ORIGINAL ARTICLE

EXPERIMENTAL STUDY OF CHANGES IN THE CHEMICAL COMPOSITION OF TOOTH ENAMEL WHEN USING HYDROGEN PEROXIDE AS THE MAIN CHEMICAL COMPONENT IN PROFESSIONAL BLEACHING

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ABSTRACT

The aim: To study changes in the chemical composition of the tooth enamel surface when using hydrogen peroxide as a chemical component of the whitening system in combination with professional oral hygiene.

Materials and methods: To achieve this goal, during the study, we studied the enamel of the teeth of the frontal area, which was removed for orthodontic and orthopedic indications. The age of the patients whose teeth were examined ranged from 18 to 44 years. In the experiment, we studied the chemical structure of enamel by a method thatcovered the selection of the study area, with the designation of areas for microanalysis, and subsequent elemental analysis in selected areas of the enamel.

Results and conclusions: Analyzing the results of this study, we can make assumptions about the impact of professional dental hygiene on the procedure of photo-whitening teeth based on 35% hydrogen peroxide gel and its subsequent impact on theother clinical indicators, which will depend on the characteristics of functional and structural resistance of the enamel.

KEY WORDS: teeth whitening, tooth color, aesthetics, chemical composition of enamel, hydrogen peroxide

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INTRODUCTION

The aesthetics of a smile needs further study and improvement. This is confirmed by scientific studies, which were published based on the results of social surveys [1,2].

74% of respondents believe that an imperfect smile has a negative impact on their career, and 92% believe that it contributes to success in personal life. The desire of patients to have an aesthetically perfect smile has always aroused great interest of dentists and led to the active development of such a direction in aesthetic dentistry as restoration and teeth whitening [3].

Much attention in this aspect is paid to the issue of tooth color in connection with the increased aesthetic requirements of patients to restore or reconstruct their smile [4]. The procedure of professional whitening in modern dentistry is quite a popular method. Various clinical and experimental aspects of the effect of whitening systems on the structure of tooth hard tissues are reflected in the modern literature. Teeth whitening is a chemical oxidation process in which free radicals of hydrogen peroxide are released, which leads to the lightening of the hard tissues of the tooth. Currently, teeth whitening is popular as a non-invasive way to improve the aesthetics of dentitions[5,6].

Methods of correction of tooth discoloration are quite diverse. Modern bleaching systems are based on the use of hydrogen peroxide or urea peroxide in combination with activating factors [7]. Bleaching substances are applied externally or placed internally in the tooth cavity during whitening depulped teeth. In both cases there is a tendency to whiten the chromogens inside the dentin, thus changing the basic color of the tooth [8,9].

THE AIM

The purpose of this study became a study changes in the chemical composition of the tooth enamel surface when using hydrogen peroxide as a chemical component of the whitening system in combination with professional oral hygiene.

MATERIALS AND METHODS

To achieve this goal, during the study, we studied the enamel of the teeth of the frontal area, which was removed for orthodontic and orthopedic indications. The age of the patients whose teeth were examined ranged from 18 to 44 years according to the WHO classification (2018).

In the experiment, we studied the chemical structure of enamel by specially preparing teeth and establishing areas for chemical microanalysis.

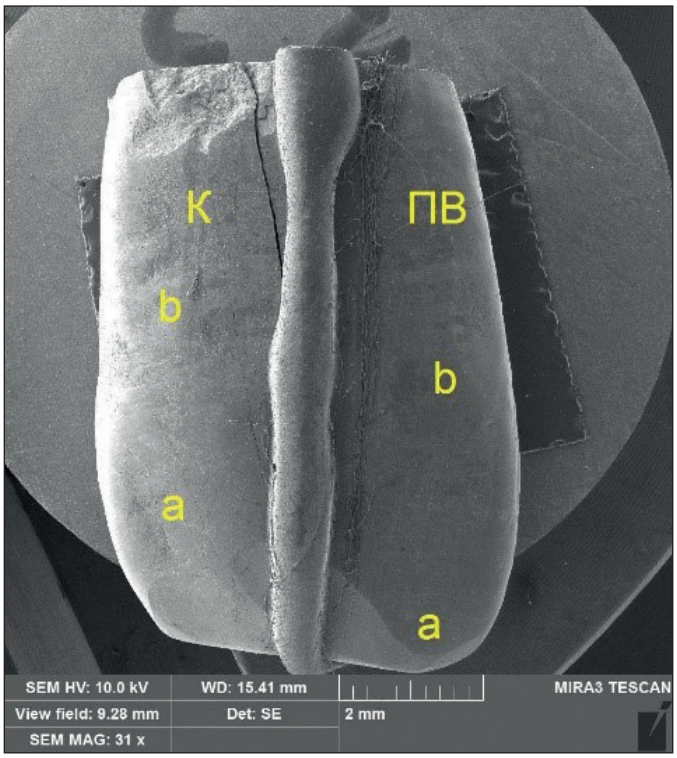

Fig. 1. Photo of the examined tooth 21 from group II with the applied distribution line (control - right, left - application of hydrogen peroxide without prior professional hygiene).

The study was performed using an energy-dispersive spectrometer "X-max 80mm2" ("Oxford Instruments", UK), which was integrated into a scanning electron microscope. The research was conducted on the basis of the Paton's Institute, Department of Nanomedical Technology (Kyiv).

The proposed research system allowed to determine the chemical structure of the enamel without the traditional procedure for dielectric samples to cover the surface with a thin layer of conductive material (C, Au, Pt). It was possible to prevent surface charge due to the significant reduction of the probe current and the high sensitivity of the detectors. The study of the elemental composition using an energy-dispersive spectrometer allows to detect chemical elements in the sample with atomic numbers from 4 to 92 and to quantify their composition.

To analyze and compare the composition and characteristics of the samples, an algorithm for their evaluation was developed, the same for all samples studied.

The method included the selection of the studied area with the designation of areas for microanalysis, followed by elemental analysis in selected areas of the enamel. Areas of microanalysis were zoned, depending on the effect of the chemical agent on the enamel surface.

The peculiarity was that the study areas differed from the right and left sides of the tooth, due to the fact that the left side in the examined teeth was the control area, and the right side allowed us to conduct and compare changes in the chemical component of enamel in each tooth. , by comparing indicators with each other.

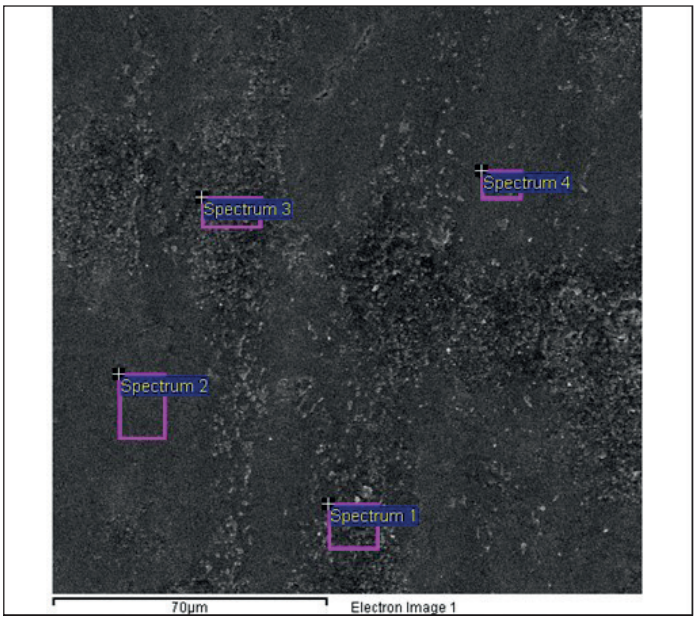

Fig. 2. Areas for studying the micronutrient composition of tooth 21 from the II research group (right).

To carry out laboratory methods of research, the studied teeth were divided into two groups, the vestibular surface of the teeth under study was conditionally divided into two sides - one of which served as a control, and the other was used to apply whitening chemicals:

Group I - teeth, without prior professional hygiene, for whitening which used the method of photobleaching using 35% concentration of hydrogen peroxide.

Group II - teeth with previous professional hygiene, for whitening which used the method of photobleaching using 35% concentration of hydrogen peroxide.

The technique of professional oral hygiene included the following stages:

1. Removal of hard and soft dental plaque with an ultrasonic tip.
2. Polishing enamel with a medium-hard nylon brush and polishing paste Cleanic (Kerr) RDA 27.

Next, a professional bleaching procedure was performed using a cold light lamp (Philips ZOOM! White Speed) and gels based on 35% hydrogen peroxide.

RESULTS AND DISCUSSION

Description. Teeth taken for the experiment were to be removed from orthodontic and orthopedic indications. The tooth to be examined (Fig. 1) was divided into 2 parts using a liquid rubber dam.

Markings were made: K-left side of the control, PV-right side, the area that was subject to professional hygiene (or without) and professional bleaching with 35% hydrogen peroxide, and b - areas that were taken for the study of enamel.

Next, the analysis of micro-plots was performed and data were obtained. In fig. 2 we can see the selected areas (spectrum 1,2,3,4) for the analysis of the chemical composition of the enamel. The results obtained are shown in

Table I. Quantitative indicators of the chemical composition of the tooth 11 (group I)

Spectrum	In stats.	C	N	Oh	On	P	Cl	Ca	Total
Spectrum 1	Yes	45.52	11.75	26.59		6.20	0.78	9.17	100.00
Spectrum 2	Yes	26.39		36.50	0.38	13.86		22.86	100.00
Spectrum 3	Yes	56.23	16.00	23.97		1.67		2.13	100.00
Spectrum 4	Yes	24.29		38.29		13.77	0.88	22.78	100.00
Max.		56.23	16.00	38.29	0.38	13.86	0.88	22.86	
Min.		24.29	11.75	23.97	0.38	1.67	0.78	2.13	

Processing option: All elements analyzed (Normalized)
All results in weight%

Table II. Quantitative indicators of the chemical composition of tooth 21 (group II)

Spectrum	In stats.	C	Oh	On	P	Cl	Ca	Total
Spectrum 1	Yes	27.79	30.43	0.64	15.41	1.12	24.61	100.00
Spectrum 2	Yes	49.78	30.10	1.70	7.11		11.31	100.00
Spectrum 3	Yes	28.55	31.49	0.51	14.64	1.20	23.62	100.00
Spectrum 4	Yes	46.95	31.17	1.37	8.21		12.31	100.00
Max.		49.78	31.49	1.70	15.41	1.20	24.61	
Min.		27.79	30.10	0.51	7.11	1.12	11.31	

Processing option: All elements analyzed (Normalized)
All results in weight%

Table III. Comparison of the chemical composition of tooth enamel in the norm and with the use of bleaching agents from hydrogen peroxide 35% without prior professional dental hygiene (at $p < 0.05$) between the indicators research

Chemical element	Control	Group I	P
	N = 56	N = 56	
C	45.91 ± 1.20	42.46 ± 1.74	0.128
O	23.03 ± 0.63	26.18 ± 0.81	0.007
Na	0.38 ± 0.03	0.57 ± 0.05	0.006
P	9.77 ± 0.39	9.56 ± 0.75	0.792
Cl	0.14 ± 0.03	0.16 ± 0.53	0.654
Ca	15.96 ± 0.64	15.21 ± 1.22	0.570
Si	0.37 ± 0.10	0.68 ± 0.30	0.213
N	2.89 ± 0.40	4.35 ± 0.76	0.075
Mg	0.07 ± 0.01	0.01 ± 0.01	0.034
Al	0.06 ± 0.02	0.09 ± 0.04	0.475
Au	1.37 ± 0.56	0.00 ± 0.00	0.143
F	0.00 ± 0.00	0.02 ± 0.01	0.004
Ba	0.00 ± 0.00	0.45 ± 0.25	0.004

tables I and II. Next, a study was conducted to determine the average values.

As a result of statistical data processing, we have the indications shown in tables III and IV.

When comparing the indicators relating to the chemical composition of the enamel in the norm and when using bleaching agents in the form of 35% hydrogen peroxide should be noted the following data indicators that have sig-

Table IV. Comparison of the chemical composition of tooth enamel in the norm and with the use of bleaching agents from hydrogen peroxide 35% with previous professional teeth cleaning (at p <0.05) between the indicators of the study

Chemical element	Control Group N = 56	Group II N = 56	P
O	36.32 ± 0.63	31.53 ± 0.81	0.000
Na	0.48 ± 0.02	0.51 ± 0.05	0.578
P	14.7 ± 0.30	14.18 ± 0.52	0.369
Cl	0.82 ± 0.05	0.83 ± 0.07	0.853
Ca	23.95 ± 0.49	23.41 ± 0.96	0.601
Si	0.05 ± 0.04	0.00 ± 0.00	0.257
N	0.00 ± 0.00	0.28 ± 0.28	0.262
Mg	0.00 ± 0.00	0.02 ± 0.01	0.114
Al	0.01 ± 0.01	0.00 ± 0.00	0.211
Au	1.25 ± 0.61	0.00 ± 0.00	0.071
F	0.05 ± 0.03	0.05 ± 0.03	0.979
C	28.55 ± 0.55	27.79 ± 0.08	0.543

nificant differences. Differences between indicators relate to carbon, sodium, chlorine, magnesium and nitrogen. At research significant decrease is noted amounts of carbon, sodium, silicon, magnesium and gold.

When conducting a comparative analysis between areas where professional cleaning was used and where it was not used, it should be noted that a significant difference between the indicators according to the results of the study was observed for nitrogen, sodium, silicon, aluminum and carbon, at p <0.05.

Elements such as sodium, phosphorus and calcium play a special role in the structure of enamel, the change in the number of which causes changes in the structure of the hard tissues of the teeth, which is directly related to the morphological features of their structure.

If we adopt as an standard enamel with the ideal formula Ca5 (PO4) 3OH, it is possible to assume changes in the ideal formula of hydroxyapatite with the possibility of replacing calcium ions with magnesium or sodium ions or exchange in PO^{3-}_4 for CO^{2-}_3 and HPO^{2-}_4. We can make assumptions about the substitution of carbon in the hydroxy group for compounds with oxygen, fluorine, chlorine or water molecules.

Comparing comparisons of indicators in the experimental groups statistically obtained a difference in carbon levels with changes from 42.46 on the surface, which was subject to professional bleaching with hydrogen peroxide 35% without professional cleaning to 27.79 using bleach based on hydrogen peroxide 35% and previous professional cleaning. There is also a decrease in the amount of nitrogen from 4.35 to 0.28 and the amount of silicon from 0.68 to 0.00, aluminum from 0.09 to 0.00. As well as reducing sodium from 0.57 to 0.51. Decreased levels of these micronutrients may indicate that when performing a protocol that includes professional brushing, the number of the above micronutrients may be reduced. It is their reduction, in our opinion, can lead to increased sensitivity in the rehabilitation period during the restoration of the chemical composition of the enamel.

All other indicators increase slightly, which may be due to the impact on the surface layer of enamel and the exposure of the subsurface layer, which has a slightly different structure and therefore a different trace element composition. The change of all these indicators will significantly affect the clinical indicators, which, in turn, will depend on the characteristics of functional and structural resistance of the enamel.

CONCLUSIONS

Therefore, the results of the evaluation of the experiment in two groups show a decrease in elements such as carbon, sodium, silicon, nitrogen and aluminum.

We can conclude that professional hygiene can affect the trace element composition of the enamel in combination with professional clinical whitening.

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