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Combined Vital Tooth Whitening: Effect of Number of In-Office Sessions on the Duration of Home Whitening. A Randomized Clinical Trial

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Featured Application: A second session in office with a high concentration product reduces three weeks of home treatment with splints with a low concentration product.

Abstract: Background: In cases of moderate to severe dental discoloration, vital tooth whitening usually requires a prolonged treatment time if it is to obtain satisfactory outcomes. Variations in the clinical efficacy of whitening products in terms of their concentration and application time mean that we need to be aware of the real bleaching capacity of each whitening method and each product. This randomized clinical trial aimed to analyze with a spectrophotometer the effect of the number of in-office vital tooth whitening sessions (one or two) on the number of weeks of ensuing home whitening until color stability was obtained. Methods: Twenty patients with moderate/severe discoloration were treated with combined vital tooth whitening. Ten patients were treated with a single in-office session consisting of two applications of a product containing 40% hydrogen peroxide, followed by home treatment with individualized splints and a 16% carbamide peroxide gel (Group 1S). The other ten patients (Group 2S) were treated in two in-office sessions with two applications of the same product as Group 1S, followed in the same way by home treatment. Results: Comparing the two groups (1S and 2S), no significant differences in Euclidean distance (ΔE) were found after in-office whitening, or when color stabilization was obtained and home whitening ceased. Significant differences in the number of weeks of home whitening until color stabilization reached the same outcomes were found between 1S and 2S; 1S required a mean of 11.6 weeks home whitening, while 2S required 8.2 weeks. Conclusions: Combined tooth whitening with two in-office sessions significantly reduces the number of weeks (by three to four weeks) of subsequent home tooth whitening needed to reach color stabilization.

Keywords: combined vital tooth whitening; hydrogen peroxide; carbamide peroxide; tooth discoloration

1. Introduction

Teeth whitening is currently one of the most common dental treatments requested by patients who demand a whiter and brighter smile. Teeth whitening is a conservative therapeutic procedure that allows tooth color change in a simple and safe way when indicated and performed correctly. The most widely used bleaching agents are hydrogen peroxide and carbamide peroxide, which can be differentiated into high and low concentration agents, and are used, respectively, in the office or at home.

In cases of moderate to severe dental discoloration, vital tooth whitening usually requires a prolonged treatment time if it is to obtain satisfactory outcomes. Variations in the clinical efficacy of whitening products in terms of their concentration and application time mean that we need to be aware of the real bleaching capacity of each whitening method and each product. This will help us to select the right treatment option in each case. Combined vital tooth whitening is a good option and achieves positive results in cases of moderate to severe tooth discoloration within a reasonable time frame. This method usually consists of one in-office session using bleaching agents of high concentration, followed by a phase carried out by patients at home using individualized splints and products of low concentration; the initial in-office session reduces the number of weeks required to obtain the desired outcome [1,2].

The bleaching capacity of whitening in-office agents has been studied [3–6], along with its advantages and disadvantages, the effect of contact of the whitening product on the tooth surface and the oral tissues of the patient compared to other bleaching techniques [1–9]. Nevertheless, there is little information available about the interrelation between the bleaching effect achieved with one in-office session and the number of weeks of home treatment necessary to obtain similar results [10–15].

The aim of this randomized clinical trial was to determine, using spectrophotometers [16,17], whether the number of in-office sessions (one or two) using high concentration agents combined with vital tooth home whitening with trays [18] and lower concentration agents influences the duration of home whitening and the total treatment time.

2. Materials and Methods

2.1. Study Design

This single blind randomized clinical trial compared two methods of combined vital tooth whitening: the first one (Group 1S) consisted of a single in-office session with two consecutive applications of twenty minutes with a chemoactivatable bleaching product containing 40% hydrogen peroxide (Figure 1) followed by home whitening with individualized splints and the application of 16% carbamide peroxide for 90 minutes per day up to the point of maximum whitening.

Figure 1. In-office chemoactivatable bleaching product containing 40% hydrogen peroxide applied to patient's teeth.

This procedure was compared with a second (Group 2S) that consisted of two in-office sessions separated, from each other by a week, with the same applications of twenty minutes of the same bleaching product, followed by home whitening with individualized splints and applications of 16% carbamide peroxide for 90 min per day until a point was reached when no further whitening occurred [3].

The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the University of Valencia in April 2019 (project identification

code no. 1234846). Each patient was provided with full information about the tooth whitening procedures, the commitment required and possible risks involved in the treatment method; each gave her/his consent to take part, signing an informed consent form [4].

2.2. Sample Size Calculation

Assuming an alpha risk of 0.05 and a beta risk of 0.2 in bilateral contrast between mean numbers of weeks of home whitening, 10 subjects were needed in the single-session group (Group 1S) and ten in the two-session group (Group 2S) to detect a difference equal to or greater than 3 weeks. It was assumed that the common standard deviation in the number of weeks would be 2.2, and a drop-out of 10% has been anticipated.

2.3. Patient Selection

Patients were selected according to the following inclusion criteria: aged between 18 and 65 years; absence of oral pathology; incisors, canines, premolars and molars´ colors darker than A3 on the Vita Classical shade guide (with shade tabs ordered according to luminosity) and free of fillings. Smokers, patients who were on long-term medications that could influence tooth color and patients who had already undergone tooth whitening at an earlier date were excluded. Finally, 20 patients were selected and assigned to one of the two groups of the same size (allocation ratio 1:1) using a simple randomized list (allocation sequence) with numeric sequential unique identifiers (online software: www.alazar.info). There were no restrictions such as blocking or block size. The name of the group was placed in a sealed opaque envelope and the sequential numbers assigned were written on the front of the envelope. Auxiliary staff assigned them to the intervention groups, following the sequence. The flow diagram is shown in Figure 2.

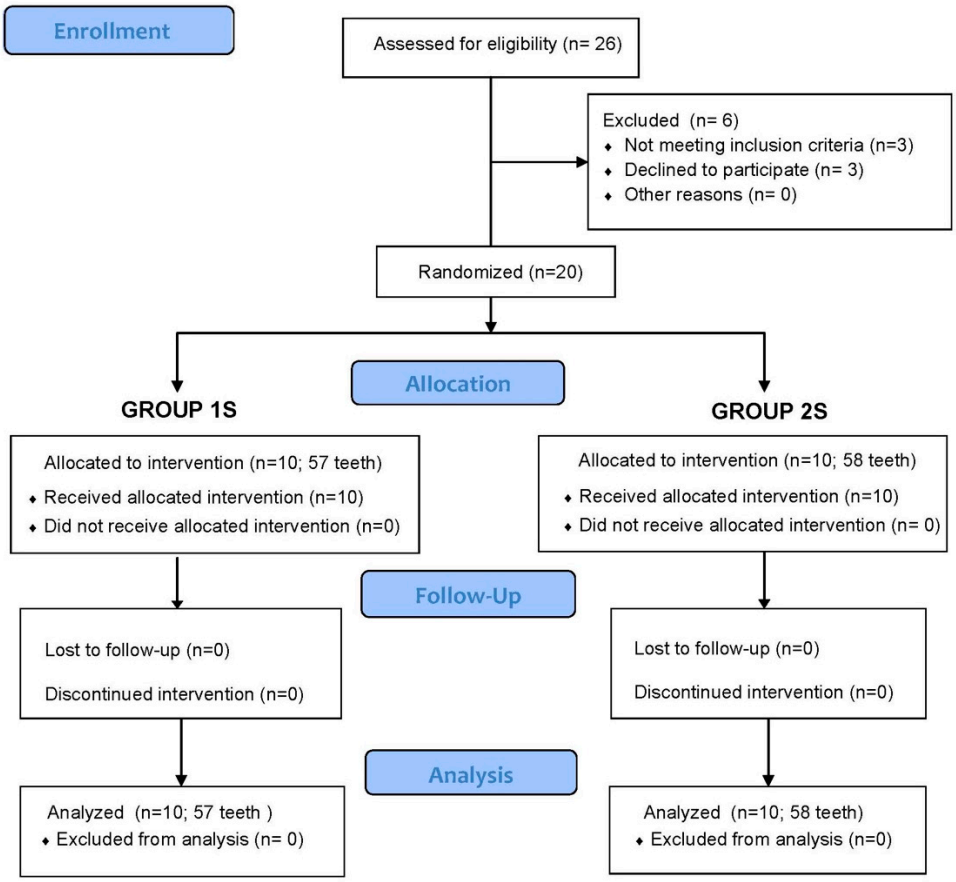

Figure 2. Flow diagram of the trial.

2.4. Procedure

Each patient's maxilla and mandible incisors, canines and premolars were subjected to the vital tooth whitening procedures. Two types of splint were made: first one was used to position the spectrophotometer used to quantify color modification (Easyshade V, Vita, Bad Säckingen, Germany) in maxilla central incisors and maxilla and mandible canines [16]; the second one was used to carry out home tooth whitening of incisors, canines and premolars in both arches (customized soft scalloped bleaching trays with 1 mm thick reservoir) [17,18].

The in-office treatment phase began with the removal of plaque and white spots from the tooth surfaces using a nylon brush with a low-speed rotating instrument and non-abrasive cleaning paste. Anterior and premolar teeth were isolated with a double arch rubber dam (OptiDam, Kerr, Bioggio, Switzerland), with the edges of the perforations inverted in the gingival sulcus and silk ligatures on the tooth necks [19]. The product used for bleaching was a chemoactivated bleaching agent whose active ingredient was hydrogen peroxide at a concentration of 40% (Boost, Ultradent, South Jordan, USA); the product was delivered using a double syringe and, when mixed, acquired a (red-colored) gel consistency.

Patients in Group 1S underwent a single in-office tooth whitening session. They received two 20-minute applications of bleaching agent on the vestibular and lingual teeth faces. Patients in Group 2S underwent two whitening sessions performed in two consecutive weeks, receiving two applications of the same bleaching agent every session in the same way as Group 1S. After each application, the bleaching agent was eliminated by aspiration, washed with water and air dried. After the second application, the cervical ligatures and dam were removed and the patient was instructed to follow oral hygienic and dietary standards and not to smoke until one week after home treatment ended [20].

The home treatment phase began seven days after the in-office treatment and after verifying that no complications had occurred. The home treatment was explained in detail to patients; patients were given a demonstration of how to load the trays with the bleaching agent and how to fit it into the mouth. Patients were also given written instructions (Table 1), including a description of the procedure (application of the whitening tray loaded with the bleaching agent and left in place for 90 minutes per day) and the schedule of follow-up check-ups. Patients were informed that the home whitening procedure had to be repeated daily until tooth color stabilization. The bleaching used was a transparent 16% carbamide peroxide gel (Opalescence PF 16, Ultradent) delivered with dispensing syringes.

Table 1. Instructions for the patient for the application of home whitening.

Handling, Care and Maintenance Instructions for Home Dental Whitening Splints
1. Before putting on the trays, brush your teeth properly and use dental floss to clean the spaces between the teeth before each application of your bleaching splint.
2. Clean the trays with your toothbrush and cold water before putting them in your mouth.
3. Dry the trays with a towel or tissue.
4. Distribute a small amount of gel in each of the holes in the tray corresponding to the teeth to be bleached.
5. Distribute the gel with the brush that has been delivered to all the holes.
6. Insert the whitening trays into the mouth until they seat properly.
7. Clean the excess gel that comes out of the trays and the gel that is in contact with the gums.
8. Wear trays for 90 minutes each day
9. At the end of the application time of the whitening gel, remove the trays and remove the rest of the product from your teeth by brushing.
10. Rinse the trays with cold water and clean them with a toothbrush.
11. Dry the trays and store them in their box.

Intraoral digital photographs were taken before the start of treatment, one week after the in-office whitening sessions and at the end of the home whitening phase [21,22]. Color modifications to six teeth were recorded (maxilla central incisors, maxilla and mandible canines) by means of the Easyshade spectrophotometer (Figure 3) used with the previously fabricated customized positioning splints in

order to take the records in the same place at all times (middle third of the buccal aspect of the tooth). The spectrophotometer was positioned and aligned correctly on the teeth using the positioning guide system which comes with the equipment (Figure 4) [21]. Three components of CIELab color parameters were recorded—L* (luminosity); a* (variation in the red–green color axis); and b* (variation in the yellow–blue color axis) [18]—before the start of treatment, after the in-office phase and at the end of the home whitening phase when color was considered to have stabilized. Using all these registers, the Euclidean distance (ΔE) between each two points of color in the CIELab space was calculated with the formula $\Delta E = ((Lf–Li)^2 + (af–ai)^2 + (bf–bi))^{1/2}$. ΔE in comparison with initial values was measured after the in-office whitening sessions and at the end of home whitening as soon as color stabilization had been reached when the color parameters L, a and b were no longer modified (final registers: Lf, af, bf). Color stabilization was considered to have occurred when ΔE values were repeated at two consecutive evaluations (weekly evaluations). The total number of weeks of home whitening were recorded. All color registers were recorded by the same blinded observer, who remained unaware of patients' group assignations.

Figure 3. Image of the Vita Easyshade spectrophotometer used in this study.

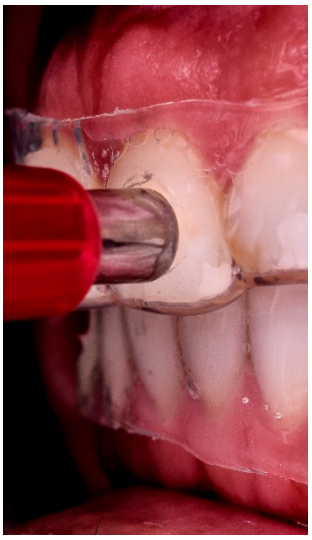

Figure 4. Color taking with spectrophotometer and positioning splints.

Photographic records and color parameters at the end of the home whitening phase were recorded in order to evaluate the maximum whitening effect achieved.

Mean values and confidence intervals were calculated for color parameters and ΔE. Non-parametric tests were used to determine differences between means: the Wilcoxon test to determine intergroup differences and the Mann–Whitney test to identify intragroup differences. To measure differences in the number of weeks of home whitening between Groups 1S and 2S (one-session and two-session) before

color stabilization was achieved, the Kaplan–Meier method was used, as well as log-rank, Breslow and Tarone–Ware tests. Statistical significance was set at $p < 0.05$.

3. Results

Significant differences were found in the number of weeks of home whitening (Figure 5) until color stabilization was reached when ΔE values were repeated at two consecutive evaluations (weekly evaluations) between Groups 1S and 2S (Mann–Whitney U test: $p < 0.001$). The single in-office whitening session group (Group 1S) required a mean number of 11.6 weeks (95% CI 10.6–12.5) while the two-session group (Group 2S) required 8.2 weeks (95% CI 7.8–8.5).

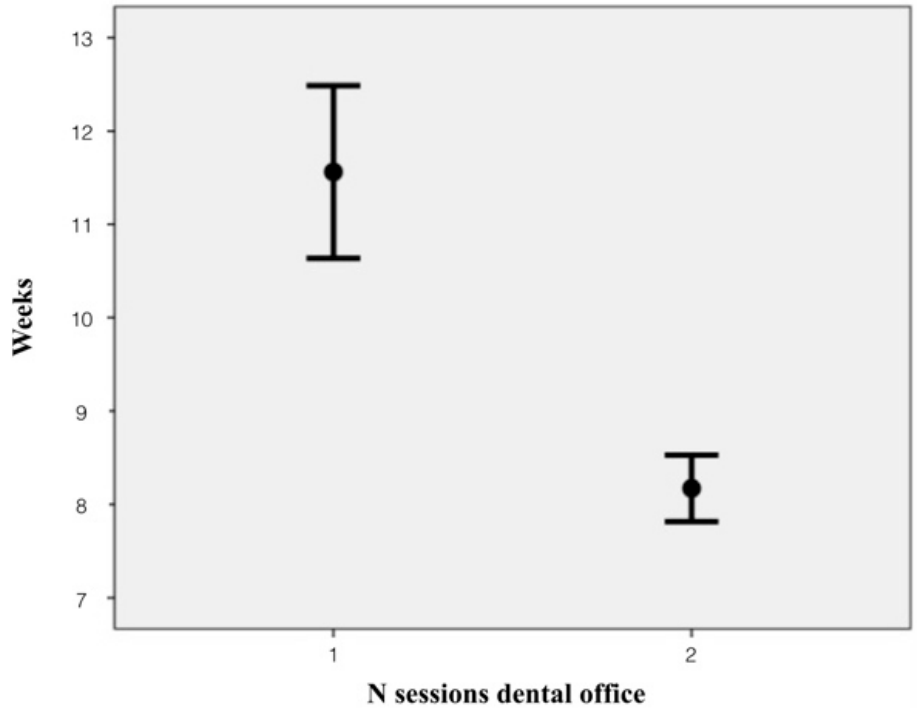

Figure 5. Mean values and confidence intervals for the number of weeks of home whitening until color stabilization was achieved in relation to number of in-office whitening sessions: 1 = Group 1S; 2 = Group 2S.

When the two groups (1S and 2S) were compared at the end of the in-office whitening phase, no significant differences in ΔE were identified (Mann–Whitney U test $p = 0.827$); nor were differences found at the end of home whitening when color had stabilized (Mann–Whitney U test $p = 0.120$). When the groups were analyzed independently, it was found that each underwent significant changes in ΔE between the end of in-office whitening and the end of home whitening (Table 2).

No differences in the three color parameters were found between the two groups at the start of the trial. L*, a* and b* values all changed significantly from the initial evaluation to the end of in-office whitening and the end of home whitening (Table 3). After in-office whitening, no significant differences in L*, a* and b* were found between the groups, but after home whitening, significant differences were identified in a* ($p = 0.033$) and b* ($p = 0.008$), but not in L* ($p = 0.154$) with equal modification of a* in Group 2S compared with Group 1S (1.4 versus 1.7) and slightly higher modification of b* in Group 2S than Group 1S (10.4 versus 9.4). So, it may be stated that all teeth exhibited an increase in luminosity as a result of whitening, a shift in the red–green axis towards green and a reduction in yellow.

Table 2. ΔE after in-office and home whitening according to the number of in-office sessions (one or two).

Group	ΔE after In-Office Whitening Phase Media 95% CI	ΔE after Home Whitening Phase Media 95% CI	
1S (one-session) N = 57 teeth	3.84 3.20–4.73	14.1 12.9–15.3	Wilcoxon test $p < 0.001$ *
2S (two-session) N = 58 teeth	3.79 3.24–4.34	12.8 11.7–14.0	Wilcoxon test $p < 0.001$ *
	Mann–Whitney U test $p = 0.827$	Mann–Whitney U test $p = 0.120$	

* Significant difference $p < 0.05$.

Table 3. Values of color parameters L*, a* and b* after in-office whitening and home whitening in relation to the number of in-office sessions (one or two). Mann–Whitney U test applied to identify intergroup differences; Wilcoxon test applied to identify intragroup differences.

Color Parameter	Group	Initial Mean 95% CI	After In-Office Whitening Mean 95% CI		After Home Whitening Mean 95% CI	
L*	1S	80.5 78.9–82.0	82.1 80.6–83.6	W test $p = 0.002$ *	86.4 85.2–87.5	W test $p < 0.001$ *
	2S	79.9 78.7–81.1	81.9 80.6–83.2	W test $p < 0.001$ *	85.1 83.8–86.3	W test $p < 0.001$ *
		U test $p = 0.317$	U test $p = 0.589$		U test $p = 0.154$	
a*	1S	−0.43 −0.76–−0.09	−0.49 −0.80–−0.18	W test $p = 0.471$	−2.20 −2.35–−2.05	W test $p < 0.001$ *
	2S	−0.12 −0.45–−0.20	−0.50 −0.80–−0.20	W test $p = 0.001$ *	−1.89 −2.03–−1.62	W test $p < 0.001$ *
		U test $p = 0.165$	U test $p = 0.935$		U test $p = 0.033$ *	
b*	1S	21.2 19.5–22.9	20.1 18.6–21.5	W test $p < 0.001$ *	9.72 8.82–10.6	W test $p < 0.001$ *
	2S	22.8 21.2–24.5	20.9 19.4–22.2	W test $p < 0.0001$ *	11.5 10.4–12.7	W test $p < 0.001$ *
		U test $p = 0.176$	U test $p = 0.548$		U test $p = 0.008$ *	

* Significant difference $p < 0.05$.

Analyzing the number of weeks of home whitening by means of the Kaplan-Meier method and comparing survival curves between the two groups (Figure 6), significant differences between the curves were observed (log-rank test (Mantel-Cox) $p < 0.001$; Breslow test $p < 0.001$; Tarone-Ware test $p < 0.001$).

Figures 7 and 8 show photographs of one patient in each group taken before the start of treatment, at the end of the in-office whitening phase and at the end of the home whitening phase (Figures 7 and 8).

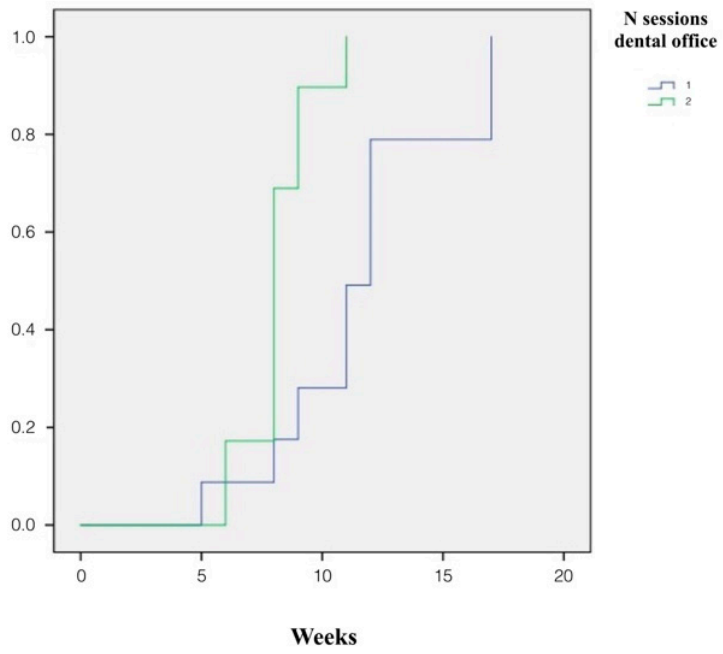

Figure 6. Survival curves (Kaplan–Meier method) of weeks required before reaching color stabilization in relation to number of in-office whitening sessions (one or two). N in-office sessions: blue line Group 1S; green line Group 2S.

(a)

(b)

Figure 7. *Cont.*

(c)

Figure 7. (**a**) Image of Group 1S patient before whitening treatment. (**b**) Photograph of Group 1S patient after in-office whitening. (**c**) Appearance of teeth of a Group 1S patient after home whitening.

(a)

(b)

Figure 8. *Cont.*

(c)

Figure 8. (**a**) Initial photograph of a Group 2S patient. (**b**) Photograph of Group 2S patient at the end of the second in-office session. (**c**) Photograph of Group 2S patient at the end of home whitening.

4. Discussion

The use of a spectrophotometer to evaluate the color changes that are generated in a tooth when it is being bleached is an objective method that allows us to establish numerically the degree of whitening achieved in a tooth at a given moment of treatment, and allows us to follow the evolution of the color changes that occur [16,17,21].

The systematic review by Cardenas et al. provides much evidence for the similar color modifications achieved by in-office tooth whitening effects, whitening realized by patients at home and combinations of the two [5]. Other research suggests that combined tooth whitening treatments reduce the total treatment time needed to achieve the desired results in comparison with home whitening alone [1,2]. In this way, the time of contact between the bleaching products used and the patient's oral tissues used in self-application by patients is shortened [6]. Treatments of shorter duration are always preferable, making combined treatments more convenient for patients [7]. At the same time, a reduction in the number of visits to the clinic will reduce the cost of whitening treatment carried exclusively in-office [8,9].

Regarding the existing literature, little research has looked into the correlation between the degree of whitening achieved in an in-office session and the number of weeks of home whitening needed to achieve the same outcome, a fact that makes a comparison of the results obtained in the present study difficult. Rodrigues et al. [10] did not find differences in the efficacy of a single session in-office whitening treatment compared with another with two sessions, and a third with one in-office session and one-week home whitening realized by the patient; however, this study did not evaluate color by means of spectrophotometry. At the same time, Delipieri et al. [8] and Radz et al. [11] showed that combined treatment achieved an appreciable color modification (evaluated by shade guides).

Quantifying color modification in combined whitening using spectrophotometers, Dourado et al. [12] found in-office whitening, home whitening and combined treatments equally effective. Comparing different whitening techniques, Marson et al. [13] showed that combined treatment obtained a statistically significant color change with a considerable increase in L*. Faus et al. [14] found greater effects with combined whitening compared with in-office whitening alone.

In the present work, no differences were found between the two study groups regarding the color modification obtained at the end of treatment. This implies that there was no need to perform a second in-office session using a bleaching product of high concentration. Eliminating the second session could reduce the risk of generating the undesirable effects on both oral soft tissues and dental tissues that this type of product can provoke [15]. Nevertheless, the significant reduction in the number of weeks of home whitening occasioned by the second in-office session (8.2 weeks in the two-session compared with 11.6 weeks in the one-session group) makes the second session recommendable in

cases of moderate/severe discoloration, which would otherwise require prolonged periods of home treatment. The second session will allow color stabilization to be reached in fewer weeks of home treatment, which releases the patient from the risks associated with prolonged exposure to a whitening agent [8,9,15], as well as dietary and oral hygiene restrictions, and reduces the overall cost of treatment as it requires smaller quantities of home whitening agent and fewer follow-up check-ups.

The clinical indications for opting for a single in-office whitening session are tooth colors lower than A2 on the Vita shade guide (Vita, Bad Säckingen, Germany), patients with dentine hypersensitivity or those aged younger than 25 years (due to the increased permeability of dental hard tissues). Clinical indications for two in-office sessions are tooth colors over A3–A2 on the Vita shade guide and patients less committed to dealing with home treatment (unable to stick to a routine, incorrect oral hygiene, intake of potentially tooth-staining foods or insufficient time available to carry out treatment).

Therefore, in this work it has been possible to establish the impact and importance of carrying out two whitening sessions in office in the number of weeks at home treatment was necessary to stabilize the color, but there is practically no data in the specialized bibliography.

When carrying out any tooth whitening treatment, we should not disregard the need to carry out clinical and radiological check-ups to ensure that patients do not suffer the possible negative effects than can occur. Further studies are needed to provide further information about the evolution and stability of the outcomes of combined tooth whitening treatments.

5. Conclusions

Combined tooth whitening with two in-office sessions significantly reduces the number of weeks (by three to four weeks) of subsequent home tooth whitening needed to reach color stabilization. There are no significant differences in the outcomes between patients undergoing one in-office session and patients undergoing two in-office sessions, either at the end of the in-office phase or at the end of home whitening.

Author Contributions: All of the authors contributed to the investigation, supervision, writing, review and editing of the study. Study conceptualization was carried out by J.A.-L., M.P.-H., R.A.-P. Data curation, data visualization and analysis were performed by J.M.M.-C., C.L.-R., M.F.S.-R. All authors have read and agreed to the published version of the manuscript.

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