

Effects of External Bleaching on the Hard Tissues of the Front Teeth

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The aim of the study was to evaluate the effect of external tooth bleaching on dental hard tissues, studying the dissolution of different ions, such as: chloride, magnesium, calcium and phosphate. For this purpose there were used eighteen extracted maxillary central incisors and three bleaching materials. None of the materials was found to be better than the others. The dissolution of chloride and calcium showed the lowest values, the major dissolution showed the phosphate ion, followed by the magnesium ion.

Keywords: bleaching, dissolution, ions

Aesthetics constitutes an increasingly important element of the modern dental medicine, most often tooth bleaching treatment being highly required in dental aesthetics category. This is due to the major importance that society attaches to exterior appearances. Modifications in the colour of the teeth occur due to extrinsic and intrinsic factors, in addition to changes associated with aging [1].

Intrinsic discoloration can be caused by abuse of fluoride (F⁻), different medication intake, progressive dystrophies, physiological process of aging, iatrogenic or traumatic factors, disorders of the dental pulp or certain systemic diseases [2]. Extrinsic discoloration – smoking can lead to severe and stubborn discoloration, while tea, coffee and red wine are associated with surface dyschromias. The consumption of certain types of food may lead to discoloration of teeth surfaces. It is well known that medium and long-term use of a mouthwash with chlorhexidine gluconate (C₃₄H₅₄Cl₂N₁₀O₁₄) causes tooth discoloration as well as the use of other specific therapeutic agents [1,3]. Age-related discoloration results from a combination of a slimmed enamel by the extrinsic discoloration and a discoloured dentin [4,5].

Tooth bleaching is not a new technique in dentistry. It was recorded over a century ago. Tooth whitening treatment means changing the colour of teeth chemically. Due to the low molecular weight of the bleaching solution, it will penetrate into the dental tissue, followed by a process of decomposing, hence will form free, unstable radicals. These unstable molecules, to reach a stable state, will bind to the double bonds of the molecules of colouring substances, thus changing their capacity to absorb light. In general, bleaching best results are obtained in cases of light and medium discoloration of the teeth, the degree of whitening is dependent on the structure and type of colorants to which the teeth are frequently exposed [6,7].

The aim of the present paper was to evaluate the effect of external tooth bleaching on dental hard tissues, studying the dissolution of different ions.

Experimental part

Materials and methods

In present research it had been compared the effects on the tooth enamel of three bleaching solutions available on the market (Opalescence, Pola Office, Signal White).

For this purpose totally eighteen maxillary central incisors were collected, extracted due to advanced stages of periodontal disease. These teeth were selected due to the fact that they constitute a particularly important group of teeth in terms of aesthetics, situated at the sight. Immediately after extraction the teeth were kept in artificial saliva prior to their processing, so it had been tried to imitate the similar conditions that generally can be found in the oral cavity.

For easy handling during the study, teeth were treated at the apical part with 37% phosphoric acid, bonding and composite material in which it had been introduced a piece of wire.

With the help of the wire the eighteen teeth were suspended so that only the crown part to be placed in artificial saliva (3 ml), thus the root of the tooth it had been excluded from the study, being unable to influence the results. Each tooth was separately suspended in a sterile, transparent container for one week (fig. 1).



Fig. 1. A tooth suspended in artificial saliva trough a wire in a sterile container
(F- = the tooth came from a non smoker patient,
L+ = whitening lamp was associated to the bleaching process, PO= Pola Office material)

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After these seven days the teeth were divided into three groups according to the three different bleaching material (Opalescence (O), Pola Office (PO), Signal White (S)). After these considerations the bleaching material it had been placed on the vestibular (buccal) enamel of each tooth. Thus each group contained six teeth out of which three teeth have been selected to be treated with whitening lamp (L+) (fig. 2). In case of the other three teeth it had not been used the whitening lamp, only the bleaching material itself (L-).



Fig. 2. Whitening lamp associated bleaching of the teeth

Each subgroup's tooth came from a smoker patient (F+). After the first round of twenty minutes of bleaching teeth was washed with water, dried, this process was followed by the second half of whitening.

After completing all the whitening procedures teeth were reintroduced in artificial saliva and it had been established the quantity of *calcium, chloride, magnesium, phosphate* ions (Ca^{2+} , Cl^- , Mg^{2+} , PO_4^{3-}) dissolved in artificial saliva using biochemical methods.

The dosage of calcium by complexometric method [8,9]

0.01 N EDTA solution (*EthyleneDiamineTetraAcetic acid* $\text{C}_{10}\text{H}_{16}\text{N}_2\text{O}_8$) was placed in a burette and the original volume had been read. Nineteen Erlenmeyer flasks were prepared, eighteen for the samples and one for the witness, blank. To each flask it was added 1 mL of artificial saliva using the pipette. 25 mL of doubly distilled water were placed in the flasks for samples and 26 mL for blank. $2 \times 50 \mu\text{L}$ 9N *sodium hydroxide* (NaOH) solution was added with the pipette (calibrated $50 \mu\text{L}$) to each Erlenmeyer flask and one drop of *murexide* indicator ($\text{C}_8\text{H}_8\text{N}_6\text{O}_6$) until it was obtained a pink colour. Samples were titrated with 0.01 N EDTA until the colour changed from pink to purple (1) (fig. 3).

Calculation: the complex from 1 mL solution complexes 0.2 mg Ca^{2+} :

$$1 \text{ mL EDTA } 0.01\text{N} \dots\dots\dots 0.2 \text{ mg Ca}^{2+}$$

$$(A - B) \times \text{FEDTA} \dots\dots\dots X$$

$$X = (A - B) \times \text{FEDTA} \times 0.2 \quad \text{mg Ca}^{2+} / 2 \text{ mL}$$

A= volume EDTA in mL used for titration of the sample



Fig.3. The nineteen samples after titration with 0.01 N EDTA - dosage of calcium by complexometric method

B= volume EDTA in mL used for titration of the standard

$$\text{FEDTA} = \text{Factor EDTA} \quad (1)$$

The dosage of magnesium by Mann and Yoe method [8, 9]

Twenty test tubes were prepared for samples and two for standard. 1 mL of buffer it had been placed in each of the twenty test tubes. For the samples it was measured 0.02 mL of standard *magnesium*. The samples were shook well and it has been added in each one 1 mL of reagent Mann and Yoe (fig. 4). 15-30 min after it was read the sample and standard extinction in 1 cm cuvette at $\lambda=505 \text{ nm}$ (2).



Fig.4. The purple colour of the samples after placing the Mann and Yoe reagent - dosage of magnesium

$$\text{Calculation : } E_p / E_s \times 2 = \text{mg Mg}^{2+} \%$$

E_p = extinction of the samples

E_s = extinction of the standard

(2)

Determination of chloride ion in the serum by the Schales method [8, 9]

It had been prepared a burette with solution of 0.01 N *mercury nitrate* ($\text{Hg}(\text{NO}_3)_2$) and nineteen Erlenmeyer flasks, eighteen for samples and one for blank, witness. 1 ml of double distilled water was added in each Erlenmeyer flask with the pipette. It has been inserted in each sample flask: 0.1 mL of artificial saliva, a drop of *sulphuric acid* (H_2SO_4) and two drops of *diphenylcarbazide* indicator ($\text{C}_{13}\text{H}_{14}\text{N}_4\text{O}$). Titration with 0.01 N *mercury nitrate* had been carried out until the same purple colour changing (fig. 5) The volume in ml used for titration of the sample (v_1) and that of the standard (v_2) were noted (3).



Fig. 5. The sample after titration with 0.01 N $\text{Hg}(\text{NO}_3)_2$ - dosage of chloride by the Schales method

Calculation:

$$1 \text{ mL Hg}(\text{NO}_3)_2 \text{ } 0.01 \text{ N corresponds to } \dots\dots\dots 0.355 \text{ mg Cl}$$

$$v_1/v_2 \dots\dots\dots X$$

$$X = \text{mg Cl} / 0.1 \text{ mL serum} = v_1 / v_2 \times 0.355 \quad (3)$$



Fig. 6. The samples after introducing all the reagents (ammonium molybdate, sodium sulfate, hydroquinone, double distilled water) next to the spectrophotometer - dosage of phosphate ions by Briggs method

The dosage of serum inorganic phosphate by the Briggs method [8, 9]

Twenty test tubes were prepared, eighteen for the samples and two for witness, blank. It had been inserted 1 mL artificial saliva in the sample tubes, and in that of the blank, 1 mL doubly distilled water. In the twenty test tubes there were added the following: 0.2 mL of ammonium molybdate ($(\text{NH}_4)_2\text{MoO}_4$), 0.2 mL of sodium sulfate solution ($\text{Na}_2\text{O}_4\text{S}$), 0.2 mL hydroquinone ($\text{C}_6\text{H}_4(\text{OH})_2$) and 0.4 mL of double distilled water (fig. 6).

The contents of the test tubes were mixed and 30 min after it had been read the extinction of the probe against the witness, blank at $\lambda=600$ nm.

Data were statistically analyzed in GraphPad (InStat) based on ANOVA, Kruskal-Wallis and Mann-Whitney tests.

Results and discussions

The statistical results have given significant differences between all three groups of materials used (Signal White/Opalescence/Pola Office) in association with the whitening lamp, what means that the dissolution of the phosphate ($p=0.0207$) and magnesium ($p=0.0031$) ions was significantly higher, as in case of chloride ($p=0.1543$) and calcium ($p=0.0914$) ions, which have not have a statistically significant dissolution. This means the following:

- regarding the phosphate ions the differences were statistically highly significant between Opalescence and Signal White ($p=0.0073$, $\text{CI}=95\%=0.3748-0.4242$), as was observed in the case of magnesium ions as well ($p=0.0010$, $\text{CI}=95\%=0.002086-0.007754$), noting that in case of utilization of whitening lamp associated Opalescence the dissolution of phosphate ions was greater, while the dissolution of magnesium ions showed the highest peak when whitening lamp associated Signal White was used.

Regarding the phosphate ions there were established statistically significant differences ($p=0.0448$) between the three types of bleaching materials used in the study without the association of the whitening lamp to the treatment. The difference was noticeably higher between the bleaching with Opalescence and Pola Office ($p=0.0180$, $\text{CI}=95\%=0.3361-0.3668$), noting that it was observed a faster and increased dissolution when using Opalescence bleaching material. There were not established statistically significant differences in case of other ions, as it follows: chloride ($p=0.9349$), calcium ($p=0.7491$) and magnesium ($p=0.1252$).

Regarding the comparison of different ions' degree of dissolution in case of bleaching with- and without associating the whitening lamp, there were established major differences in case of: - phosphate ions ($p=0.0122$) in case of all materials used, especially between lamp

Dissolution of magnesium ion- Opalescence

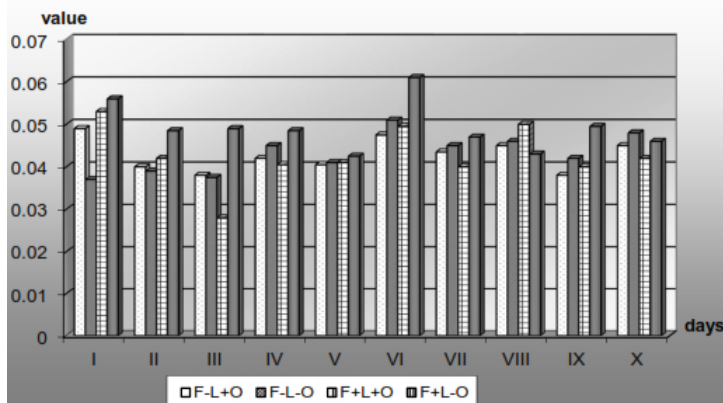


Fig. 7. Tracking of the dissolution of magnesium ion during ten days after bleaching with Opalescence material (F=non smoker, F+= active smoker, L=bleaching without whitening lamp, L+=bleaching with whitening lamp, O = opalescence)

associated Opalescence and the same material without the lamp ($p=0.0012$, $\text{CI}=0.3748=0.4242$).

- magnesium ions ($p=0.0049$) in case of all materials used, especially between lamp associated Opalescence and the same material without the lamp ($p=0.0061$, $\text{CI}=95\%=0.001182-0.006778$).

Regarding the dissolution of other ions there were not established significant differences: chloride ($p=0.4633$) and calcium ($p=0.3370$).

Following the dissolution of the studied ions during ten days it was found that:

- in case of magnesium ion's dissolution the highest values were recorded in the first and sixth day (Signal White, Opalescence), and only in the first day when Pola Office was used (fig. 7);

- the chloride ion's dissolution reached its highest peak in the first two (Opalescence), four (Signal White) and six days (Pola Office) (fig. 8);

- regarding the dissolution of the calcium ions the results were identical for all the three materials: the highest values have been recorded in the first two days (fig. 9);

- in case of phosphate ions' dissolution the highest values were observed in the sixth day (Signal White, Pola Office) and in the sixth and ninth day (Opalescence) (fig. 10).

Generally speaking the majority of teeth bleaching techniques used in the private practice, prescribed by the dentist or used at home shown to be effective, although the results may vary depending on factors such as: the type of the stain, the age of the patient, the concentration of the active agent, the length and the frequency of the treatment [10]. In all cases a dental examination, including

Dissolution of chloride ion - Opalescence

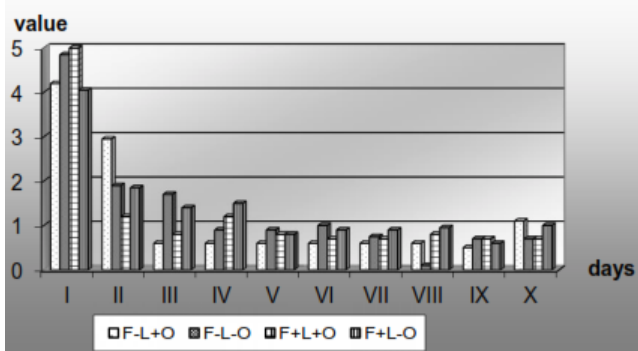


Fig. 8. Tracking of the dissolution of chloride ion during ten days after bleaching with Opalescence material (F=non smoker, F+= active smoker, L=bleaching without whitening lamp, L+=bleaching with whitening lamp, O = opalescence)

Dissolution of calcium ion - Opalescence

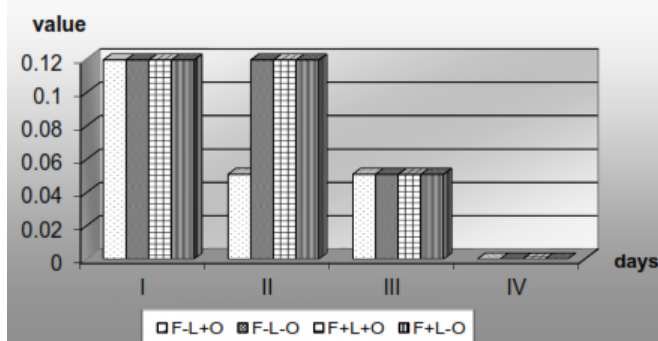


Fig. 9. Tracking of the dissolution of calcium ion during four days (after the 4 th day the results were the same) after bleaching with Opalescence material (F-=non smoker, F+= active smoker, L-=bleaching without whitening lamp, L+=bleaching with whitening lamp, O = opalescence)

the necessary X-rays, should precede the retreatment. When the bleaching is made in the private practice (so called *chair side*), the proper isolation and protection of the tissues of oral mucosa are essential. Dentists can also opt to prescribe NSAIDs (NonSteroidal Anti-Inflammatory Drug) prior to treatment because the sensitivity after treatment is unpredictable [11]. In some cases it was found that the temperature of the dental pulp may be increased in case of using the whitening lamp according to the light source and the exposure range. An in vitro study suggest that the use of certain lights can lead to increased radiation exposure levels associated with light approaching or exceeding safety limits [11]. Dental pulp irritation and tooth sensitivity may be higher when using whitening lamp or heat, therefore, it is recommended their safe and prudent utilization.

During their investigation regarding the effect of peroxides on tooth enamel Aboussi and colleagues found both qualitatively and quantitatively a slight difference between *carbamide peroxide* ($\text{CH}_4\text{N}_2\text{O}\cdot\text{H}_2\text{O}_2$) and *hydrogen peroxide* (H_2O_2). The effect of the bleaching material on dental hard tissues depends on the concentration of active components of the whitening material [12].

Similar results, regarding the effect of peroxides on dental hard tissues, were found by Bistey and colleagues, which enhances the increased effects of *carbamide peroxide* and *hydrogen peroxide* on tooth enamel. Morphological changes of the surface of the tooth enamel are proportional to peroxide concentration. The changes that take place in the inorganic content of the teeth, that includes the dissolution of different ions as well, are directly proportional to the concentration of the peroxide [13].

Although in the last ten years it has increased the use of bleaching materials, the patients has to be informed regarding the undesired, negative sides of tooth whitening as well.

Conclusions

The amount of dissolved ions under the action of bleaching material in case of teeth received from active smoker patients, respectively in case of those from non-smoker patients, it was found to be similar.

Following the dissolution chart of the ions for ten days it was found that it is almost identical in case of the three bleaching materials used, with very small differences.

It can be noted that none of the material is better than the other each material is the same in terms of dissolution of the studied ions.

Dissolution of phosphate ion - Opalescence

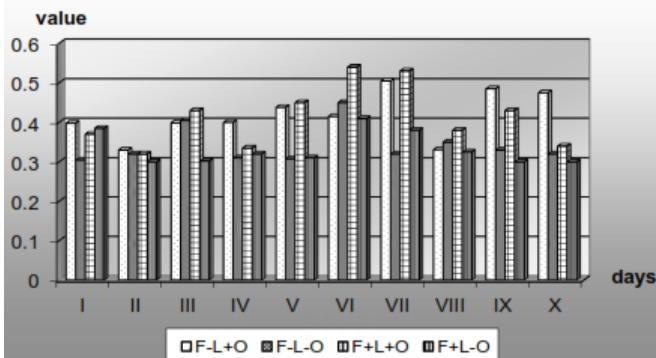


Fig.10. Tracking of the dissolution of phosphate ion during ten days after bleaching with Opalescence material (F-=non smoker, F+= active smoker, L-=bleaching without whitening lamp, L+=bleaching with whitening lamp, O = opalescence)

The dissolution of *chloride* and *calcium* ions was not influenced after the bleaching process by the type of material used, nor the association/ non-association of the whitening lamp to the treatment.

In case of phosphate ions the dissolution was greater when whitening lamp was associated, especially in case of Opalescence. The dissolution of magnesium ions was higher when the whitening lamp was not associated to the bleaching treatment, especially in case of Opalescence.

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