Original Article

Dental sensitivity in tooth whitening and its relationship to peroxides concentrations: a cross-sectional retrospective study

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Background: Dental sensitivity is a common secondary effect related to vital tooth whitening (VTW) treatment and it's associated with the concentrations and time of application of the bleaching agents. The aim of this research was to evaluate the relationship of dental sensitivity and the combinations of different concentrations of peroxides [hydrogen peroxide (HP) 10%/HP 40%] in order to define a tooth whitening protocol that is effective, while minimizing the discomfort experienced by patients.

Methods: A cross-sectional retrospective study was carried out based on secondary de-identified data of 27 patients collected from a previous VTW clinical trial. The days of dental sensitivity and levels of sensitivity were measured. Descriptive statistics and the Pearson correlation coefficient were calculated. A level of significance P<0.05 was established.

Results: The mean values obtained for the variables "day of dental sensitivity" and "levels of sensitivity" were 1.0741 (SD =0.91676) and 0.8148 (SD =0.62247), respectively. The Pearson correlation (r) obtained was 0.766, 95% CI: 0.55, 0.89, P=0.01.

Conclusions: The findings indicate that dental sensitivity when occurs during or after VTW with HP 10% and HP 40% tends to be mild and does not last more than a day. The clinical implications and recommendations indicate that clinicians can safely use the treatment and that patients must be informed that dental sensitivity due to VTW may occur.

Keywords: Tooth whitening; hydrogen peroxide (HP); tooth sensitivity; tooth bleaching; dental esthetics

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Introduction

Vital tooth whitening (VTW) is a common procedure in dental practice in response to patients who request aesthetic bleaching of their teeth to enhance their appearance (1). The hydrogen peroxide (HP) is one of the chemicals normally used for this treatment and it's been employed for over 100 years. In the 1980s, the use of a gel containing 10% carbamide peroxide (CP) equivalent to 3.6% of HP was introduced, and nowadays is also widely commercialized (2-4). It is understood that these substances produce a chemical degradation of the chromogens throughout a "Redox Reaction", where the peroxide (HP/CP) is the oxidizing agent and the tooth is the reduction one (5,6).

Dental sensitivity derived from VTW can be defined as a defence response of the pulp usually originated by microscopic flush or small defects of the dental enamel, which allow the whitening gel to penetrate into the tubules, eventually causing reversible pulpitis and thermal sensitivity. This secondary effect is directly associated with the concentration of peroxides, time and frequency of application, and the rise of pulp temperature after activation with a light source (7,8).

The in-office VTW has been the technique more related to dental sensitivity due to the employment of high concentrations of peroxides. Actually, 60–90% of the patients complained about this issue after the treatment (1,5,6). To face this mishap, it has been developed in-house (ambulatory) and over the counter bleaching products, which not only reduces the dental sensitivity because of the lower levels of the whitening agents, but also maintain the tooth color obtained for a longer period of time (1,2,8,9). Nevertheless, this technique has the disadvantage of required routine applications for two to five weeks, when compared to the two to four sessions needed for the in-office modality (2,3,10). Therefore, the challenge in these cases is the patient's adherence to the treatment (9).

Efforts have been made in order to find solutions to prevent and manage dental sensitivity related to this treatment, such as the use of potassium nitrate and fluoride during and after the bleaching process, and the use of 2-hydroxyethyl-glutaraldehyde (G2H) with peroxides (1,9). Other solution that has been provided is to avoid the use of light sources, taking into consideration that there is not enough evidence to support the idea that light activated systems used in-office drift in better immediate results (11-13).

In addition, the combined use of different concentrations of peroxides has been suggested in order to prevent dental sensitivity. Thereby, the patient can benefit from the advantages of both treatment modalities. However, the clinical evidence is limited and controversial (8,11,14,15).

In this framework, Féliz-Matos *et al.* reported the results of a randomized clinical trial (RCT), in 2018, where it was combined different concentrations of peroxides with the ambulatory and in-office VTW techniques. The research showed favourable outcomes in terms of tooth color change, dental sensitivity and length of the treatment (16,17). This has been one of the few recent studies that have evaluated the association of dental sensitivity with distinct percentages of the whitening agents employing the combined technique, because most of the authors have focused their investigations on the at-home or in-office techniques applied individually (18-20).

Therefore, a secondary analysis of the aforementioned RCT will strengthen the evidence related to this topic, complementing this investigation with valuable additional results. Thus, the aim of this research was to evaluate the relationship of dental sensitivity and the combinations of different concentrations of peroxides (HP 10%/HP 40%) used for dental bleaching in order to define a tooth whitening protocol that is effective, while minimizing the discomfort experienced by patients. We present the following article in accordance with the STROBE reporting checklist (available at https://fomm.amegroups.com/article/view/10.21037/fomm-21-121/rc).

Methods

A cross-sectional retrospective study was carried out based on a secondary analysis of the data obtained in a completed clinical trial, identified by the code NCT02682329. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). IRB approval was not required due to the study design. However, the RCT from which the database was obtained was approved by UNIBE's IRB No. CEI2013-07 and The National Committee for Health Bioethics (CONABIOS) (No. 024-2013). Informed consent was taken from all the patients enrolled in the clinical study.

Sample and eligibility criteria

The dataset was selected from one of the four groups (group #4) studied in the RCT, composed of 27 de-identified subjects who attended the dental clinic of Universidad Iberoamericana (UNIBE), Santo Domingo, Dominican Republic, from September 2013–February 2014 (17). The time span was determined by the sample behaviour, taking into account that a non-probabilistic sample was chosen.

The participants enrolled in the RCT were between 18–45 years old who required VTW and accepted to sign the informed consent. Individuals with active caries, restorations, veneers of full crowns or endodontic treatment, severe stains, enamel hypoplasia, severe internal tooth discoloration, gingival recession, spontaneous tooth pain, and previous bleaching procedure were excluded. Pregnant or lactating women were also excluded as well as subjects using orthodontics appliances up to the second premolar of both dental arches, patients with bruxism habits, smokers, or taking analgesic or anti-inflammatory drugs.

Study intervention

The subjects received VTW treatment with two applications of in-office technique with HP 40% (Opalescence Xtra Boost, Ultradent, USA) for 20 minutes without light activation. Also, the participants underwent an ambulatory treatment between the two in-office sessions with HP

Table 1 Description of the bleaching agents

Material	Brand	Composition	Mode of application
Opalescence® Boost (HP 40%)	Ultradent Products Inc., South Jordan, US	40% hydrogen peroxide, chemical activator, 1.1% fluoride, 3% potassium nitrate	In-office bleaching agent. Three applications of 20 minutes. Remove it with a soft pellet; rinse twice with copious water. Repeat the procedure in 2 other applications with 3-day interval between each one
Opalescence® TresWhite Supreme (HP 10%)	Ultradent Products Inc., South Jordan, US	10% hydrogen peroxide, glycerin, flavoring	Remove the tray and align it correctly over your teeth. Gently suck on the tray to create suction, so that the tray will adhere to your teeth. Detach the external part of the tray. Tap gently on the remaining part of the tray to ensure that it is securely attached to your teeth. Leave it in place for 30 to 60 minutes. Remove the tray from your mouth and cleanse your teeth of the excess gel by brushing as necessary

 HP, hydrogen peroxide.

10% (Opalescence TresWhite Supreme, Ultradent, USA) for 2 days during 1 hour. The teeth bleaching process was completed in 4 days. The rights and welfare of the patients were not adversely affected; no PHI was included.

Details of the composition and mode of applications recommended by the manufacturer of the whitening products are described in *Table 1* (17).

The primary outcomes of dental sensitivity measured were "days with dental sensitivity" and "levels of sensitivity". Levels of sensitivity were evaluated with the evaporative stimuli and tactile stimuli test (21).

The evaporative stimuli test consisted in a direct application of compressed air for 1 second using a triple air dental syringe at 60 psi (±5 psi), perpendicular to the teeth surface, with a temperature in the range of 19 ℃ (±5 ℃). The assessment was carried out at a 1 cm distance. On the other hand, for the tactile stimuli test a dental explorer was used passing it three times across the facial surface of the teeth, perpendicular to its long axis, and with an approximated constant force (21).

Days of sensitivity were reported from days 1 to 4, and levels of sensitivity were classified in 4 levels employing a visual analogue scale method: no sensitivity [0], mild [1], moderate [2] and severe [3].

The database was protected with a password, and only the principal investigator had access to it.

Statistical analysis

A level of significance $P<0.05$ was established and frequencies were obtained. A Pearson correlation coefficient (r) was calculated in order to establish a correlation between peroxides (HP 10%/HP 40%) concentration and dental sensitivity. The confidence level was established at 95% and a degree of freedom (df) of 25. The correlation was calculated between the variables "days with sensitivity" and "levels of sensitivity". A normal distribution was observed (22).

The analysis of the de-identified data was calculated in SPSS Statistical Software V.23.

Results

The data obtained from 27 de-identified subjects who received VTW with HP 10% and HP 40% for four days were analysed with descriptive statistics. Initially, 30 subjects, without history of dental sensitivity, were allocated into this group, but three participants were lost through the follow-up period due to non-attendance at scheduled appointments. (*Figure 1*). The enrolled participants were between 18–45 years old.

For the variable "days with sensitivity" the mean value obtained was 1.0741, with a standard deviation of 0.91676. For the variable "levels of sensitivity", the mean value obtained was 0.8148, with a standard deviation of 0.62247, the values are shown in *Table 2*.

To establish correlation between the variables "days with sensitivity" and "levels of sensitivity", a Pearson correlation coefficient (r) was calculated, the value obtained was 0.766, 95% CI: 0.55, 0.89. The correlation is significant at the 0.01 level and the values are shown in *Table 3*.

Detailed information regarding tooth whitening effectiveness in terms of color change could be found on the original RCT (17).

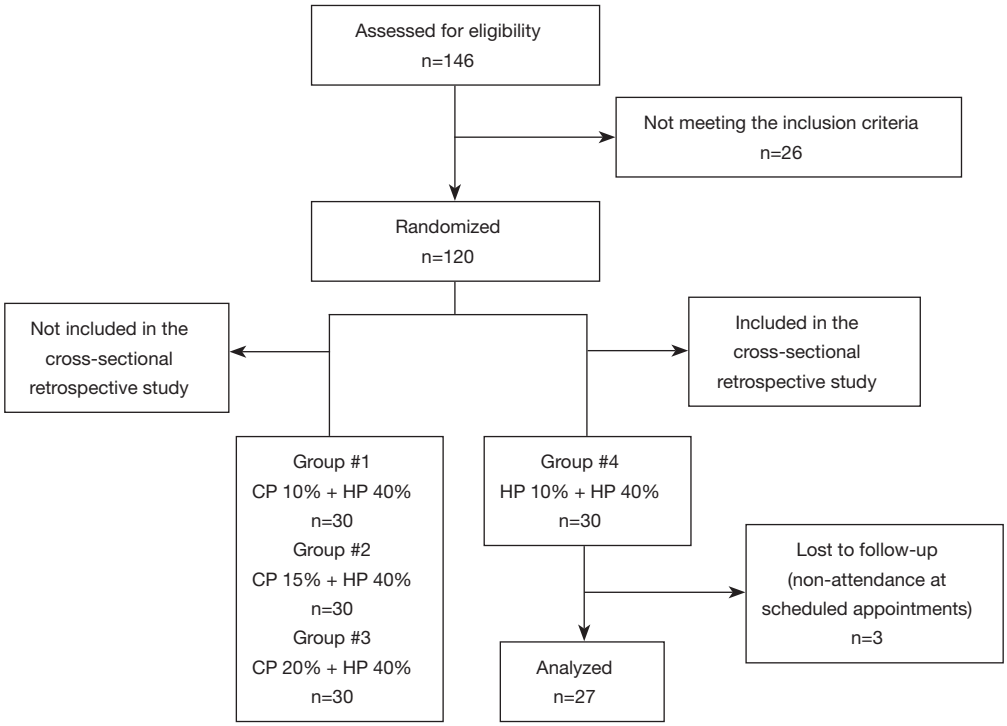

Figure 1 Flow diagram of the study's stages. CP, carbamide peroxide; HP, hydrogen peroxide.

Table 2 Mean values and standard deviation of the variables "days with sensitivity" and "levels of sensitivity"

Variables	Mean	SD	N
Days with sensitivity	1.0741	0.91676	27
Levels of sensitivity	0.8148	0.62247	27

SD, standard deviation; N, sample.

Table 3 Correlation between the variables "days with sensitivity" and "levels of sensitivity"

	Days with sensitivity	Levels of sensitivity
Days with sensitivity		
Pearson correlation	1	0.766**
Sig. (2-tailed)	–	0.000
N	27	27
Levels of sensitivity		
Pearson correlation	0.766**	1
Sig. (2-tailed)	0.000	–
N	27	27

**, correlation is significant at the 0.01 level (2-tailed). N, sample.

Discussion

Dental sensitivity when related to VTW treatment can appear during or after the procedure. Nevertheless, findings from a recent RCT using a combination of HP 10% and HP 40% in a group of subjects yielded favourable results regarding the intensity and time of duration of this side effect (16,17). The present study was based on a secondary analysis of the aforementioned RCT, which evaluated the correlation between levels of sensitivity and days with sensitivity on a sample of 27 subjects who received VTW.

The data obtained showed a significant correlation of the technique employed with the non-appearance, low levels and few days of dental sensitivity. These outcomes represent an improvement in the protocols taking into account the frequency of this side effect. In fact, Fiorillo *et al.* on their research concluded that dental sensitivity was a common issue reported in different studies related with VTW (23). Therefore, it can be assumed that the combined use of these two VTW techniques, as well as the reduced frequency and time of application, might be related to the satisfactory results.

Multiple meta-analyses have been published in recent years evaluating tooth whitening and the risk/intensity of

dental sensitivity. For instance, de Geus *et al.* investigated the topic applying the at-home vs in-office bleaching modalities individually (24). Cardenas *et al.* did inquire about the differences in terms of color change and tooth sensibility comparing the combined technique vs at-home and in-office modalities. They concluded, based on low/very low quality of the evidence, that the at-home technique was the safer one and indicated that the combined bleaching may potentiate the risk of dental sensitivity without benefits in color change, being equivalent to the in-office modality (15). Moreover, it's highlighted that none of these meta-analyses took into consideration decisive factors of the protocol, such as the time of daily use, the amount of sessions or the product concentration (15,24).

Maran *et al.* (20) in their meta-analysis evaluated the effect of different peroxides concentration on color and dental sensitivity. The authors demonstrated that low and medium hydrogen peroxide concentrate products have lower risk and intensity of tooth sensitivity without difference in color change efficacy. Nevertheless, this research limited the evaluation on the in-office technique exclusively.

Other studies already have reported the combination of low concentrations of peroxides together with short-time use of the professional and ambulatory treatment could reduce dental sensitivity (8,11,14). Moghadam *et al.* (8), reported that time of application as indicated by manufacturers must be minimum due to high concentrations of the peroxides, which leads to a decrease of the diffusion potential of peroxides through the enamel, thus reducing the effect. Conversely, Meireles *et al.* (25) demonstrated on their RCT that a reduced protocol (2 applications of 37.5% of HP *vs.* 3 applications proposed by manufacturer) produces the same effect on whitening and risk and intensity of dental sensitivity. Anyhow, it's important to consider they just employed the in-office protocol.

On the other hand, Dawson *et al.* (14) didn't find significant differences in levels of dental sensitivity when combining vital teeth whitening techniques. Those results are controversial in relation to the findings of the present study. Nonetheless, the applied protocol (14 consecutive nights for at least seven hours per night with 16% CP alone or + one in-office session with 9% or 27% HP) differs from the one used in the present study.

Dental sensitivity may cause interruption of the treatment due to the discomfort that the patient could experience; therefore, final results of tooth color change might not be achieved. Certain alternatives have been proposed in order to prevent and control this secondary effect, such as the restriction of light sources activation and the application of desensitizing agents, which can be used even in toothpastes (e.g., stannous fluoride, sodium fluoride, chitosan) (1,9,11,26-28). However, recent meta-analyses have concluded that the clinical effect of desensitizing agents is questionable, since the reduction in the risk and intensity of tooth sensitivity after whitening procedures has been null or subtle (29,30).

An important fact to highlight is that the protocol applied in this research demonstrated to be effective avoiding severe cases of patients with dental sensitivity without the use of any desensitizing agent.

Finally, the main limitation identified in the present study was the lack of control on how the patients were selected and how the data was collected since this is a secondary analysis. Nevertheless, it can be interpreted from the findings that dental sensitivity when appeared during or after vital teeth whitening with HP 10% and HP 40% tends to be mild and does not last more than a day.

Conclusions

Regarding the variables days with sensitivity and levels of sensitivity, the Pearson correlation (r) obtained was 0.766; the correlation is significant at the 0.001 level. Therefore, in the clinical field the use of HP 10% and HP 40% can be effectively employed for VTW, even decreasing the length of the treatment. The findings of the present study showed that combining concentrations of the bleaching agents and reducing time of application are effective decisions to prevent and manage dental sensitivity.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://fomm.amegroups.com/article/view/10.21037/fomm-21-121/rc

Data Sharing Statement: Available at https://fomm.amegroups.com/article/view/10.21037/fomm-21-121/dss

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Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://fomm.amegroups.com/article/view/10.21037/fomm-21-121/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). IRB approval was not required due to the study design. However, the RCT from which the database was obtained was approved by UNIBE's IRB No. CEI2013-07 and The National Committee for Health Bioethics (CONABIOS) (No. 024-2013). Informed consent was taken from all the patients enrolled in the clinical study.

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