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Does the Bleaching Gel Application Site Interfere With the Whitening Result? A Randomized Clinical Trial

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Clinical Relevance

Whitening gel can act at a distance, and its application on the total tooth is not necessary for an effective and homogeneous result. In addition, contact of the gel on cervical areas causes events of dental sensitivity.

SUMMARY

This study aimed to evaluate the effect of the bleaching gel application site on chromatic changes and postoperative sensitivity in teeth. Thirty patients were selected and allocated to three groups (n=10 per group), according to the location of the gel: GI, cervical application; GII, incisal application; and GIII, total facial. The amount and time of application of the 35% hydrogen peroxide (H_2O_2) gel were standardized. Color changes were analyzed by ΔE and W_{id} (bleaching index), using the values obtained in the readings conducted on a digital spectrophotometer in the cervical (CRs) and incisal regions (IRs) of the teeth. Spontaneous sensitivity was assessed using

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the questionnaire, and the stimulated sensitivity caused by the thermosensory analysis (TSA). The analysis occurred in five stages: baseline, after the first, second, and third whitening sessions (S), and 14 days after the end of the whitening, using the linear regression statistical model with mixed effects and post-test by orthogonal contrasts ($p<0.05$). Although the IR was momentarily favored, at the end of the treatment, the restriction of the application site provided results similar to those obtained when the gel was applied over the entire facial surface. Regarding sensitivity, only the GI showed spontaneous sensitivity. In the TSA, GIII had less influence on the threshold of the thermal sensation. It was concluded that the chromatic alteration does not depend on the gel application site. Spontaneous sensitivity is greater when the gel is concentrated in the cervical region (CR), and the teeth remain sensitized by thermal stimuli even after 14 days.

INTRODUCTION

Aligned teeth, presenting harmonious shapes with smile lines and facial proportions as well as with light tones, are part of patient desires for esthetics in dental treatment planning. The chromatic alterations of the unit or the entire dentition can be attenuated or even resolved using whitening techniques, which has been considered a low complexity procedure that is accessible to a large part of the population.[1,2]

Tooth whitening can be performed using the at-home technique in which the patient performs the treatment at home under the supervision of the dentist or using the in-office technique that is performed in the dental office. Both treatment options have hydrogen peroxide (H_2O_2) as an active ingredient; however, the peroxide concentration is generally considerably higher in the in-office technique as compared to the home technique.[3-5]

It is believed that for tooth whitening, H_2O_2 and other reactive oxygen species (ROS) present in the whitening gel diffuse rapidly through the dental tissues, seeking molecular stability when reacting with the chromophore agents. This reaction results in the continuous cleavage of the pigments until the saturation point occurs. This process is only possible because ROS are low in molecular weight and can permeate quickly through dental structures.[6-9]

Different hypotheses are being studied in order to better understand this treatment fully. Whitening can be considered a therapy in which an oxidizing substance is applied topically to the tooth enamel, as it is believed that it complies with Fick's second law, where the diffusion would be related to the residence time, the area of contact of the bleaching gel with the tooth surface, the volume of the product, and the thickness of the substrate.[10]

Regarding the area of application of the product, there are few clinical reports that point to a possible polydirectional action of peroxides, which could act on spots distant from the regions that received the product.[11-13] In 1990,[5] Haywood reported the possibility of the diffusion of H_2O_2 not only in the applied area but also in the entire tooth.

Despite this, when there is tooth staining, the professional often opts for the application of the product specifically on an affected area, with no intention of enhancing the whitening effect in the region and achieving chromatic uniformity in the tooth. The clinical results performed in patients with orthodontic brackets also indicate that the restriction of the contact area of the bleaching gel with enamel is of secondary importance, although, to date, controlled investigations that objectively evaluate this type of procedure have not been devised and developed.[14-16]

Thus, understanding the role of the bleaching gel application site in the chromatic alteration of different regions of the clinical crown can bring advances in whitening therapy and result in significant changes in the clinical protocols of in-office treatments. Therefore, the objective of this study was to evaluate the effect of the bleaching gel application site clinically on the chromatic alteration that occurred in different regions of the crown (cervical and incisal) and on the postoperative sensitivity reported by patients undergoing bleaching treatment in the office. The following null hypotheses were tested: 1) the gel application site would not influence the result of the crown whitening, and 2) the gel application site would not influence the postoperative sensitivity.

METHODS AND MATERIALS

Prior to this research, the project was submitted to the Research Ethics Committee. The study followed the CONSORT statement. Only after approval, clinical procedures were started.

Experimental Design

This was a randomized clinical study evaluating two factors: 1) Place of application of the gel on three levels: half-cervical, half-incisal, and total facial surface; and 2) Analysis times at five levels: baseline (T0), after the first (T1), second (T2), and third (T3) whitening session, as well as at 14 days (T4) after the end of the treatment. The experimental units evaluated were maxillary canines and the response variables were 1) Chromatic

alteration in the cervical part; 2) chromatic alteration in the incisal part, and 3) postoperative sensitivity.

Selection of Patients

The study included 30 volunteers of both sexes, aged between 18 and 30 years (average age 24.8 years). For the selection of patients, clinical and radiographic examinations were performed, as well as detailed anamnesis to verified whether the patients met the inclusion criteria (Table 1). The selected individuals were informed about the research, the possible risks, and the benefits obtained. In addition, patients were given instructions such as not taking analgesic or anti-inflammatory drugs and maintaining good oral hygiene and care, so that there would be no interference in the research results.

The sample calculation was performed based on a previous study,[17] using the software Sigma Plot 14.0. The test details were as follows: Significance level (α)=0.05; test power (1-β)=0.80; and dropout (β)=0.20. Thus, the minimal sample size required was 30 patients.

In the entire study, when considering elements 13 and 23 of these 30 patients, 60 dental elements were available for the study at random and independently.

Table 1: *Inclusion and Exclusion Criteria*

Inclusion Criteria
Patients who wanted to undergo whitening treatment
Patients with healthy and vital teeth 13 and 23
Patients with no carious or noncarious lesion
Patients without orthodontic appliances
Patients who have never performed whitening
Patients with good systemic conditions
Healthy oral soft tissue patients
Nonsmoking patients
Exclusion Criteria
Patients with indirect restorations in the teeth involved in the analysis
Patients who had a history of adverse reaction to peroxide
Patients who used opioids or drugs that influence the sensorineural response
Patients with tooth stains (tetracycline, trauma, fluorosis, and unknown etiology)
Patients with neurological diseases
Patients with chronic or acute diseases
Patients with exposed dental tissue
Patients with dental sensitivity or a history of treatment

Thus, it was possible to compare two techniques in the same patient, simultaneously, in order to reduce the influence of variables such as patient habits, environmental and habitual conditions of the oral cavity, and obtaining a minimum bias for the study (Table 1).

Randomization and Intervention

Randomization and dosage used in each arcade were determined by drawing lots. The possible combinations of treatments (Figure 1) for the study of gel application area were cervical application (CA) × total facial (TB) and incisal application (IA) × total facial (TB).

These combinations were recorded on 30 cards, contained in sealed, opaque envelopes, and numbered sequentially. These were drawn by a team member not directly involved in the study. The group allocation was revealed when opening the envelope on the day of the bleaching procedure.

Whitening Therapy

The volume of the bleaching gel used on each tooth was standardized, using the information provided by the manufacturer as a parameter. Thus, as each bleaching gel syringe contains 5 g and is intended for four bleaching sessions with 20 teeth in each, each tooth received the amount of 0.06 g per session.

The patients received treatment using the office whitening technique, which used the whiteness HP AutoMixx whitening product (FGM Dental Products, Joinville, Santa Catarina, Brazil) composed of 35% H_2O_2, using no source of physical activation.

Initially, dental prophylaxis was performed with a rubber cup and a paste, obtained by mixing pumice and water, moving at a low speed. Subsequently, the

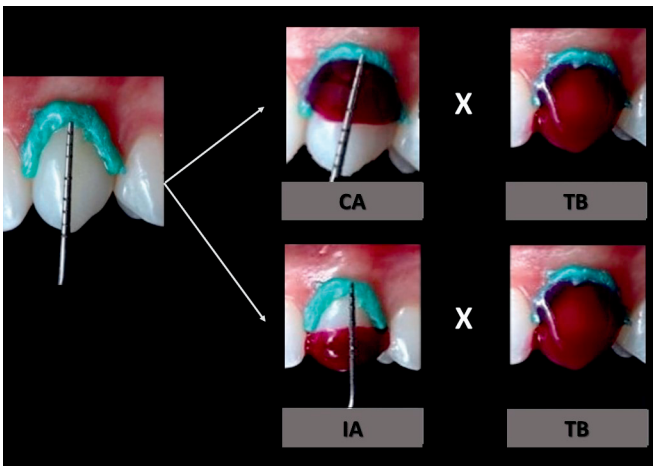

Figure 1. *Combinations of whitening treatments (CR × TV; IR × TV).*

oral soft tissues were isolated with a photoactivated TopDam (FGM) gingival barrier.

The bleaching product used was provided in double-body syringes, with peroxide and thickening agents in separate compartments. Through a self-mixing tip, the resulting gel was provided in pipettes for viscous liquids, (Microman E Gilson, West Beltline, Hwy Middleton – EUA) being applied as 0.06 g of bleaching product on each tooth, according to the proposed design. The bleaching gel remained in the area of interest for 45 minutes. After 7 and 14 days, the procedures were repeated.

The remaining teeth received the whitening therapy in a conventional way, after completing the three whitening sessions and the follow-up period.

Analysis Times

The analysis was performed at the pre-established study times: T0, baseline; T1, after the first whitening session; T2, after the second whitening session; T3, after the third whitening session; and T4, 14 days after the end of the whitening therapy.

Digital Analysis of Color Change

The study of the chromatic alteration occurring in the tooth was carried out with the digital spectrophotometer, Vita Easyshade Advance (Vita Zahnfabrik, Bad Säckingen, Germany). In order to standardize the reading area, initially, patient impressions were cast, and plaster models were obtained for later making two acetate trays on each model—one containing a perforation in the cervical region (CR) and the other intended for reading in the incisal region (IR). Regardless of the treatment received for each tooth for research (teeth #6 and #11), measurements were made on both the cervical and incisal portions of the teeth. Thus, the acetate trays with their perforations enabled the standardized positioning of the tip of the portable spectrophotometer in order to perform the measurement always in the same region of interest, according to the previously established times.

The perforations made it possible to standardize the Easyshade using the CIE $L^*a^*b^*$ color model, established by the Commission International de I'Eclairage—CIE (International Commission on Lighting), which allows the specification of color perceptions in three-dimensional models. The axial "L" is known as the luminosity and extends from 0 (black) to 100 (perfect white). The "a" coordinate represents the amount of red (positive values) and green (negative values), while the "b" coordinate represents the amount of yellow (positive values) and blue (negative values).

The color readings were performed on the incisal half and cervical half of teeth #6 and #11, respecting the pre-established compared times with the initial reading, through the calculation below:

$$\Delta E=[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Whitening Index (W_{id})

To verify the perception of tooth whitening, the whitening index (W_{id}) was also calculated. The W_{id} is a simple, linear formulation that uses values of the chromatic coordinates of CIELab, and the higher the values obtained by the calculation the greater the lightening effect provided by a given procedure. *The whitening index* was calculated using the following formula[18]:

$$W_{id} = (0.511 \times L^*) - (2.324 \times a^*) - (1.100 \times b^*)$$

Sensitivity Analysis

Spontaneous Sensitivity—Visual Analog Analysis (VAS)— Dental sensitivity was assessed daily. The patients themselves reported the presence or absence and the intensity of sensitivity in the period between the whitening sessions. The highest score recorded in the period under analysis was considered for the comparison of the groups under study. The patients were asked about the location (tooth #6 or #11) and the intensity of the discomfort caused by the treatment, with a value of 0 for patients who did not present with any painful symptoms and 10 when severe sensitivity occurred.[19,20]

Analysis of Thermal Sensation Threshold—TSA II— For this analysis, another acetate tray was made, now containing a central perforation in order to standardize the location of the thermal stimulus positioning. For that, the TSA-II equipment (Medoc Advanced Medical Systems Ltd, Ramat Yishai, Israel) was used, which has an intraoral thermal mode that was always positioned in the same region of the crown. Prior to its use, 0.02 mL of thermally conductive paste, composed of silver oxide, was applied to the enamel to ensure that the thermal stimulus generated by the equipment reached the same area of the crown. This test was carried out at the previously established times.

To check the sensation threshold, the TSA II equipment was configured in the "Limits" function, which performs three tests with falling temperatures (from 36°C to 0°C). Each test starts at 36°C, and the thermal mode temperature is gradually reduced at a speed of 1°C/second. When the thermal stimulus is perceived by the patient, it interrupts the stimulus, and the temperature is registered in the software that

manages the production of the thermal stimuli. Thus, the lower the recorded temperature, the less sensitive the tooth was.[21,22,19]

Statistical Analysis

After tabulation, descriptive, and exploratory analysis of the data, compliance with the assumptions of normality and homogeneity with the SAS 9.4 software was found. Then, the data were submitted to the linear regression model with mixed effects (random and fixed effects). For comparisons, the post-test using orthogonal contrasts was used. All tests adopted a significance level of 5%.

RESULTS

Demographic Characteristics and Adherence

After evaluating 52 patients, 30 volunteers met the inclusion criteria. The allocation of patients was described using the CONSORT flowchart (Figure 2). Table 2 shows the demographic characteristics of the volunteers.

Chromatic Change Analysis—ΔE and W_{id}

Table 3 shows that, when comparing the results obtained with the application of the product in the CR with those throughout the crown, except for the second whitening session, the chromatic alteration (ΔE) of the cervical and the IRs were always similar. When analyzing the evolution of treatment over time, both the CR and the IR had a progressive increase in ΔE. Note that the IRs were saturated in the second whitening session, while, in the CR, the biggest changes were observed after the third session, regardless of the location of the gel application. It was also observed that the CR always presented chromatic recurrence, while the IR only relapsed when the gel was applied to the CR. The application site did not influence the cervical or incisal chromatic alteration in any analyzed time.

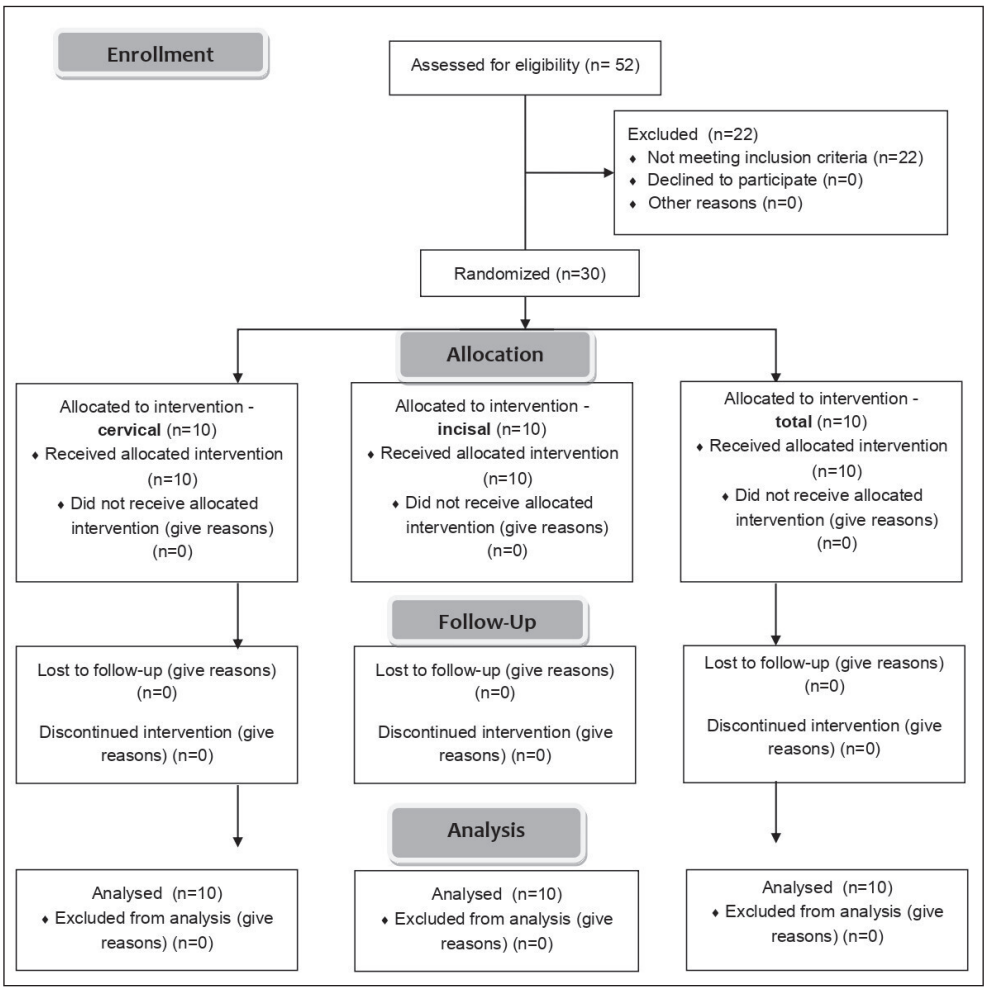

Figure 2. *CONSORT flowchart with allocation, monitoring, and analysis during the study.*

Table 2: *Demographic Characteristics of Patients*		
Age	**24.8 (±3.68)**	
Sex (%)	Female	66.66%
	Male	33.33%
Ethnic-racial (%)	White	50%
	Brown	23.33%
	Black	26.66%

Table 3: *Averages of ΔE and W_{id} Values in Different Reading Regions (CR) and (IR), with Application of the Whitening Gel in (CA) and (TB), at Different Times Analyzed*[a]

Cervical x Total Facial (TB) application									
CA		**1 Session**		**2 Session**		**3 Session**		**14 days**	
		TB	**CA**	**TB**	**CA**	**TB**	**CA**	**TB**	**CA**
ΔE	CR	8.9 Ab	6.8 Ac	9.8 Abc	9.0 Bb	14.5 Aa	12.7 Aa	11.7 Ab	10.3 Ab
	IR	7.9 Ac	8.5 Ab	12.0 Aab	12.0 Aa	14.8 Aa	13.7 Aa	11.9 Ab	11.9 Aa
W_{id}	CR	8.9 Ac	8.0 Bc	11.8 Abc	11.5 Bb	17.8 Ba	17.3 Ba	14.6 Ab	14.6 Bb
	IR	11.5 Ac	10.6 Ac	15.4 Aab	14.4 Ab	20.9 Aa	20.5 Aa	17.2 Ab	16.2 Aab

[a] *Uppercase letters compare lines in each application area. Lowercase letters compare columns (time). Asterisk compares the application area at the same reading location and at the same time.*

Regarding the whitening index, it can be observed that, in general, the changes produced in the region were more pronounced in the IR than those observed in the CR, especially when the gel was applied across the crown. When the gel was applied to the CR, the whitening effect was similar in both the regions (in the first and second sessions, and 14 days after). An analysis of the evolution of the whitening effect showed that the best results were found after a third whitening session, with significant recurrence at 14 days. The application area (in the cervical or whole crown) did not influence any lightening effect in any analyzed time or region (Tables 3 and 4).

Table 3 shows the averages of ΔE and W_{Id} values in different reading regions (CR) and (IR), with the application of the whitening gel in (CA) and (TB), at different times analyzed. Table 4 shows the values of ΔE and W_{id} obtained in different regions of the crown when the application was carried out in the IA or in the total facial (TB) region.

When comparing the ΔE values in the different regions, it was found that in the first and second whitening session, the IR showed more pronounced changes than the cervical, when the gel was applied to the IR. However, in the third session as well as 14 days later, the incisal and CRs provided similar values of ΔE, regardless of the application site. It was also found that throughout the treatment the IR showed chromatic stabilization after the second session, while the CR continued to show an increase in ΔE values until the third whitening session. Chromatic recurrence did not occur in the IR when the gel was applied in the same region and in the CR when the gel was applied to the entire crown. When comparing the effect of the gel application site on the chromatic alteration (IA × TB), it was observed that the incisal application provided higher values of ΔE in this region in the second and third sessions but returned to be similar after 14 days. In the CR, they were always similar.

Regarding the whitening index, it was found that the changes produced in the IR were similar to those observed in the CR, when the gel was applied in the IA, except after the third whitening session in which the IR presented the largest change. When evaluating the whitening effect when the gel was applied TB, the changes produced in the IR were more pronounced than those observed in the CR at all the times analyzed. The analysis of the evolution of the whitening effect showed that the IR was stabilized after the second session, when the gel was applied to the same area. However, when the gel was spread throughout the crown, the IR continued to be cleared until the third session. The CR always showed the greatest whitening effect in the third session. It was also observed that both the cervical and IRs showed a decrease in the W_{id} after 14 days. The effect of the application site was not significant in the

Table 4: *Averages of ΔE and W_{id} Values in Different Reading Regions (CR) and (IR), with Application of the Whitening Gel in (IA) and (TB), at Different Times Analyzed*[a]

Incisal × Total Facial (TB) Application									
IA		**1 Session**		**2 Session**		**3 Session**		**14 Days**	
		TB	**IA**	**TB**	**IA**	**TB**	**IA**	**TB**	**CA**
ΔE	CR	7.1 Bc	6.8 Ac	9.5 Bb	9.0 Bbc	13.1 Aa	12.7 Aa	10.5 Ab	10.3 Aab
	IR	9.2 Ab	8.5 Ac	13.6 Aa*	12.0 Aab	15.4 Aa*	13.7 Aa	12.8 Aa	11.9 Ab
W_{id}	CR	8.9 Ac	8.0 Bc	11.8 Abc	11.5 Bb	17.8 Ba	17.3 Ba	14.6 Ab	14.6 Bb
	IR	11.5 Ac	10.6 Ac	15.4 Aab	14.4 Ab	20.9 Aa	20.5 Aa	17.2 Ab	16.2 Aab

[a] *Uppercase letters compare lines in each application area. Lowercase letters compare columns (time). Asterisk compares the application area at the same reading location and at the same time.*

W_{id} values at any analyzed time or in any region (Table 4 and Figure 3).

Analysis of Postoperative Sensitivity

Absolute Risk and Spontaneous Sensitivity—When analyzing the absolute risk of sensitivity, it was observed that only the group in which the gel was restricted in the CR generated spontaneous sensitivity, which affected 15% of patients after the second session and 10% after the third whitening session (Table 5). At these times, the maximum intensity reported by patients was a score of 5.

Assessment of Neurosensory Analysis—TSA II—Figure 4 shows that after the first session all forms of application provided a similar effect on the sensitive threshold of canines. The average cold detection temperature ranged between 8.7°C and 10.3°C. However, after the second and third sessions, and even after 14 days, the application of the gel across the crown was the form that left the teeth less sensitive to cold stimuli and was still similar to the results obtained when the application was at the IR. It was also observed that when the application of the gel was in the CR, the sensory threshold was changed until the third whitening session, while when the application was in the IR or in the entire crown, the thermal stimulus that caused the discomfort grew only until the second session. Despite this, in all forms of application, the teeth remained sensitized after 14 days.

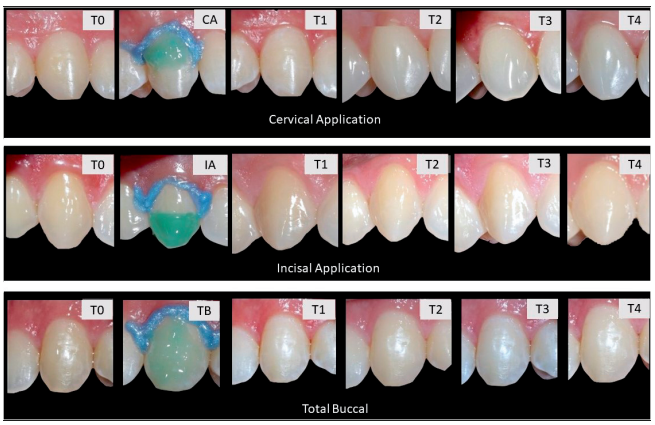

Figure 3. *Chromatic change in different applications in the previously established operative times.*

DISCUSSION

Despite the knowledge of the permeability of dental structures to whitening agents, most professionals extend the area of application of the whitening gel to the maximum extent—both in the home and office techniques.[3-5] It is also very common among professionals to deposit the gel in darker areas, believing that the application site plays a decisive role in the success of whitening therapy.[14,15] This approach can expose the patient to accidental contact of the gel with the gingival tissue, generating mild burns, which decreases the feeling of satisfaction with the treatment.[23,24]

In this context, one of the objectives of this study was to evaluate whether the application of the whitening product in the CR or IR would provide different results compared to those obtained when the same volume of gel is applied throughout the crown. Δ*E* values showed that although the IR may be momentarily favored by the application of the gel directly in this region, at the end of the session as well as 14 days after the end of the treatment, the restriction of the application site of the gel in the cervical or IR provided results similar to those obtained when the gel was applied across the crown; therefore, the first hypothesis was accepted.

This result shows that the diffusion of peroxide and other reactive oxygen substances occurs quickly and in a polydirectional manner and does not depend exclusively on the main orientation of the expressed diffusion pathways, formed by the porosities in the

Table 5: *Absolute Risk and Maximum Intensity of Sensitivity at the Different Analyzed Times*[a]

	After the 1st Session		After the 2st Session		After the 3st Session		14 Days After Treatment	
	Absolute Risk	Maximum Intensity	Absolute Risk	Maximum Intensity	Absolute Risk	Maximum Intensity	Absolute Risk	Maximum Intensity
CA	0% Ab	0 Ab	15% Aa	5 Aa	10% Aa	5 Aa	0% Ab	0 Ab
IA	0% Aa	0 Aa	0% Ba	0 Ba	0% Ba	0 Ba	0% Aa	0 Aa
TB	0% Aa	0 Aa	0% Ba	0 Ba	0% Ba	0 Ba	0% Aa	0 Aa

[a] *Uppercase letters compare lines in each application area. Lowercase letters compare columns (time).*

interprismatic region, in the nuclei of the prisms, and the dentinal tubules. This is because the reactive oxygen substances are low-molecular-weight molecules that have the ability to pass through the intertubular secondary pathways, allowing regions that have not received the gel to show significant chromatic changes, at least when the whitening treatment produces a large amount of ROS, like in the in-office technique.[6,7,25,26]

The penetration of H_2O_2 is only possible because the enamel is a semipermeable structure formed by prisms and a sheath rich in proteins of approximately 26 nm, directing and modulating the intensity of the diffusion of ROS through interprismatic and intercrystalline spaces.[26,27,28,29] Once in the dentinal tissue, ROS travel easily through the tubules towards the pulp chamber, because the tubules have an increasing diameter and density in relation to the pulp. In addition, they have canaliculi that promote intertubular communication, which explains the bleaching action far from where the gel is applied. Thus, when running through the entire structure of the tooth, reactive oxygen species from the whitening product interact with the chromophore molecules present in the dental structures, cleaving them, increasing the luminosity of the tooth, and decreasing its chroma.[3,4,28,30]

As a complementary analysis, the evolution of treatments over time was analyzed, noting that the IR had already saturated in the second whitening session, while the CR achieved the greatest variations in chromatic alteration after the third session. It is known that H_2O_2 and other reactive radicals have a very short useful life and, as a consequence, it can be assumed that the layers closest to the bleaching product respond more quickly to whitening than the dentin.[31] Thus, it can be inferred that the IR, being thinner, responds more quickly to treatment. In addition, Ma in 2011[32] and Vieira in 2008[33] stated that during whitening the enamel can increase the amount of water present in the structure, which makes it the most luminous enamel with the least visibility of the underlying dentin.[34-36]

It is worth mentioning that in addition to the chromatic alteration evaluated by ΔE, the result of the W_{id} bleaching was also analyzed, which allowed the analysis of the bleaching of the structures. This

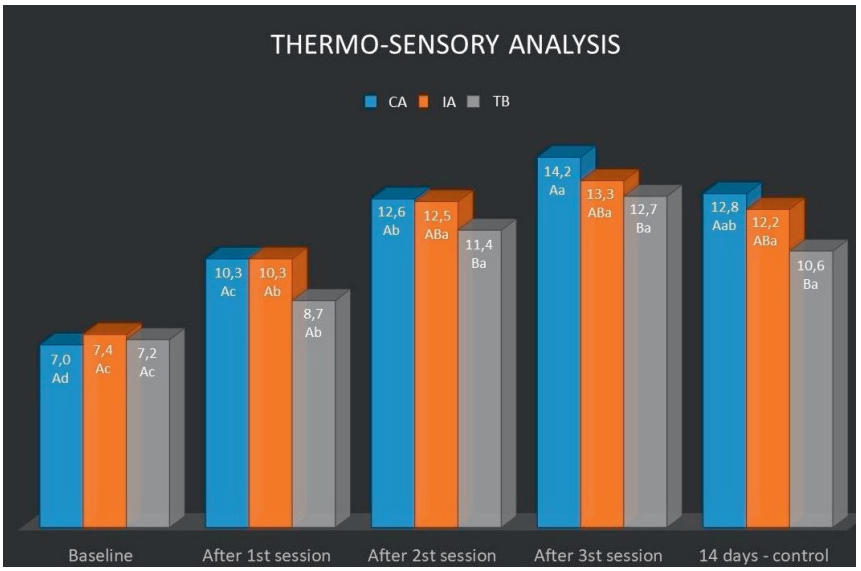

Figure 4: *Averages of the values of the thermosensory analysis (TSA) for each group in the analyzed times.*

index allows an evaluation through the correlation of visual perception and the coordinates of the CIELab system. Thus, it was possible to observe that the greatest whitening effect occurred in the IR, especially when that region received the whitening gel. This can be explained by the fact that the middle- and cervical-thirds have a greater thickness and opacity, as they have a pulp chamber filled with connective tissue as a background, which can limit the lightening effect of the region.[37,38]

Although some research has shown that whitening saturation can be achieved in the second session,[39-41] in the present study, the highest values of the whitening index were observed after the third session in all the variations of application area present in the study design, with standardization of time and volume of bleaching gel. These results are probably related to the teeth used in this work, that is, canines, which are darker and more opaque than the maxillary-central incisors, which are generally used in clinical research to measure the lightening effect.[31,42]

The results observed in the present study confirm the polydirectional whitening action—a fact already explored in previously published clinical case reports. In this context, Gomes and others[14] showed that the whitening treatment performed on patients with orthodontic accessories showed no difference from the results observed when the gel was applied to the entire crown.

Another objective of the study was to analyze the influence of the gel application site on tooth sensitivity. Spontaneous sensitivity analysis detected the greatest propensity for sensitivity events when the gel was applied in the CR after the second and third whitening sessions. Possibly, the diminished enamel thickness in this region favored the spread of ROS speed to the pulp–dentin complex. It is known that the penetration of H_2O_2 into the pulp results in the release of biochemical mediators involved in the inflammatory process, which sensitizes pulp nociceptors, changing the sensitivity threshold of nerve fibers and obtaining spontaneous sensitivity reports.[43-45]

Despite this, the occurrence of sensitivity was very low in relation to that reported in other studies, in which the treatment was carried out in the entire arch, using various dental groups with nonindividualized volumes of gel, which resulted in a higher occurrence of sensitivity, mainly in the lower and upper incisors. [20,46-49]

Regarding postbleaching sensitivity, it was found that the sensitivity to thermal stimuli gradually increased until the third whitening session, and that the teeth remained sensitized until 14 days after the end of treatment. The permanence of dental sensitization was also reported by Rahal and others,[19] who associated this phenomenon with the activation of the TRPA1 ion channel, generating an inflammation process and subsequent stimulation of precipitated thermal sensation—the result of a possible reversible inflammation in pulp tissue. In addition, events of histomorphological changes in the dental enamel, through the direct action of the whitening agent on the proteins present in the tooth and an increase of the tissue's diffusion and permeability channels, can directly affect the influence of the response to the thermal stimulus, making the tooth more susceptible to the thermal sensation when subjected to a cold stimulus.[19,44,50] Thus, the results showed that spontaneous and provoked sensitivity varied according to the product's application protocol, and, therefore, the second hypothesis of the study was rejected.

Thus, it was observed that the diffusion capacity of ROS resulted in a chromatic alteration in all the evaluated regions, regardless of the place of application of the gel. In addition, the application restricted to the CR had a negative influence on the sensory response. Therefore, new studies are suggested that address the influence of the area of application of the whitening gel as well as the incorporation of new variables of direct influence in the response of the whitening therapy, such as the volume of the whitening gel and the influence of the anatomy of different teeth.

CONCLUSIONS

- The chromatic changes of the CRs and IRs do not depend on the place of application of the bleaching gel.
- The IR reaches chromatic saturation faster than the CR.
- The restricted application of the bleaching gel in the CR left the teeth more sensitive.
- Despite the remission of spontaneous symptoms, all groups remained sensitized to low temperature 14 days after the end of treatment.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the human subjects' oversight committee guidelines and policies of the Research Ethics Committee FOA/UNESP. The approval code issued for this study is 91141018.6.0000.5420.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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