The Role of Peroxide Based Bleaching Agents in the Induction of Tooth Sensitivity

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Tooth whitening is increasingly requested lately due to increased aesthetic demands of patients. The aim of our study was to analyse if there are differences, in terms of tooth sensitivity, between at-home and in-office bleaching agents used in tooth whitening, and also, if a higher concentration of bleaching agents leads to increased the tooth sensitivity. We used four bleaching agents in our study, two at-home use (Opalescence PF –Ultradent, with 10% and 20% concentration), and two in-office use (Opalescence Boost 40% - Ultradent and Pola Office 35% - SDI). The studied patients (161) were divided into four groups, after the used bleaching agent. After the tooth whitening procedures, the patients were recalled twice a week for two weeks, so that we conducted four sessions of determining the tooth sensitivity. The results showed that the patients with higher tooth sensitivity were from those with at-home whitening procedures, with a lower concentration of the peroxide-based bleaching agents.

Keywords: bleaching agents, at-home and in-office tooth whitening, tooth sensitivity

Tooth whitening or tooth bleaching (when is used a bleach), represent the restoration of natural tooth shade or whitening the natural tooth shade [1]. Tooth bleaching is one of the conservative and cost-effective dental treatments for improve a person's smile and has become one of the most popular esthetic dental treatments [2,3]. Dental whitening/bleaching are mentioned already out of the antiquity, but in researches appeared to the early 1800s [4].

Beginning with 1900s, started the production of home application tooth whitening products [5]. The tooth whitening procedures evolved in four fundamental approaches: professionally applied in the dental office; dentist-prescribed/dispensed, with patient home-use; consumer-purchased/over-the-counter (=OTC), applied by patients; other non-dental options as gum shields, strips, dentifrices. Additionally, dentist-dispensed bleaching materials are sometimes used at home, after dental office bleaching, in order to maintain or to improve the whitening results [6]. The used solutions for tooth whitening/ bleaching were chloride-based aluminum, oxalic acid, pyrozone hydrogen dioxide, sodium peroxide and cyanide of potassium [7]. Known constituents of actually used bleaching gels are represented by carbamide peroxide, hydrogen peroxide, non-hydrogen peroxide containing materials, thickening agents (Carbopol or Polix), urea, vehicle (glycerin, dentifrice, glycerol), surfactant and pigments dispersant, preservative materials, flavoring, and sometime fluoride [8,9].

Hydrogen peroxide (H(2)O(2)) is a powerful oxidizing agent. The mechanisms of bleaching by hydrogen peroxide are not well understood, but involve the degradation of the extracellular matrix and oxidation of chromophores located within enamel and dentin. Hydrogen peroxide bleaching acts usually through the perhydroxyl anion ($HO2^-$). Other conditions which can determine the free radical formation, are the cleavage of either an O–H bond, or the O–O bond in hydrogen peroxide, to obtain H^- + ^-OOH and 2^-OH (hydroxyl radical) [10]. When diffuses into the tooth, hydrogen peroxide dissociates and produce unstable free radicals, like hydroxyl radicals (HO^-), perhydroxyl radicals (HOO^-), perhydroxyl anions (HOO^-), and superoxide anions (OO^-–). These free radicals will attack the organic pigmented molecules situated in the spaces between the inorganic salts of enamel at level of double bonds of chromophore molecules [11]. Double-bond change determine the apparition of smaller and less pigmented constituents, with a shift in the absorption spectrum of chromophore molecules, so, the bleaching of tooth tissues occurs [12].

Carbamide peroxide, also called urea peroxide, is an oxidizing agent, consisting of hydrogen peroxide compounded with urea. The molecular formula is $CH_6N_2O_3$, or $CH_4N_2O{\cdot}H_2O_2$ [13]. It is white crystalline that in contact with water reacts, form hydrogen peroxide and releases oxygen [14]. Off-the-shelf products typically rely on a carbamide peroxide solution varying in concentration from 10% to 44% [15]. Carbamide peroxide has about a third of the strength of hydrogen peroxide. This means that a 15% solution of carbamide peroxide is the rough equivalent of a 5% solution of hydrogen peroxide. The peroxide oxidizing agent penetrates the porosities in the rod-like crystal structure of enamel and breaks down stain deposits in the dentin [16]. Hydrogen peroxide can produce local undesirable effects on tooth structures and oral mucosa. Some are transient adverse effects; others are local effects like pulp sensitivity, cervical resorption, release of selected components of dental restorative materials, and alteration of the enamel surface [17]. Bleaching solutions may be applied directly to the teeth, embedded

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in a plastic strip that is placed on the teeth or by using the gel form, deposited in a bleaching tray [18].

Tooth sensitivity is a typical side effect associated with tooth bleaching procedures. Transient mild to moderate tooth sensitivity can occur in up to two-thirds of users during early stages of bleaching treatment [19]. According to the Canadian consensus document [20], tooth sensitivity (TS) has been defined as pain derived from response to chemicals, thermal, tactile or osmotic stimuli, which cannot be explained as arising from any other dental defect or disease. TS generally related to the peroxide concentration of the bleaching material and the contact time, but is most likely the result of the easy passage of the peroxide through intact enamel and dentin to the tooth pulp, during a 5 to 15 minute exposure interval [19,21]. The incidence and the degree of tooth sensitivity depend on the properties of the bleaching material, the employed techniques, and on the individual's response of patients to the bleaching materials and methods [22].

The aim of our study was to analyse if there are differences in terms of tooth sensitivity (TS), between at-home and in-office bleaching agents used in tooth whitening, and also, if the high concentration of bleaching agents leads to increased TS.

Experimental part

Materials and methods

The requirements for an acceptable dental material are many, but one of the most important is the biocompatibility, because it should contain no toxic, leachable, or diffusible substances that can be absorbed into the circulatory system, causing systemic responses [23].

The bleaching agents for at-home use, utilised in our study were represented by Opalescence PF 10 and 20% (Ultradent Products, SUA), respectively for in-office use were represented by Opalescence Boost 40% (Ultradent Products, SUA) and Pola Office 35% (SDI Limited, Australia).

Opalescence PF 10 and 20% bleaching gels are syringe which contains 20% water to prevent dehydration. Their sticky and viscous formula helps keep the gel and tray in place. The gels do not contain potassium nitrate or fluoride. The compositions and the *p*H of at-home use bleaching agents utilized in study are presented in table 1 [24, 25].

Opalescence Boost 40% for in office use has 60 min bleach time. It is chemically activated, so it not requires light for whitening. Opalescence Boost 40% is in the form of two syringes: base and accelerator, which are putted in contact and mixed. Syringe-to-syringe mixing activates the product just prior to application. The activated 40% hydrogen peroxide is conveniently delivered via syringe and applied to teeth for whitening [26].

Pola Office 35% is a bleaching agent for in-office use. Pola Pola Office 35% is in the form of powder and liquid in the syringe, which is mixed before applying. Pola Office gingival barrier contain 83.95% methacrylic ester, 16% silica, 0.04% pigment and 0.01% butylated hydroxy toluene. The compositions of in-office use bleaching agents utilized in the study are presented in table 2 [27,28].

Our study was conducted in five Dental Faculties of Romania (Oradea, Bucharest, Craiova, Cluj-Napoca and Tirgu Mures). The patients were selected after a detailed anamnesis and were attended only by those that entered voluntarily in the research program and signed their consent forms for participation in the study. The established exclusion criteria were the presence of untreated caries/ occlusal pits/ fissures, incorrect restorations, ongoing orthodontic or periodontal treatment, the presence of gingival recession and/or non-carious cervical lesions, patients which presented systemic diseases, pregnant women or lactating mothers, patients with poor oral hygiene and those with initial dentinal sensitivity. The

Fig. 1. The presentation mode of bleaching agents used in our study: Opalescence PF 10%, Opalescence Boost 40% and Pola Office 35%

Bleaching agent	Opalescence PF 10%	Opalescence PF 20%
Composition	10% carbamide peroxide 0.5% potassium nitrate 0.11% fluoride ions (1000 ppm)	20% carbamide peroxide 0.5% potassium nitrate 0.11% fluoride ions (1000 ppm)
pH	6.5	6.5
Manufacturer	Ultradent Products, USA	Ultradent Products, USA

Table 1
COMPOSITION OF AT-HOME USE BLEACHING AGENTS UTILIZED IN STUDY

Bleaching agent	Pola Office 35%	Opalescence Boost PF 40%
Composition	Liquid: - 65% hydrogen peroxide - 35% distilled water - stabilizers; Powder: - 73.26% thickener - 26.2% catalyst - 0.04% dye - 0.5% potassium nitrate	40% carbamide peroxide 3% potassium nitrate 1,1% fluoride ions (1000 ppm)
pH	7	7
Manufacturer	SDI Limited, Australia	Ultradent Products, USA

Table 2
COMPOSITION OF IN OFFICE USE BLEACHING AGENTS UTILIZED IN STUDY

established inclusion criteria were patients who entered voluntarily in the research program and cooperating patients with good oral hygiene. After the initial examination and the medical history, from 200 patients initial included into this program, remained 161 patients at the study endpoint (71 males=44.09% and 90=55.90% females), aged between 19 and 40 years. The age range of the patients was with a median age of 29.5 years and a mean of 29.5±10.5 years (fig. 2).

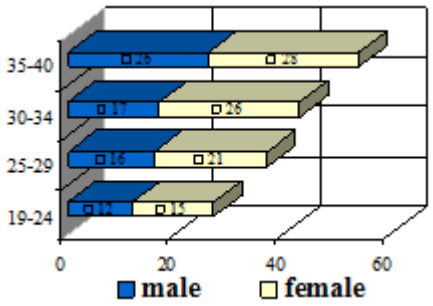

Fig. 2. Distribution of patients after age and gender

The used protocol consisted by the professionally cleaning of oral cavity and the choosing the specific manner tooth whitening/bleaching method, impression with alginate of the patients dental arches in universal trays, casting of impression and manufacturing the whitening trays by heat-forming, and training the patient, including the instructions for ensuring the oral hygiene and the list with the colorful foods and beverages. The color of teeth was determined both at the beginning and at the end whitening procedure, but the obtained color shade not represented the subject of this study. For the use at-home of bleaching agents, we gave to the patients the teeth whitening trays, 3 syringes with bleaching agent and the written instructions regarding the at home use of bleaching agents. The method of in-office use of the bleaching agents involves cleaning, isolation and drying the teeth, application of gingival barrier on gums and its polymerization, application of bleaching substance in whitening tray and on the teeth, its maintaining for 20 min and its reapplied if need. The products were prepared and used by following the instructions of the manufacturers.

The patients were divided into four groups, after the applied method of tooth whitening. After the teeth whitening sessions, the patients were recalled twice a week for two weeks, so that we conducted four sessions of determining and recording the tooth sensitivity (TS).

The determinations of TS were realised after the patient's response to air-blast stimuli, applied with the air-water syringe of the dental unit, for 15 s, at a distance of 5mm from the labial tooth surface. The neighbouring teeth were protected with dental gauze and operator's hand. We used the modified Visual Analog Scale to assess the TS, scored as follows: 0=no sensitivity; 1= moderate sensitivity, but no severe pain.

Results and discussions

Analyzing the number of studied patients, we observed that up to the last session were patients which were eliminated or by their absence at the sessions or by recording a high degree of the tooth sensitivity (TS) during and after whitening sessions (13 patients). Patients with very pronounced TS during and after teeth whitening were excluded.

First group of patients benefited at-home tooth whitening with Opalescence PF 10% and initially presented 50 patients, but at the study endpoint remaining 39 patients (all patients have completed the program of teeth whitening, and 7 patients was forced to abandon for personal reasons and 4 because of severe degree of TS at first determination). In the second group, the tooth whitening was realized with Opalescence PF 20%, but at the study endpoint remaining 38 patients (43 patients have completed the whitening program, but 5 patients presented high degree of TS). In the third group, with Pola Office 35%, from 50 patients remaining 41 patients (43 patients have completed the whitening program, but 2 patients presented high degree of TS during the tooth whitening). In the fourth group, with Opalescence Boost 40% gel, from 50 patients remaining 43 patients (45 patients have completed the whitening program, but 2 patients presented high degree of TS at second bleaching). The results of TS determined after bleaching are summarized in table 3, both in numbers and in absolute percentage.

It can be observed that the highest percentage of patients with TS at the end of the study was in the first (12 patients) and second group (24 patients) in comparison with the patients of third (2 patients) and fourth groups (2 patients). We also observed relative high values of TS in the fourth week of determinations. The smallest number of patients with TS was found in third and fourth group (4 patients with in-office tooth whitening).

The total distribution of TS degree of patients, in all four sessions of determinations, is presented in figure 3.

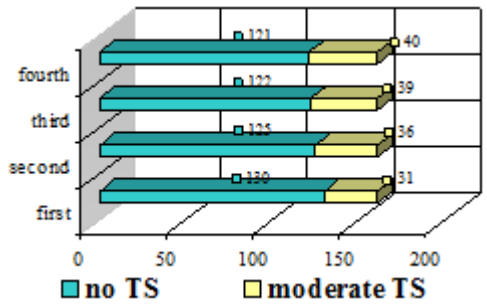

Fig. 3. Distribution of TS degree of patients in all four determinations

Determination / Responses	TOOTH SENSIBILITY (TS) DEGREE							
	Opalescence 10% 39 patients		Opalescence 20% 38 patients		Pola Office 35% 41 patients		Opalescence Boost 40%; 43 patients	
	0	1	0	1	0	1	0	1
First determination	33 84.61%	6 15.39%	20 52.63%	18 47.37%	38 92.68%	3 7.32%	39 90.69%	4 9.31%
Second determination	29 74.35%	10 25.65%	19 50%	19 50%	38 92.68%	3 7.32%	39 90.69%	4 9.31%
Third determination	28 71.79%	11 28.21%	16 42.11%	22 57.89%	38 92.68%	3 7.32%	40 93.02%	3 6.98%
Fourth determination	27 69.23%	12 30.77%	14 36.84%	24 60%	39 95.12%	2 4.88%	41 95.34%	2 4.66%

0=no TS; 1= moderate TS, but no severe pain

Table 3
PREVALENCE OF TOOTH SENSITIVITY REPORTED BY PATIENTS AFTER GROUPS

Subsidiary, we observed at final of whitening program that the tooth sensitivity degree remained moderate in the same patients. Starting from these findings, we had again a meeting with these patients who reported TS, for not omit a variable that can influence the results of the study. We applied a rating of anxiety (STAI 1) in these patients, and the results were: in 40 patients who were accusing moderate sensibility, 36 were tested positive for anxiety and in 13 patients with severe TS (those who left the program), 11 were tested positive for anxiety. Of course, it is necessary to continue the research in this area, because it seems that there are too other factors that influence the onset of TS after bleaching.

The great majority of people are able to tolerate tooth whitening sensitivity. Studies have shown that the prevalence of sensitivity during home-use or in-office bleaching treatments varies from 0 to 100% of participants [29]. Many authors reported a higher rate of TS for the in-office bleaching treatment compared with the at-home use technique, although others showed similar levels of tooth sensitivity when comparing both techniques [30,31]. These suggest that TS is not only related to the high peroxide concentration used in the in-office techniques, but it is also a symptom that may vary greatly from person to person.

Pola office 35% bleaching agent contain potassium nitrate as desensitizing agent, which acts on the nerve endings by blocking transmission of sensitive nerve impulses and providing a calming effect [31].

Wang et al [32] evaluated the efficacy of desensitizing agents, potassium nitrate and sodium fluoride, for tooth bleaching treatments and concluded that potassium nitrate and sodium fluoride reduce tooth sensitivity. This fact can be a motif of lower percentage of TS in patients with in-office tooth whitening, because both bleaching agents (Pola Office 35% and Opalescence Boost 40%) used in the third and fourth group of patients contain potassium nitrate.

Murariu et al [33], recommended to perform tooth whitening with low concentration of carbamide peroxide (10%), and shorten treatment time (<30 min), in order to reduce the possible destructions of dental structures. In their study, Vasluianu et al [34] utilised FTIR method for the analyse of dental structure after the use of 35% peroxide carbamide. They concluded that the concentration and the exposure time affect the dental structures, especially in higher concentration of 35% peroxide carbamide. After the researches of Munteanu et al [35], bleaching agents that contain 35% hydrogen peroxide and 17 or 15% carbamide peroxide increased the composite resins surface roughness. Moldovan et al [36] evaluated the colour modifications of some composites, in contact with different natural or artificial colorants and their behaviour after bleaching. The authors concluded that the bleaching agent with 35% carbamide peroxide was efficient, also to coloured composites in natural dye and in the coloured food. The studies of Filip et al [37], presented the first report referring to the organic acids from teeth bleaching gels prepared with natural fruit juices, as active agent with action on teeth coloration and stain removal. Mesaros et al [38] concluded in their studies regarding the shear bond strength of brackets that belongs to the bleaching groups had lower values, correlated with the incomplete diffusion of the peroxide into the tooth structure immediately after bleaching.

More recently, amorphous calcium phosphate (ACP) has been added to some of the tooth whitening products, to reduce sensitivity and the demineralization of enamel through a remineralization process after whitening treatments, and add a lustrous shine to teeth (Berger et al., 2012, cited by [7]).

Conclusions

Within the limitations of this study, the following conclusions can be drawn:

- We can not confirm the hypothesis that a higher concentration of active substance induced TS after whitening procedure;
- Our research shows that in-office method, even if the concentration of the bleaching agent is double (35-40% vs. 10-20%), are not so aggressive as those of at-home tooth whitening, because of lower contact time of tooth surface with the bleaching agent (20 min compared to several hours) and of the reduced number of sessions;
- After our results, is also possible to expand the researches in other directions, by identifying other factors that can lead to post-whitening tooth sensitivity (anxiety factors, environmental factors, and so).

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