In Vitro Evaluation of the Efficacy of Two Different At-home Bleaching Agents: Solo or Combined

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Abstract

Background: Combining at-home and in-office vital teeth bleaching techniques has proven to be effective; however, the efficacy of combining at-home bleaching agents is still unclear.

Objective: To compare the effectiveness of 10% and 35% carbamide peroxide at-home bleaching agents solo or in combination.

Materials and Methods: Forty enamel samples from human premolars were divided into four groups (n=10) to receive different at-home bleaching protocols. The samples were bleached for two weeks as follow: G1 bleached with 10%CP for 8h/day; G2 bleached with 35%CP for 30 minutes/day; G3 starting with 35%CP for three days and continue with 10%CP for the last 11 days; and G4 bleached with 10%CP for the first 11 days and with 35%CP for the last three days. Teeth color measurements were recorded by a colorimeter in reference to the CIE L*a*b* at different periods. Student's t-test was used to compare between the groups at each measuring period.

Results: No significant differences were seen among the four groups neither in ΔE*1& ΔE*2 nor in ΔE*6 ($p>0.05$).

Conclusion: Both 10% and 35%CP, used for two weeks, were effective in teeth whitening. Compared with 10% CP, combination treatments whether starting with 35% CP or ending with it produced no significant difference in teeth whitening during the treatment or one month post operatively.

Key words: Combination, 35% carbamide peroxide, at-home bleaching agents, colorimeter.

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Introduction

Whitening of vital teeth has become one of the fastest growing fields in cosmetic dentistry. Nowadays, patients are well aware that by improving their smile they can improve not only their appearance but also their self-esteem. However, while seeking for the best teeth whitening results, the patients are looking for faster and safer ways to bleach their teeth. In-office bleaching technique generally requires the use of up to 40% hydrogen peroxide (HP) or up to 37% carbamide peroxide (CP) bleaching agents to obtain tooth whitening in a relatively short period of time [1,2]. However, it needs more than one in-office bleaching session to achieve satisfactory results [3]. Hence, it is more expensive and requires more chair time at the dental clinic. On the other hand, at-home bleaching regimen, using bleaching trays with 10% CP overnight, produces the optimal result

with the least side-effects [4], and this technique has become the gold standard by which other techniques are judged [5]. Yet, reaching the desired whitening result needs persistent wear of the bleaching trays for the required period of time [5]. Such kind of treatment might be intolerable for all patients.

Several researchers have suggested the use of a combination of both in-office and at-home bleaching techniques to potentiate the bleaching effect and improve color stability [6-8]. In-office bleaching with high concentration of bleaching agent is performed during the first session to provide an initial jump-start whitening effect. Then, and before the color relapse, the patient is given at-home bleaching agent until the desired shade is obtained [4]. It has been reported that both at home and in-office bleaching techniques alone or in combination are equally efficient when used for 14 days [9]. Using high concentration of in-office bleaching agent followed by tray use with 10% CP may produce faster whitening with fewer side effects [6].

Recently, different concentrations of CP bleaching agents for at-home bleaching technique have been marketed, ranging from 10-35%. Several studies have compared between different concentrations of CP when used within a bleaching tray [10, 11]. The American Dental Association (ADA) has reported that alterations in bleaching products and treatment duration or intervals are sometimes necessary during the bleaching treatment [12]. However, up to date, no data is available on the efficacy of using a combination of different concentrations of at-home bleaching agents within a bleaching tray.

The aim of the current in vitro study was to compare the efficacy of two at-home bleaching agents (10%CP and 35%CP) when used alone for two weeks, and two combined regimens of both agents. Thus, the null hypotheses tested were, there is no difference in teeth color whitening with the use of 10%CP alone, 35%CP alone, a combination of 35%CP for 3 days and 10%CP for 11 days, and a combination of 10%CP for 11 days and 35%CP for 3 days; and similar color regression can be seen with the use of the four bleaching regimens

Patients and Methods

Forty human premolars, extracted for orthodontic reasons, were collected. Teeth were cleaned and polished with pumice and the roots were cut about 1mm below the cementoenamel junction. The crowns were then artificially stained using black tea solution. The staining solution was prepared by boiling 2g of black tea in 100 ml of distilled water for five minutes. The samples were immersed in the staining solution for 3 days. Then each sample, with the enamel surface exposed, was individually embedded in chemically cured acrylic resin within a plastic mould. later, the samples were divided into four groups (n=10) according to the bleaching regimen.

Bleaching regimens

Two bleaching agents, used for at-home bleaching technique, were used in this study; 10%CP and 35%CP (Opalescence PF, Ultradent Products, USA). The bleaching agents were used according to the manufacturer's instruction in which 10%CP was used for 8 hours/day, while 35%CP was used for 30 minutes/day. The bleaching treatment was performed for the four groups as follow:

G1: Bleached with 10% CP for two weeks.
G2: Bleached with 35% CP for two weeks.
G3: A combined group in which 35% CP was used for the first three days followed by 10% CP for the following 11 days.
G4: A combined group in which 10% CP was used for the first 11 days followed by 35% CP for the last three days.

During the bleaching procedure, about 1 mm thick of the bleaching agents was applied on the enamel surfaces for the required

period of time. After the bleaching period, the gel was removed from the enamel surfaces by placing it under running water for 10 seconds. After that, the specimens were immersed in normal saline for the rest of the day.

Color measurements

Color measurement for the samples of all the groups was adopted objectively using a colorimeter (Vita Easyshade, Zahnfabrik; H. Rauter GmbH & Co, KG, Bad Sackingen, Germany). The color measurements were performed at five periods: at baseline (T0), one week of bleaching (T1), two weeks of bleaching (T2), one week after bleaching (T3), and four weeks after bleaching (T6). To ensure a standardized position of the measuring spot of the colorimeter, a custom-fabricated positioning template was fabricated with a polysiloxane c-silicon impression material (Zetaplus; Zermack, Rovigo, Italy). For positioning the colorimeter tip, a 6 mm diameter spot facing the center of each sample was performed on the template with a punch.

The color measurements were evaluated in reference to the CIE L*a*b* parameters established by the Commission International de l´Eclairage in 1976 [13] and to Vita classical shade guide provided by the colorimeter. Based on the CIE L*a*b* color system, the color of an object is located in a three-dimensional color space. The coordinates L*, representing the lightness; a*, represents shade and saturation in the red-green axis and b*, represents saturation in the blue-yellow axis (Figure 1). Color differences of the three coordinates (ΔL*, Δa* and Δb*) were calculated at each measuring period minus their values at the baseline measurements. Total color difference (ΔE*) at each measuring period was calculated as:

The records of Vita classical shade guide were given values from 1 to 16 for the 16 shade tabs, starting from the lightest (B1= 1) to the darkest (C4=16) as shown in table 1 [14].

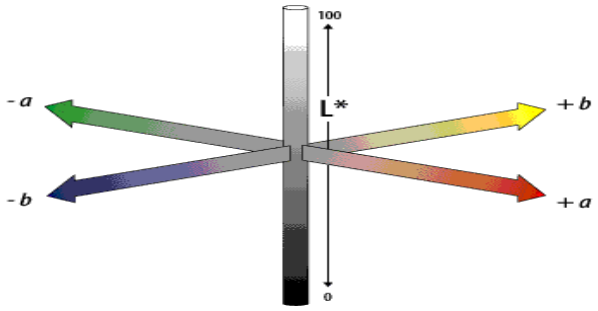


Figure (1): Diagram of CIE L*a*b* color space.

Table (1): Values of Vita classical shade guide tabs.

Tab	Value	Tab	Value	Tab	Value	Tab	Value
B1	1	**A2**	5	**A3**	9	**B4**	13
A1	2	**C1**	6	**D3**	10	**C3**	14
B2	3	**C2**	7	**B3**	11	**A4**	15
D1	4	**D2**	8	**A3.5**	12	**C4**	16

The data were analyzed using SPSS program (SPSS 19.0 for windows, SPSS Inc., Chicago, USA). One-way ANOVA and Tukey's test were used to analyze means of ΔL*, Δa*, Δb* and ΔE* at all measuring periods. Student's t-test was used to compare between the groups at each measuring period. Repeated measure of variance and Pairwise comparisons were used to compare values of Vita classical shade guide. All the statistic tests were adopted at the significance level of 0.05.

Results

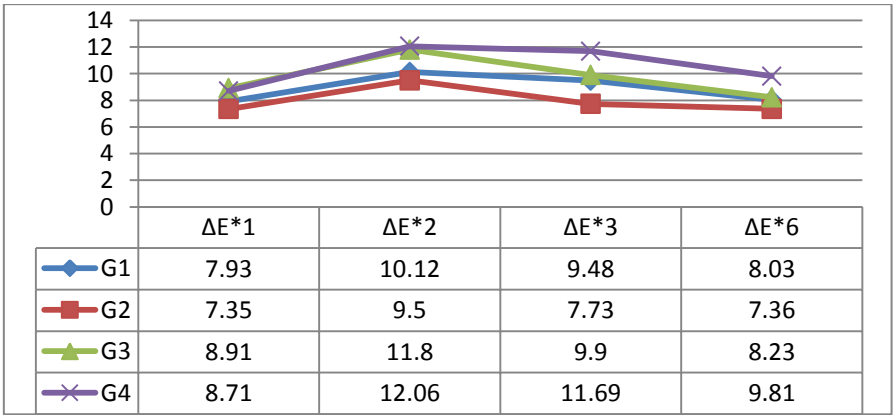
Table 2 presented the means (SD) of ΔL*, Δa*, and Δb* for all groups at each evaluation period. No significant differences were recorded among all groups neither in ΔL* nor Δb* at all measuring periods (p>0.05). Significant differences in Δa* were recorded for G2, G3 and G4 at T1, T2, T3 and T6 (p<0.05). Figure 2 showed the means of total color differences (ΔE*) at the different measuring periods. Significant differences were observed between G2 and G4 in ΔE*3 (p=0.007). However, no significant differences were found among the four groups in ΔE*1, ΔE*2 & ΔE*6 (p>0.05).

The mean values of Vita classical shade guide for all the groups at the five measuring periods are represented in Figure 3. Repeated measure analysis of variance showed that there was a statistically significant difference in teeth color change over time (p=0.000), with no significant differences between the groups (p=0.144). Pairwise comparisons showed significant differences between all measuring periods (p=0.000), except between T3 and T6 (p=1.00).

Table (2): Means (SD) of ΔL*, Δa*, and Δb* for all groups at weeks 1& 2 of bleaching and 1 & 4 after bleaching.

Groups		Week 1	Week 2	Week 3	Week 6
G1	**ΔL***	3.43 (1.91)	5.08 (1.45)	3.86 (1.70)	3.00 (2.11)
	Δa*	-1.72 (1.41)	-1.86 (1.51)	-1.33 (1.57)	-0.80 (1.40)
	Δb*	-6.41 (3.69)	-8.25 (3.00)	-8.19 (3.16)	-6.88 (3.51)
G2	**ΔL***	3.84 (2.33)	4.61 (2.51)	3.76 (2.24)	3.53 (2.78)
	Δa*	-1.75(1.81)**ad**	-1.95 (1.31)**gj**	-1.55 (1.31)**aj**	-1.34 (1.36)**dg**
	Δb*	-5.69 (2.58)	-7.77 (3.03)	-6.25 (2.74)	-5.93 (2.65)
G3	**ΔL***	3.08 (1.62)	6.13 (1.81)	4.24 (1.65)	3.30 (1.79)
	Δa*	-2.74 (1.70)**cf**	-3.65 (1.78)**i**	-2.91 (1.69)**c**	-2.63 (1.43)**fi**
	Δb*	-6.85 (3.26)	-9.31 (3.21)	-8.25 (3.00)	-6.85 (2.79)
G4	**ΔL***	4.13 (1.49)	6.40 (1.26)	5.33 (1.52)	4.10 (1.31)
	Δa*	-2.71(1.25)**be**	-3.27 (1.42)**hk**	-2.78 (1.28)**bk**	-2.47 (1.50)**eh**
	Δb*	-7.04 (2.87)	-9.59 (2.76)	-9.92 (2.63)	-8.41 (3.09)

Values with same letter are significantly different at p<0.05.



	ΔE*1	ΔE*2	ΔE*3	ΔE*6
G1	7.93	10.12	9.48	8.03
G2	7.35	9.5	7.73	7.36
G3	8.91	11.8	9.9	8.23
G4	8.71	12.06	11.69	9.81

Figure (2): Means of total color differences (ΔE*) for the four groups (ΔE*1: one week of bleaching, ΔE*2: two weeks of bleaching, ΔE*3: one week after bleaching, and ΔE*6: four weeks after bleaching).

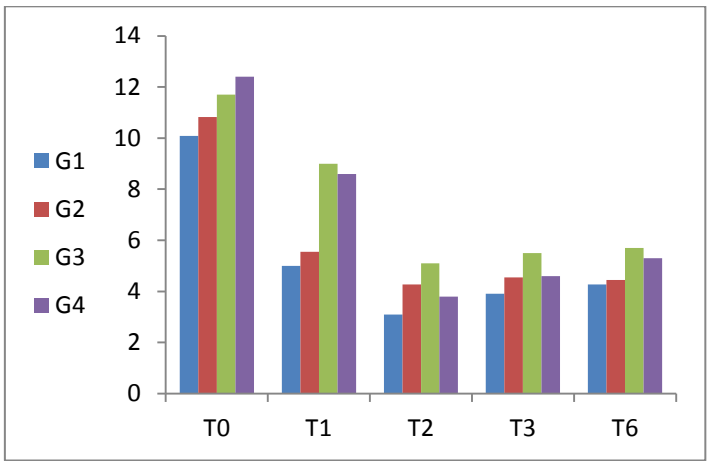


Figure (3): Mean values (SD) of Vita classical shade guide for the four groups at all measuring periods (T0: baseline, T1:one week of bleaching, T2: Two weeks of bleaching, T3: one week after bleaching, and T6: four weeks after bleaching).

Discussion

At-home bleaching technique has become widely accepted due to its relative ease of use, low cost, safety and high success rate. Using 10% CP for two weeks has proven to be not only efficient [2,3] but also safe [12]. However, lower concentration of the bleaching gel requires longer time of bleaching tray use. Such a procedure requires patients' compliance. High rates of patients' dropout of at-home bleaching treatment have been reported [15]. Providing the patients with faster whitening results in a shorter duration of tray use may necessitate using various concentrations of bleaching techniques and/or bleaching agents. A combination of both in-office and at-home bleaching techniques has been adopted by clinicians in which in-office bleaching agent was applied first, to give a boost effect, then followed by low concentration home bleaching agent to enhance and support the whitening results [6-8]. However, this procedure may not be accepted to some patients since an additional cost of the in-office session is required. It has been stated by the American Dental association (ADA) that alteration in bleaching treatment duration, intervals and delivery system is sometime needed during the treatment [12]. In the present study, simulating a combination of in-office and at-home bleaching techniques was performed by the use of a high concentration of at-home bleaching agent (35% CP) in a bleaching tray for the first three days as a substitute to a one in-office bleaching session (G3). While starting with night-time use of 10% CP for 11 days ending with 35%CP for 30 minutes/day for the last 3 days, was intended when patients' compliance issue jeopardizing the continuity of the treatment (G4).

It is well known that, the bleaching process depends on several factors such as: the concentration of the bleaching agent, the contact time and peroxide dose [5]. Carbamide peroxide is composed of hydrogen peroxide (the active ingredient) and urea. When carbamide peroxide bleaching agent comes in contact with saliva, it dissociates back to HP and urea. Hydrogen peroxide represents a ratio of about 1/3 of the agents' concentration. Hence, while 10% CP equals about 3.5 HP, 35%CP equals about 10.6 HP [16]. The active agent needs to be in contact with the tooth surface for a period of time in order to penetrate into the tooth substrate to produce the bleaching action. Therefore, the required daily time depends on the percentage of the peroxide that is used. A

relationship between the concentration and bleaching results has been confirmed by researchers [5,11]. The results of the present study showed an overall improvement in all the 3 color coordinates (L*, a*, and b*) during the two bleaching weeks for the four groups. Increasing in L* values representing enhancement in lightness, while decreasing in both a* and b* values representing shifting to the greenish and bluish axes, respectively. No significant differences between the groups were recorded in ΔL*, Δa*, and Δb* for all periods.

Total color difference (ΔE*) is consider a more informative value as an indicator for clinically perceivable color change [2]. The results of the current study recorded remarkable color change for all the groups after two weeks of bleaching as represented by the values of both total color differences (ΔE*) and Vita shade guide (Figures 2&3). Although lower values of ΔE*2 were recorded for G2 (9.5) than the other groups, it was not significantly different from the other groups. Using 10%CP for 8 hours/day and 35%CP for half an hour/day solo or in combination produced no significant differences in neither ΔE*1 nor ΔE*2. The results are in accordance with the results of an *in vitro* study reported by Meireles et al.[10] and a clinical study reported by Braun et al. [17]. Meireles et al.[10] concluded that, 10%, 16%CP home bleaching agent, and 37%CP in-office bleaching gel, when used as recommended by the manufacturer, all the bleaching agents produced similar teeth whitening. Braun et al. [17] reported that during one week of bleaching, similar effects can be achieved with both a high (17%CP) and a low (10%CP) concentration bleaching agents. However, the results are inconsistent with the results reported by Sulieman et al. [11] using 10%, 15%, 20%, 22% and 30% CP home bleaching agents. In their study, they assumed that higher concentration (30% CP) produced faster whitening results compared with 10%CP. However, in the later study they used all the bleaching agents for 8 hours/day. In the present study the time was adopted as recommended by the manufacturer. It is not surprising that a higher-concentration agents used for a longer period of time would produce better overall teeth whitening [18].

Regression of tooth whitening after termination of the bleaching regimen has been supported by researchers. Measurement of the color changes after at least 4 weeks of the termination of the bleaching regimen is essential to identify the true teeth whitening endpoint [2]. Color regression was recorded with in-office bleaching as well as with at-home bleaching [6-8]. The result of the current study showed that significant difference in ΔE*3 (one week after bleaching) was recorded between G2 and G4. However, after one month of bleaching, all the groups were not significantly different in ΔE*6. These results were supported by the results of the values of Vita classical shade guide (Figure 3). All the four groups showed significant changes in treatment over time compared with the baseline values. No significance differences were recorded between the values of week 3 and week 6. Such results are in accordance with the results recorded by Cunha et al. in 2011 in their review. They stated that when used for two weeks, both at-home and in-office vital teeth bleaching techniques alone or in combination are equally efficient [9]. It has also been stated that higher concentration of CP may produce faster initial shade changes than lower concentrations; however, by the end of the bleaching treatment, all the concentrations produce no difference in the final teeth whitening results [10].

It is well known that higher concentration of bleaching agents might be associated with higher incidence of teeth sensitivity [19] and other potential tooth substrates' related harsh

effects [20]. Therefore, it is essential to use high concentration of bleaching agent for a short period of time. However, the addition of potassium nitrate and fluoride in carbamide peroxide bleaching agents may play an important role in preventing teeth sensitivity [19]. Both bleaching agents used in the present study (Opalescence PF) were incorporated with these agents.

The results of the present study require the acceptance of both null hypotheses tested. With the increase marketing of new bleaching agents, in vitro studies proceeding clinical studies are essential for evaluating their effects in relation to the standard agents already in use. Thus, further in vitro as well as clinical studies are needed to evaluate the effects of long term use of high concentrations of carbamide peroxide at-home bleaching agents on the tooth surface potential changes and teeth and gingival sensitivity.

In conclusions, Within the limitation of the current in vitro study, it can be concluded that:35% CP at-home bleaching agent used according to the manufacturer's recommended time for two weeks produced similar teeth whitening to 10% CP post operatively. Two weeks of a combined bleaching regimen, whether starting with 35% for three days or ending with it, can produce no statistically significant effect on the bleaching results during the treatment or one month post operatively compared with overnight use of 10% CP.

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