Effect of different remineralization protocols on color change with two bleaching systems

Thesis submitted to the Faculty of Dentistry,

Ain Shams University in partial fulfillment of requirement

Of Master Degree in Operative Dentistry.

By

Ahmed Salah Abdel Aty Hassan

B.D.S., October 6 University (2009)

Faculty of Dentistry

Ain Shams University

2019

Supervisors:

Dr. Mokhtar Nagy

Professor of Operative Dentistry Department,

Faculty of Dentistry, Ain Shams University.

Dr. Khaled Aly Nour

Assistant Professor of Operative Dentistry Department,

Faculty of Dentistry, Ain Shams University.

Dr. Dena Safwat Mohamed Mustafa

Lecturer of Operative Dentistry Department,

Faculty of Dentistry, Ain shams University.

Acknowledgement

First of all, I would like to thank God Almighty for giving me the strength to accomplish this work.

I am greatly honored to express my gratitude to **Dr. Mokhtar Nagi Ibrahim**, Professor of Operative Dentistry, Faculty of Dentistry, Ain Shams University.

I would like to express my sincere thanks and deep gratitude to **Dr. Khaled Aly Nour,** Assistant Professor of Operative Dentistry Department, Faculty of Dentistry, Ain Shams University, for his valuable unlimited guidance, and mentor attitude. I benefited greatly from his experience and knowledge throughout the research work.

I would also like to express my deepest thanks and gratitude to **Dr. Dena Safwat Mohamed Mustafa**, Lecturer of Operative Dentistry Department, Faculty of Dentistry, Ain shams University**,** for her continuous support during preparation of this work.

For my family, especially, my Parents and my wife for their continuous support and care.

List of Contents

List of Tables

List of Figures

Color has been regarded as an important factor for esthetics. A discrepancy in tooth color may be perceived more quickly than any other anatomical dental alteration. [1] With careful diagnosis and appropriate attention to technique, bleaching can be considered a conservative and safe approach to treat discolored teeth. Different methods and concentrations of bleaching gels have been described for vital teeth bleaching. Regardless of the method used, all bleaching agents are based on the use of Hydrogen peroxide or carbamide peroxide. [2]

The color change of tooth structure achieved by bleaching occurs by Hydrogen Peroxide dissociation into free radicals. Because of its low molecular weight, Hydrogen peroxide diffuses deeply through tooth structures toward the dentin to reach organic molecules. It changes the chemical structure of molecules by attacking chromophores, causing their degradation resulting in a bleaching effect. [3]

Unfortunately, many clinical studies have demonstrated that more than 63% of the patients experience post-operative complaints of tooth sensitivity. Demineralization and calcium loss have also been reported in bleached enamel. Also, microscopic changes, such as increased porosity, superficial irregularities, increased roughness and decreased hardness have been associated with bleaching. [4] Therefore, many strategies were developed to overcome this change of tooth structure. Among these strategies was the application of a desensitizing agent and using the remineralization agent. The addition of desensitizing gel containing 5% potassium nitrate and 2% sodium fluoride to the bleaching agent was developed in an attempt to reduce the incidence and intensity of hypersensitivity. [5] Another strategy is using remineralizing agents to increase the hardness and acid resistance of demineralized teeth and treating the tooth sensitivity by occluding the dentinal tubules and reducing dentinal fluid flow. A calcium phosphate remineralization technique based on casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) has been developed. The use of bleaching techniques modified by remineralizing agents such as (CPP-ACP) has been suggested aiming to replace the minerals lost after bleaching to reduce demineralization and enhance remineralization. [6]

On the other hand, it is believed that the use of remineralization agents (CPP-ACP) during bleaching will lead to chemical reaction on enamel surface with increased hydroxyapatite crystals size which may impair the enamel's permeability and consequently impair the quality of the bleaching treatment. [7] The penetration of reactive oxygen species and free radicals may be prevented by the deposition of ionic crystals on the tooth surface. [2] So the question that remains to be answered: will these protocols affect the effectiveness of the bleaching procedure itself. Therefore, it was found beneficial to study the effect of those remineralizing agents on the color change occurring in enamel.

Tooth discoloration is broadly classified as extrinsic or intrinsic, depending on the origin of the stain. [8] Extrinsic stains arise due to the accumulation of residue on the enamel surface and can be accentuated by pitting or irregularities of the enamel, salivary composition, salivary flow rates, and poor oral hygiene. Extrinsic stains take on a variety of colors, which reflect the nature of the stain. Despite the fact that extrinsic discolorations may vary in color, severity, and location, all stains can be easily removed by dental prophylaxis. [9]

Intrinsic stains are usually caused by deeper internal stains or enamel defects. They are caused by aging, ingestion of chromatogenic food and drinks, tobacco usage, enamel microcracks, tetracycline medication, excessive fluoride ingestion, severe jaundice in infancy, porphyria and the thinning of the enamel layer. [10] Aging is a common cause of discoloration. [11] Intrinsic stains cannot be removed by regular prophylactic procedures it can be removed with tooth whitening. Tooth stains caused by aging, genetics, smoking, or coffee are the fastest to respond to bleaching. Yellowish aging stains respond quickly to bleaching in most cases, whereas blue-gray tetracycline stains are the slowest to respond to bleaching, while teeth with brown fluorescence are moderately responsive. [12]

Although a wide variety of whitening products are currently available, in most cases, Hydrogen peroxide is the most common active agent used in whitening. Hydrogen peroxide is slightly more viscous than water and acts as a strong oxidizing agent. [13] The rate of decomposition and the type of active oxygen formed depends on the temperature and concentration of peroxide, as well as the pH and presence of co-catalysts. [3] In concentrated Hydrogen peroxide solution at room temperature, the peroxide molecules exist in equilibrium with protons and perhydroxyl ions through the reaction:

$$H_2O_2 \leftrightarrow H^+ + HOO^-$$

This gives rise to an acidic pH of typically ~4. If the pH is adjusted upwards, then this reaction is driven towards completion and large concentrations of perhydroxyl ions are generated. [14]

When the solution is heated this reaction rate increases, but at the same time the peroxide decomposes according to the following reaction:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

This is accelerated at high pH. This exothermic reaction can lead to the bubbling of the solutions under certain conditions and even to thermal-run-away, which is undesirable since it produces no reaction with the stain molecules.

The anticipated final outcome of tooth whitening is to increase color lightness and reduce chroma in the yellow-blue and red-green spectra based on the CIE Lab system. [15] Changes in the enamel have been attributed to micromorphological alterations through deproteinization, demineralization, and oxidation of the most superficial enamel layer. [16]

Effect of bleaching agents on tooth structure:

A) Change in Color of Tooth Structure:

The bleaching process is believed to occur via the action of the low-molecular-weight HP, which easily diffuses through the enamel and dentin, releasing reactive oxygen species that effectively promote the oxidation of the organic substrate present in the tooth structure. As a result, dental pigmentation molecules become simpler or are eliminated.

The factors that make the bleaching process more effective:

1) The need to irradiate the in-office bleaching product with a light source.
2) HP concentration in bleaching gels.
3) Contact time of the product with the dental surface.
4) The need for reapplication of the product on the tooth surface at the same session.
5) The composition of the bleaching gel.
6) Combined use of at-home and in-office bleaching techniques. [17]

The use of irradiation of in-office bleaching with a light source is known as power bleaching which accelerates the bleaching procedure the action mechanism proposed for

irradiation with light is based on thermo catalysis, resulting in a twofold increase in HP decomposition with a temperature increase of 10 °C. Patients who underwent bleaching with light irradiation reported a longer duration and greater intensity of tooth sensitivity. [18]

In relation to the HP concentration used in the in-office technique, the color change was saturated after three or four sessions when 35 % HP gels were used, with about 50–60 % of the color change obtained after the first bleaching session. The advantage of using in-office bleaching materials of lower concentration is based on the fact that these products minimize HP diffusion over the tooth structure by about 60 %, which has a positive biological effect on pulp cells.[19] The bleaching gels with reduced HP concentration can reach the same bleaching standard attained with more commonly used higher HP concentrations. However, the effects of lower HP concentrations are more gradual and depend on the intensity of the stains. [20] Similar results were obtained for the at-home bleaching technique. After treatment, gels with 16 % and 20 % CP were observed to have the same bleaching potential as a 10 % CP gel, with the latter resulting in less tooth sensitivity and lower incidence of soft tissue irritation. [21]

Regarding reapplication of the bleaching product during the same clinical session. It was found that that bleaching gels with 35–38% HP retains about 86% of the initial concentration of HP after 45 min of contact with the tooth structure. [22]

B) <u>Effect on sensitivity of tooth structure:</u>

Tooth sensitivity is the most frequent clinically detectable side effect of the bleaching treatment. [23.24] The etiology of this sensitivity results from the easy passage of the Hydrogen peroxide through the enamel and the dentin to the pulp, which takes 5 to 15 minutes and it is shown that the dentin changes color next to the pulp as fast as it does next to the dentin-enamel junction. [25] This penetration of HP in dental pulp results in the release of biochemical mediators involved in the inflammatory process, which sensitize the pulp nociceptors and play a role in pain modulation by causing an increase in vascular permeability and vasodilation, changing the sensitivity threshold of nerve fibers. [26]

The methods used to minimize patient discomfort rely on the administration of analgesics and/or the use of topical desensitizing agents, which may be added into the composition of bleaching agents. Several types of desensitizing agents with different action mechanisms have been used, some having physical action that seals the dentinal tubules and others having neural action that blocks nerve stimulation. [27] In fact, some desensitizers are effective and reduce the discomfort caused by the bleaching treatment. The bleaching agents containing Potassium nitrate showed a reduction in the neurosensorial response of teeth. Potassium nitrate penetrates the enamel and dentin to travel to the pulp and creates a calming effect on the nerve by affecting the transmission of nerve impulses. Potassium nitrate has almost an anesthetic effect on the nerve. The bleaching agents containing fluoride could counteract any deleterious effect of bleaching agents on tooth structure. It is well known that fluoride inhibits enamel demineralization and enhances remineralization. [28]

Navarra CO et al., 2014 evaluated the effects of two 10% carbamide peroxide agents with or without fluoride and potassium nitrate on color change, tooth sensitivity and enamel morphological changes by using twenty subjects used a 10% carbamide peroxide gel with or without fluoride and potassium nitrate for 2 weeks. Spectrophotometric evaluation of color change and morphological analyses of replicas with scanning electron microscope (SEM) were performed before and after treatment. They found that no difference in bleaching effectiveness was found between the tested bleaching gels and both bleaching agents induced sensitivity; however, the 10% CP bleaching agent with fluoride and potassium nitrate produced significantly lower sensitivity than the bleaching product without desensitizing agents. The SEM analysis confirmed the absence of relevant alterations of the enamel surface in both groups. [29]

Alexandrino L et al., 2014 evaluated the effects of a bleaching treatment containing 35% Hydrogen Peroxide with or without calcium on bovine enamel, using the Knoop hardness number (KHN), tristimulus colorimetry (TC), and scanning electron microscopy. Forty-five specimens were randomly divided into groups (n = 5), which included artificial saliva (negative control [NC]), 35% HP (positive control [PC]), and 35% HP Blue Calcium (HP Blue). Before and after bleaching, KHN tests were conducted using a force of 25 gf for

5 s. Tooth Color was performed using the CIE-L*a*b* system and readouts were obtained at the following 4 time points: Before the bleaching treatment; after the first session, the second session, and the third session. The specimens were dehydrated and coated with gold, and the photomicrographs were analyzed in a double-blind manner with a LEO microscope. They found that treatment with HP containing calcium prevented changes in the microhardness without reducing the efficacy of bleaching. [30]

Wang Y et al., 2015 evaluated the efficacy of sodium fluoride and potassium nitrate as desensitizing agents during tooth bleaching treatment. They found that sodium fluoride and potassium nitrate reduce tooth sensitivity while no consistent conclusion of tooth color change was found. [31]

Bernardon JK et al., 2016 evaluated effectiveness of 4 carbamide peroxide-based bleaching gels containing sodium fluoride regarding to color change, tooth sensitivity, degree of participant satisfaction, and gingival irritation. The maxillary arch of the 50 participants was bleached using a split mouth, home-bleaching technique. The participants were divided into 2 groups: G1, 10% CP (Opalescence PF; Ultradent Products, Inc) (right) and 10% CP (Power Bleaching 10%; BM4) (left); and G2, 15% CP (Opalescence PF) (right) and 16% CP (Power Bleaching 16%) (Left). Each gel was used in a 2-hour daily regimen for 45 days. The shade of the 6 maxillary anterior teeth was recorded with a shade guide and spectrophotometer at baseline, and after 15, 30, 45, and 180 days of treatment. Tooth sensitivity was evaluated with a visual analog scale (rated on a 0 to 10 scale). They found that the sodium fluoride was effective in reducing tooth sensitivity during and after bleaching and did not compromise the effectiveness of treatment. [32]

Kyaw KY et al., 2018 evaluated the effect of sodium fluoride (NaF) on the bleaching efficacy using an artificial discolored bovine tooth model. Twenty specimens were prepared from bovine teeth by staining with black tea extract and were divided into two groups (n = 10). In control group, specimens were immersed in distilled water for 30 min. In NaF group, specimens were applied with 0.2% NaF for 30 min. Then, the specimens in each group were bleached by an in-office bleaching material. The CIE L*a*b* values were measured by a dental colorimeter before and after 10 consecutive bleaching treatments, and the color