensitivity. Activation of HP with diode laser did not affect bleaching effectiveness and hypersensitivity but reduced the operation time.

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