QUANTITATIVE SENSORY TESTING OF THE EFFECT OF DESENSITIZING TREATMENT AFTER DENTAL BLEACHING

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ABSTRACT

The aim of this study was to quantify tooth sensitivity during bleaching and after a desensitizing treatment. Sensitivity was measured with a new device, TSA-II, which uses thermal stimuli for Quantitative Sensory Testing (QST). Ten patients underwent bleaching treatment using Whiteness HP Maxx (FGM Produtos Odontológicos Ltda) containing 35% hydrogen peroxide. After the bleaching session, the teeth were cleaned with air/water spray and the product Desensibilize KF 2% (FGM Produtos Odontológicos Ltda) was applied to the upper left teeth. Saline solution at room temperature was applied in the upper right teeth. QST was performed before bleaching, immediately after bleaching, and immediately after desensitizing treatment. In order to standardize tooth analysis, a 100% ethylene copolymer and vinyl acetate tray with circular perforations was used during measurements. Analysis of variance and the Student's t-test were used (α=0.05). Mean temperatures (SD) of cold sensation threshold for the upper right quadrant were: BB-13.898 (4.81), AB-19.241 (3.68), AD-20.646 (3.72) and for the upper left quadrant they were: BB-14.102 (3.22), AB-19.646 (4.82), AD-13.835 (3.63). Dental bleaching with highly concentrated peroxides changed dental cold sensation thresholds, but the topical desensitizer changed the immediate cold sensation thresholds produced by the cold stimulus.

Key words: *Clinical Trial; Hydrogen Peroxide; Tooth Bleaching; Dentine Sensitivity.*

TESTE SENSORIAL QUANTITATIVO DO EFEITO DE UM TRATAMENTO DESSENSIBILIZANTE APÓS O CLAREAMENTO DENTAL

RESUMO

O objetivo do presente estudo foi quantificar a sensibilidade dentária durante o tratamento clareador e após a aplicação de um dessensibilizante utilizando um equipamento de análise neurosensorial, o TSA II, que utiliza estímulos térmicos para a realização do Teste Sensorial Quantitativo (QST). Assim, dez pacientes (n=10) receberam o tratamento clareador com Whiteness HP Maxx (FGM Produtos Odontológicos Ltda.) contendo peróxido de hidrogênio a 35%. Após a sessão clareadora, os dentes foram limpos com jatos de ar/água e foi realizada a aplicação do Desensibilize KF 2% (FGM Produtos Odontológicos Ltda.), um dessensibilizante tópico a base de nitrato de potássio a 5% e fluoreto de sódio a 2%, apenas no hemi-arco esquerdo da maxila, utilizando o método da boca dividida. No hemi-arco direito foi aplicada uma solução salina a temperatura ambiente (controle). O QST foi realizado antes do clareamento (AC), imediatamente depois do clareamento (DC) e imediatamente após a aplicação do dessensibilizante (DD). Para padronizar o local do estímulo, uma moldeira de acetato com perfurações circulares foi utilizada durante as mensurações. A análise estatística foi realizada por meio do teste t de Student (α=0,05). As temperaturas médias (DP) do limiar de sensação ao frio para o hemi-arco direito foram: AC-13,898 (4,81), DC-19,241 (3,68), DD-20,646 (3,72) e para o hemi-arco esquerdo foram: AC-14,102 (3,22), DC-19,646 (4,82), DD-13,835 (3,63). Clareamento dental com peróxidos de alta concentração exacerbaram a sensibilidade dental ao estímulo térmico e o uso do dessensibilizante foi efetivo para reverter esta situação.

Palavras-chave: *Ensaio Clínico; Peróxido de Hidrogênio; Clareamento Dental; Sensibilidade Dentária.*

INTRODUCTION

The in-office dental bleaching technique with highly concentrated hydrogen peroxide has been widely used because it provides quick results without the use of trays.[1,2]

Dental professionals usually apply products containing 30% to 38% hydrogen peroxide while protecting soft tissues against deleterious effects.[3] Despite the effectiveness of dental bleaching, current studies reveal that patients who undergo it report different frequency and intensity of dental sensitivity,[3] a negative treatment outcome that reduces patient satisfaction.

The current literature does not explain the origin of dental sensitivity. Knowing the cause would be crucial in establishing an effective bleaching technique that would cause minimum patient discomfort. Desensitizers have been applied to reduce discomfort with no apparent influence on bleaching efficacy.[4,5]

Clinical studies have evaluated the frequency and intensity of dental sensitivity and presented subjective data based on personal reports and pain questionnaires according to the Visual Analogue Scale (VAS).[6] However, misunderstanding of data may have affected the reliability and reproducibility of results, leading to the search for a more reliable quantification method of patient discomfort concomitant with the dental bleaching process.

Devices such as the TSA II (Medoc Advanced Medical Systems Ltd., Ramat Yishai, Israel) enable the quantification of the neurosensory response related to major and minor nerve fibers[7] through Quantitative Sensory Testing (QST) using thermal or mechanical stimuli.[8-11] Because QST is a fast and useful method resulting from accurate standardized analyses,[9,11] it is used in several fields, including anesthesiology,[10] acupuncture,[11] endocrinology,[12] neurology,[13] and dermatology.[14] In dentistry, it was initially employed to quantify maxillofacial surgery and orofacial pain[8,9,15] for evaluation of neurological responses after third molar exodontia and orthognathic surgery. However, to date, research has not evaluated dental sensitivity using QST, a method that might improve the accuracy of these studies.

The aim of this study was to use neurosensory analysis to quantify dental thermal sensitivity before and after dental bleaching and to compare patient cold sensations with and without desensitization methods. More accurate knowledge of patient symptomology in the dental bleaching process may help the development of safe and comfortable bleaching therapies.

As a null hypothesis, it was assumed that dental bleaching with highly concentrated peroxides would not influence cold sensation thresholds and that the use of topical desensitizer containing sodium fluoride and potassium nitrate would not change the immediate cold sensation thresholds produced by a specific cold stimulus.

Table 1: Inclusion and exclusion criteria for selection of patients.

Inclusion Criteria
Dental bleaching using in-office technique indicated
Healthy and vital upper teeth
No decayed teeth
No visible enamel defects
No orthodontic brackets
Overall good systemic health
Healthy oral soft tissue
Non-smoking
Exclusion Criteria
Direct and indirect restorations in the upper anterior region
Adverse reaction to peroxide
Use of opioids or medications influencing neurosensory response
Use of pacemaker
Presence of dental staining (tetracycline, trauma, fluorosis, and unknown etiology)
Neurological diseases
Chronic or acute diseases
Dentine exposure

Table 2: Treatment according to the split-mouth design method.

	Treatment	Posology
Right maxillary quadrant (n=10)	35% hydrogen peroxide*	3 15-minute applications every 7 days
	Saline	1 10-minute application immediately after each bleaching session
Left maxillary quadrant (n=10)	35% hydrogen peroxide*	3 15-minute applications every 7 days
	5% potassium nitrate + 2% sodium fluoride*	1 10-minute application immediately after each bleaching session

* FGM – Dental products

MATERIALS AND METHODS

After approval by the Committee of Ethics in Research (00278/2011), 10 patients aged 18 to 25 years were selected according to the criteria shown in Table 1. The maxillary arch was divided into right and left quadrants, which would undergo different desensitizing treatments (Table 2). When two interventions are applied in the same patient, in a split-mouth approach, there are paired observations and the required sample size is smaller because of the reduced variability. The split-mouth design resembles the crossover design, more often encountered in clinical trials, like this study[16].

Sample size was calculated considering the type-I error rate (α) - the probability of finding a difference when a difference does not exist. Most medical literature uses an alpha cut-off of 5% (0.05), indicating a 5% chance that a significant difference is actually due to chance and is not a true difference; type-II error rate (β) - the probability of not detecting a difference when one actually exists. Beta is directly related to study power (Power = 1 - β). A beta cut-off of 20% (0.2) is usually used, indicating a 20% chance that a significant difference is missed. It was also considered a 5% level of significance, which means that the chance of the finding being true is 95%, and power of the test 80%, which means that, if indeed there is any difference, the probability of detecting it will be 80%.[16,17]

After the patients provided informed consent, they underwent careful evaluation, anamnesis and appropriate clinical and radiographic exams before allocation (Fig. 1).

This study is a factorial, blinded clinical trial with equal randomization, and includes the factors: (1) desensitizing treatment at 2 levels (5% potassium nitrate associated with 2% sodium fluoride or saline) and (2) 3 periods of evaluation: before bleaching (BB), immediately after bleaching (AB), and immediately after desensitizing (AD). Dental sensitivity to thermal stimuli was evaluated, and the split-mouth design method was used.

Quantitative Sensory Testing (QST)

Quantitative Sensory Testing (QST) for cold sensation thresholds was conducted during the first bleaching session from upper right canine to upper left canine. The evaluation was performed in the following sequence: upper right canine, upper left canine, upper right lateral incisor, upper left lateral incisor, upper right central incisor, and upper left

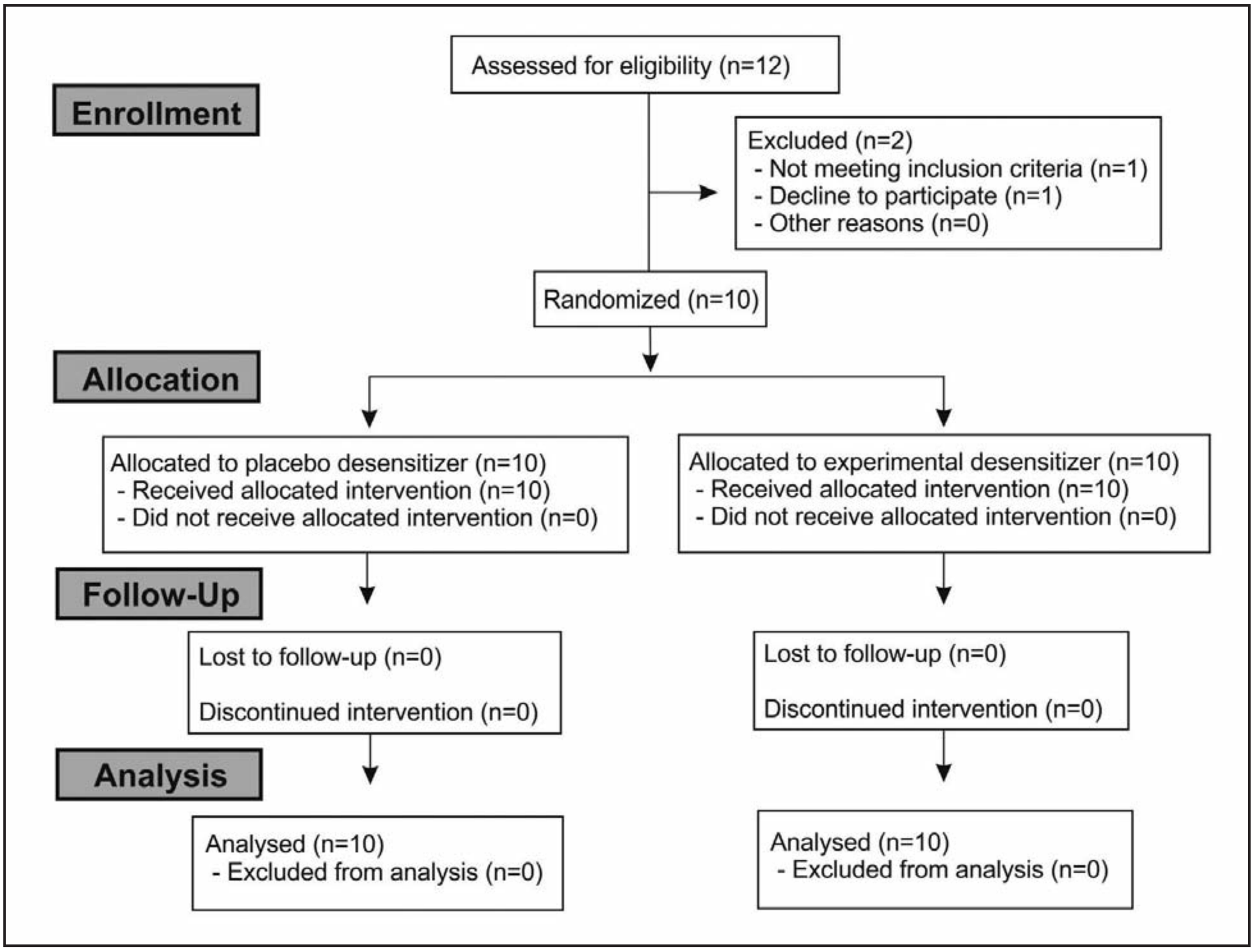

Fig. 1: Flow chart diagram showing enrollment, allocation, follow-up and analysis during the study (CONSORT Statement).

central incisor. Analyses were conducted before bleaching (BB), immediately after bleaching (AB), and immediately after application of either desensitizer or saline (AD).

For standardization of tooth analysis, a 100% ethylene copolymer and vinyl acetate tray was fabricated for each patient. The tray had circular perforations with a diameter similar to the active tip of the intraoral thermode. The perforations were created on the buccal surface and 2 mm below the cervical, incisal, and proximal margins of the upper teeth, except the canine position, which was perforated 3 mm below the distal margin (Fig. 2).

Before measurement, each tooth was covered with 0.05 ml of thermal conductive paste containing silver oxide (IPT - Pasta Térmica Implastec, Implastec Eletroquímica Ltd., Votorantim, São Paulo, Brazil) to optimize thermal conduction. The tests were performed at a dental clinic in a silent environment with a constant temperature of 26º C. The sessions were conducted from 8:00 a.m. to 10:00 a.m.

Fig. 2: Individual tray fabricated with circular perforations for Quantitative Sensory Testing.

The neurosensory analyzer TSA II (Medoc TSA II Neurosensory Analyzer, Ramat Yishai, Israel) was used to test cold sensation thresholds employing CST. TSA II consists of a central unit that generates thermal signals, controlled by software and connected to another device held by the patient. The patient is able to stop cooling of the intraoral thermode at any time (Fig. 3).

The TSA II was configured using the "Limits" function, and three descending temperature tests were performed on each tooth. The test began at 36º C, and the thermode cooling speed was 0.5º C per second, resulting in slow temperature variation that allowed even transference of the thermal stimulus to the dentine-pulp complex. After patient perception of temperature alteration, the patient paused the stimulus, and the measurement was repeated for two times, 30 seconds after the previous one.

The values obtained during the first test were discarded, and the mean of the following tests was used as the initial temperature for cold sensation threshold testing in each tooth. Subsequently, the cold sensation thresholds for all teeth from the same quadrant were grouped for comparison between treatments.

Bleaching Treatment

The in-office bleaching technique used 35% hydrogen peroxide (Whiteness HP Maxx, FGM Produtos Odontológicos – Ltda., Joinville, Santa Catarina, Brazil) (Table 3) and no physical activation. The product is commercially available as a two-bottle system (one bottle contains the peroxide and the other contains the activator, and the substances are mixed in a peroxide/activator ratio of 3:1 drops.

After tooth prophylaxis and soft tissue isolation using a light cured resin gingival barrier (Top Dam

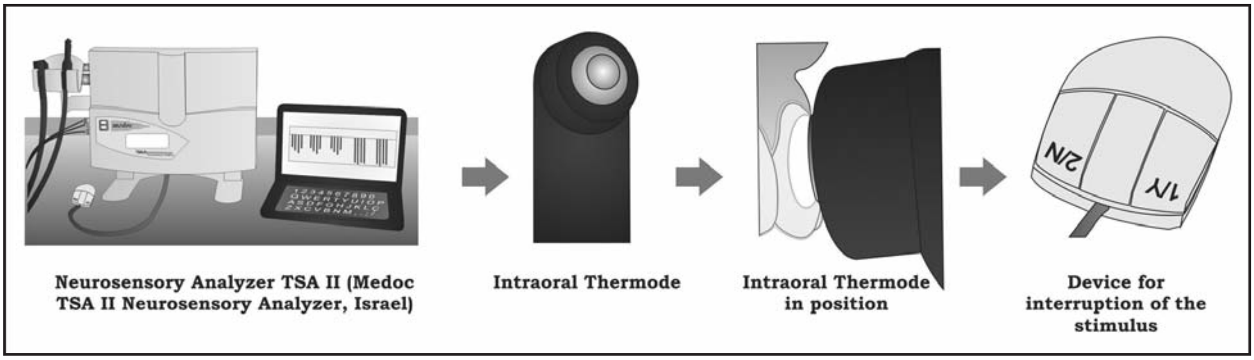

Fig. 3: Diagram of TSA II equipment used for neurosensory analysis.

– FGM Produtos Odontológicos Ltda., Joinville, Santa Catarina, Brazil), the bleaching agent was inserted into a graduated syringe, and 0.06 mL of the bleaching product was applied on the buccal surface of the teeth for 15 minutes. After the first application, the teeth were cleaned and dried with gauze, and the procedure was repeated twice, totalizing 45 minutes of contact between the bleaching product and enamel (Fig. 4).

Desensitizing Treatment

After the bleaching session and immediately after the second cold sensation measurement, the teeth were cleaned with an air/water spray and 5% potassium nitrate with 2% sodium fluoride (Desensibilize KF 2%, FGM Produtos Odontológicos Ltda., Joinville, Santa Catarina, Brazil) (Table 3) was applied to the teeth of the maxillary left quadrant, according to the manufacturer's instructions. In the right quadrant, saline at room temperature was applied as described above. After 10 minutes, the tooth surfaces were rinsed thoroughly (Fig. 5).

Statistical Analysis

The mean values obtained were grouped according to the period of evaluation: before bleaching (BB), after bleaching (AB), and after application of either desensitizer or saline (AD). The data for each quadrant was submitted to Student's t-test at a 5% level of significance using Pacotico 5.1 statistics software.

RESULTS

This study applied one treatment to the right quadrant (saline solution) and another to the left (desensitizing). Table 4 shows the mean temperature of cold sensation thresholds in each quadrant, the comparison between the values of each quadrant (uppercase letters) and the comparison between values for the same quadrant according to the evaluation period (lowercase letters).

In the periods BB and AB, there was no statistically significant difference between quadrants. However, in period AD, a significant difference (p =0.0000) was observed between the right and left quadrants.

Table 3: Composition of the products used in this study.

Product	Composition	LOT
Whiteness HP MAXX 35%*	30%–35% hydrogen peroxide, thickener, pigments, glycol, inorganic compound and de-ionized water	260111
Desensibilize KF 2%*	5% potassium nitrate, 2% sodium fluoride, de-ionized water, glycerin, neutralizer and thickener	281111
Saline	0.9% NaCl solution in distilled water	11099311

* FGM– Dental products.

Fig. 4: In-office bleaching procedure using 35% hydrogen peroxide.

Fig. 5: Desensitizing agent application.

Table 4: Mean temperatures and standard deviation of cold sensation threshold (ºC) in right and left quadrants.

Periods	Right quadrant	Left quadrant
Before bleaching (BB)	13.898 (4.81) Ba	14.102 (3.22) Ba
After bleaching (AB)	19.241 (3.68)Aa	19.646 (4.82)Aa
After desensitizing (AD)	20.646 (3.72) Aa	13.835 (3.63) Bb

Means followed by different letters (uppercase in columns and lowercase in rows) represent a statistically significant difference according to Student's t-test, $p \leq 0.05$.

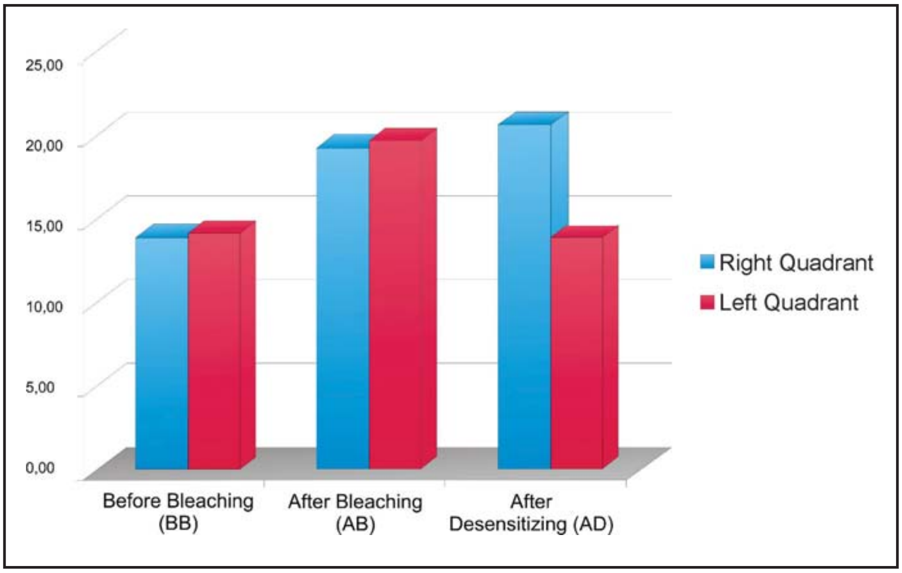

Fig. 6: Data of cold sensation threshold on the right and left quadrants during the periods of evaluation.

The device provides a slow temperature decrease (from 36ºC to 0ºC) that allows the patient to detect the threshold accurately, and the data are parametric quantitative values. It is important to note that our findings were described considering a 5% level of significance to decide whether the difference is statistically significant.

Quantitative Sensory Testing (QST), widely used in skin and oral mucosa, was adapted here for testing cold sensation thresholds on tooth surfaces. Because QST requires patients' collaboration by stopping the thermal stimulus as soon as it is perceived, the test must be conducted in a silent environment with a constant temperature.[7,19] In addition, test reliability depends on the control group. In this study, the control consisted of use of saline as a desensitizer in the right quadrant. [8,20]

The TSA II should be carefully configured to avoid any influence of repetition on tests on the same tooth. An interval between tests was crucial to achieve 36ºC, a temperature comfortable for patients, and to avoid the unwanted addition of stimuli. Similarly, cooling speed was relevant in the transference of thermal stimuli to the dentine-pulp complex.

Dental bleaching increased the mean values of cold sensation thresholds, which means that the teeth became more sensitive. In the right quadrant, dental cold sensation after bleaching remained the same after use of saline solution. However, in the left quadrant, the values measured at AD were similar to the initial values obtained at BB ($p = 0.7645$). Overall, results revealed a reduction of dental sensitivity after desensitizing (Fig. 6).

DISCUSSION

Quantitative Sensory Testing (QST): Advantages and Limitations of the Method

Different results in dental sensitivity show that sensory function is not consistent and uniform, therefore, reliable and reproducible methods should be applied.[18] In this regard, the development of an accurate pain-testing methodology is helpful for the evaluation of dental sensitivity and for indicating proper treatments. The cold sensation threshold can be defined as the moment at which patients feel the cold temperature (in degrees Celsius) in contact with the dental surface. This detection can show their ability to feel discomfort during the bleaching treatment because it indicates whether or not the tooth was more sensitive. This is why we chose to determine the experimental and control group in the same person, who had similar initial mean values of cold sensation (baselines) in both quadrants.

Bleaching and Desensitizing Treatments

High concentrations of hydrogen peroxide[21] and the pH of the bleaching products have been associated with histomorphological alterations in enamel, increase in enamel permeability, and penetration of byproducts generated by the breakdown of bleaching agents.[22,23] These phenomena are related to a high frequency of dental sensitivity, which is considered the most common side effect of dental bleaching.[24,25]

The physiology of dental sensitivity after bleaching remains unclear due to the functional and structural complexity of teeth, including nerves, odontoblastic features, and internal movement of fluids.[10,11,26-28] The hydrodynamic theory[29] is based on the movement of dentin fluid as the result of several stimuli that excite the pulp nerve fibers and cause pain.[28,30] The excessive oxygen generated by bleaching products in the pulp also stimulates the release of inflammatory chemical mediators, such as substance P, which sensitize the pulp nociceptors and play a role in pain modulation,[31] as can be observed in the values of cold sensation thresholds near patients' comfortable temperature (36°C).

The presence of surface alterations on teeth suggests that the topical action of some products may reverse those alterations or treat dental sensitivity. The positive response to desensitizing after dental bleaching is consistent with the results of studies by Tay et al., 2009[4] and Reis et al., 2011[31] which demonstrate the effectiveness of 5% potassium nitrate used with 2% sodium fluoride. Such evidence may result from the neurological action of potassium nitrate, which disturbs the depolarization of neurons and reduces the effectiveness of sensory nerve conduction.[4,31,32] Quadrants treated with this desensitizing agent exhibited lower temperatures of cold sensation thresholds than the quadrants treated with saline. In addition, the formation of calcium fluoride on flaws, diffusion channels, and gaps in the dentine-pulp complex represented a physical barrier with this desensitizer.[31] Thus, the null hypothesis was rejected because similar data were obtained in the periods BB and AD in the left maxillary quadrant treated with desensitizer.

An interesting complement to our study would be the inversion of the quadrant treatments, using saline solution on the left quadrant and the desensitizing agent on the right. However, the interpretation of the data would be impaired, since the mechanism of action of this topical agent takes place by means of neural blockade. Thus, in this second stage of the study there may already be inhibition of the neural response due to the previous treatment.

Considering the data found in this study and previous results related to desensitizing effectiveness,[4,31] the quantitative analysis of dental sensitivity using a neurosensory method is a promising approach for further clinical studies of this symptom caused by several dental treatments.

CONCLUSIONS

- Dental bleaching with highly concentrated peroxides increased dental cold sensation thresholds.
- Topical desensitizer containing sodium fluoride and potassium nitrate reversed the immediate cold sensation thresholds produced by the cold stimulus.

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