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STUDIES ON THE CHEMICAL COMPOSITION OF DENTAL ENAMEL DURING PROFESSIONAL BLEACHING WITH CARBAMIDE PEROXIDE COMPLEX

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This study examined changes in the chemical composition of the tooth enamel surface during the professional hygiene and the use of carbamide peroxide complex as a chemical component of the clinical teeth bleaching system. Because of the performed studies, we found a difference in carbon levels with changes in values from 40.03 on the untreated surface to 0.87, when using 44 % carbamide peroxide-based bleaching agents. There were also changes in the oxygen amount from 25.24 to 0.44, sodium content from 0.46 to 0.02, a decrease in the phosphorus amount from 11.32 to 0.3 and a significant calcium content decrease from 18.4 to 0.52. We also observed a decrease in the nitrogen amount from 2.4 to 0.27 and in the magnesium content – from 0.05 to 0.008. Changes in these indices will significantly affect changes in the values of the oral cavity indices and clinical manifestations, which in turn will depend on the characteristics of functional and structural resistance of enamel.

Key words: teeth bleaching, tooth color, chemical composition of dental enamel.

І.М. Ткаченко, А.В. Лемешко, Н.М. Браїлко, В.В. Коваленко, М.А. Шундрік ДОСЛІДЖЕННЯ ХІМІЧНОГО СКЛАДУ ЕМАЛІ ЗУБІВ ПРИ ПРОВЕДЕННІ ПРОФЕСІЙНОГО ВІДБІЛЮВАННЯ З ВИКОРИСТАННЯМ ПЕРОКСИДУ КАРБАМІДУ

В даному дослідженні вивчені зміни хімічного складу поверхні емалі зубів при застосуванні професійної гігієни та використанні пероксиду карбаміду в якості хімічного компоненту системи для клінічного відбілювання зубів. В результаті проведених досліджень встановлено різницю за показниками рівня вуглецю із змінами показників від 40,03 на поверхні, яка не підлягала обробці до 0,87 при використанні засобів для відбілювання на основі пероксиду карбаміду 44 %. Зміна кількості кисню від 25,24 до 0,44, вмісту натрію від 0,46 до 0,02, зменшення кількості фосфору від 11,32 до 0,3 та істотне зменшення кальцію від 18,4 до 0,52. Відмічено також зменшення кількості азоту від 2,4 до 0,27 та кількості магнію від 0,05 до 0,008. Зміна цих показників буде істотно впливати на зміну значень показників ротової порожнини, клінічних проявів, що в свою чергу буде залежати від особливостей функціональної та структурної резистентності емалі.

Ключові слова: відбілювання зубів, колір зубів, хімічний склад емалі зубів.

The study is a fragment of the research projects "Contribution of the gene clock components in the periodontal tissues damage in its inflammatory diseases for the development of prevention and treatment methods", state registration No. 0120U101151 and "Differential approach to the choice of treatment depending on the morphofunctional features of the dental ivory and the oral cavity tissues", state registration No. 0120U104124.

Teeth bleaching is now one of the most common dental procedures among the population. Society demands whiter, perfect smiles, and in response, many options for teeth bleaching have been proposed [6].

Teeth whitening is the restoration of the natural teeth color by applying a chemical agent that oxidizes the organic pigments of dentine. Indeed, qualified measures provide a quick effect while keeping teeth intact. New technologies and modern bleaching systems open up the possibility for the patient to have white teeth and a brilliant smile without the discomfort caused by the hard tissues preparation and orthopedic structures manufacturing. That is why the number of supporters of conservative methods of unsatisfactory enamel color correction is increasing [2, 9].

Currently, the most commonly used bleaching agents are hydrogen peroxide and carbamide peroxide. Their mechanism of action mainly related to the oxidative ability of these agents to react to pigment molecules responsible for dental discoloration [10, 11].

In our opinion, it would be very relevant to consider the chemical structure of the enamel of bleached teeth. Enamel behaves like a porous membrane, and small ions penetrate deeper than large molecules that are adsorbed on the surface and can be desorbed without changing the shape of the crystals. The surface layer of enamel differs from deeper ones by greater mineralization, density, microhardness, caries resistance and higher content of trace elements, including fluoride. The enamel surface is less exposed to acids than its inner parts [3].

Despite the contradictory opinions of many researchers about teeth bleaching, it is noted that the effect of whitening systems and techniques is reduced to the discoloration of the organic matrix of interprismatic enamel [4]. Many researchers believe that discoloration during teeth whitening is determined primarily by changes in the dentin [1]. Others deny the idea of dentin discoloration and believe that it occurs only in the enamel, masking the unaltered dentin [4, 5, 9]. Due to the fact that professional teeth bleaching has become widespread in the world dental practice, it is important to have scientifically sound conclusions about its effectiveness and safety, obtained in experimental models in vitro and in vivo [4].

The purpose of the study was to access changes in the chemical composition of enamel surface using professional hygiene methods and carbamide peroxide as the main chemical component of the whitening system to analyze changes in the chemical composition of enamel between groups of teeth for further selection of the most optimal whitening system.

Materials and methods. To achieve this purpose, we studied the chemical structure of enamel by special teeth alteration, followed by the determination of areas for chemical microanalysis in the enamel.

The anterior area teeth, which were removed according to the indications, were subject to examination and study. The age of the patients whose teeth were examined ranged from 18 to 44 years according to the WHO classification (2018).

Microanalysis sites in the enamel area were analyzed using an energy-dispersive spectrometer “X-max 80mm²” (Oxford Instruments, UK), which was integrated into a scanning electron microscope. The study was carried out on the basis of the Paton Electric Welding Institute, Laboratory of Electron Beam Nanotechnology of Inorganic Materials for Medicine (Kyiv).

When studying the trace substance composition of the enamel of the studied teeth, we exposed the zones for microanalysis. The peculiarity was that the study areas differed from the right and left sides of the tooth. The left side in the studied teeth was the control zone, and the right side allowed us to carry out and to compare changes in the chemical component of the enamel for each tooth separately, by comparing the indices with each other.

Depending on the use of the bleaching system, we identified 2 groups for the study:

Group I (19 teeth) – teeth with professional hygiene, which included the use of ultrasonic treatment, mechanical, manual cleaning and the use of polishing agents.

Group II (56 teeth) – teeth that were bleached using a photo-bleaching technique with 44 % carbamide peroxide, without prior mechanical treatment.

To analyze and compare the composition and characteristics of the samples, we have developed an algorithm for their assessment, the same for all samples studied.

At the first stage, the examined teeth were altered to a teeth whitening and dividing their surface with a liquid rubber dam into two halves, one of them was a control (without bleaching intervention), and the other was used for the study.

After that, studying areas of the chemical component of enamel (right and left side) were applied to the experimental sides of the teeth.

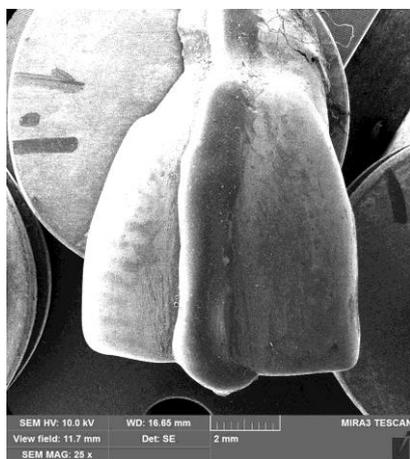


Fig. 1. Photo of the examined tooth 21 (study protocol 1.1) with a plotted distribution line, study group II.

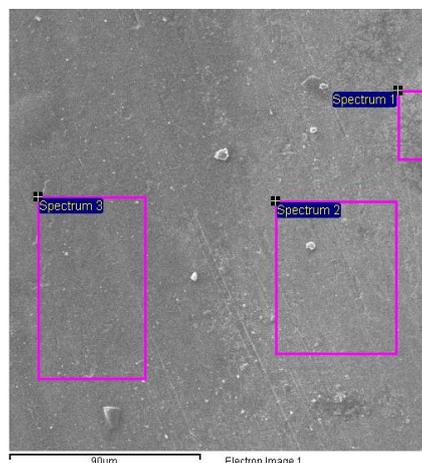


Fig. 2. Areas for studying the trace element composition of tooth 21 (right side), study group II.

Because of the study of the chemical structure, we obtained the following data on the quantitative indices of teeth's chemical composition (tables 1, 2).

Table 1

Quantitative indices of the chemical composition of tooth 21 (right side)

Spectrum	In stats.	C	O	Na	P	Cl	K	Ca	Total
Spectrum 1	Yes	27.69	15.48	5.47	12.22	10.85	2.32	25.97	100.00
Spectrum 2	Yes	19.68	21.59	1.12	18.20	2.81		36.60	100.00
Spectrum 3	Yes	24.05	20.66	0.79	17.31	2.19		35.00	100.00
Max.		27.69	21.59	5.47	18.20	10.85	2.32	36.60	
Min.		19.68	15.48	0.79	12.22	2.19	2.32	25.97	

Table 2

Quantitative indices of the chemical composition of tooth 21 (left side)

Spectrum	In stats.	C	O	Na	P	Cl	K	Ca	Total
Spectrum 1	Yes	27.69	15.48	5.47	12.22	10.85	2.32	25.97	100.00
Spectrum 2	Yes	19.68	21.59	1.12	18.20	2.81		36.60	100.00
Spectrum 3	Yes	24.05	20.66	0.79	17.31	2.19		35.00	100.00
Max.		27.69	21.59	5.47	18.20	10.85	2.32	36.60	
Min.		19.68	15.48	0.79	12.22	2.19	2.32	25.97	

The obtained results of laboratory tests were analyzed using the methods of biological statistics. Mathematical processing of the obtained data was carried out using the standard method of variational analysis on a personal computer. Quantitative indices obtained in the course of laboratory researches were processed by mathematical statistics methods with calculation of sample mean (M) and standard error of mean (m) in the groups of examined persons. The analysis of the results was carried out using the programs "Microsoft Excel 2010", "IBM SPSS Statistics V22" [7].

Results of the study and their discussion. The bleaching process is possible due to the ability of active chemical components (carbamide peroxide, etc.) to penetrate through enamel and dentin into all parts of the tooth. Bleaching is also possible with the use of mechanical cleaning, which is accompanied by the removal of surface organic film on the teeth, which, in turn, has the feature of binding to the pigments in the oral fluid. It was found that normally the dental pellicle consists of saliva micelles, in the center of which there is a large white and round crystal of calcium phosphate. In most cases, manipulations performed by a dentist allow to remove the bacterial film from the tooth surface and, when using certain substances, activate decay with the activation of oxygen radicals that destroy colored pigments, the formation of which changes tooth color without changing tooth structure.

Table 3

Features of the chemical composition of enamel in the studied group of teeth with mechanical cleaning (group I, n=19)

Chemical element name		N	Mean value	Standard deviation
C	0	19	38.0482	0.88808
	1	19	32.0274	1.79693
	Total	38	37.6962	0.84598
O	0	19	26.9114	0.46890
	1	19	23.7432	1.20733
	Total	38	26.7268	0.44872
Na	0	19	0.4553	0.02125
	1	19	0.7074	0.20328
	Total	38	0.4700	0.02334
P	0	19	11.5576	0.28690
	1	19	14.8879	0.84989
	Total	38	11.7517	0.27782
Cl	0	19	0.387466	0.0298595
	1	19	0.624211	0.1421006
	Total	38	0.401264	0.0294140
Ca	0	19	18.8195	0.48173
	1	19	24.5326	1.55020
	Total	38	19.1525	0.46800
Si	0	19	0.3079	0.07367
	1	19	0.1916	0.12228
	Total	38	0.3011	0.06973
N	0	19	2.1726	0.25153
	1	19	0.7616	0.52730
	Total	38	2.0904	0.23944
Mg	0	19	0.04649	0.007797
	1	19	0.04737	0.018126
	Total	38	0.04654	0.007414
Al	0	19	0.05059	0.012230
	1	19	0.01789	0.010722
	Total	38	0.04868	0.011540
Au	0	19	1.0094	0.30593
	1	19	2.6384	1.80833
	Total	38	1.1044	0.30658

The quality of bleaching depends on the reasons that caused discoloration, the size of the color defect, the duration of pigments penetration into the dentine.

Upon contact with water, carbamide peroxide ($\text{CH}_6\text{H}_2\text{O}_3$ or $\text{CH}_4\text{H}_2\text{OH}_2\text{O}_2$) dissociates into hydrogen peroxide (H_2O_2) and urea ($\text{N}_2\text{H}_4\text{CO}$). Urea is further broken down into ammonia and carbon dioxide. It is reported that 10 % carbamide peroxide usually produces 3.35 % hydrogen peroxide. The exact mechanism of bleaching is not fully understood. It is believed that hydrogen peroxide first diffuses through the enamel to the dentin and begins to produce free radicals. Free radicals with unpaired electrons are extremely unstable and react with highly pigmented organic molecules (carboatomic rings) found in the tooth structure and decay them into smaller, less pigmented components (carbon chains). These smaller molecules reflect less light, thus creating a color reduction or bleaching effect.

When studying the trace element composition of the teeth enamel of group I (right and left side), we obtained the following results, which are presented in table 3.

After performing a comparative analysis between the areas where mechanical cleaning was used and those where it was not used, it should be noted that according to the results of the study, a significant difference was observed in terms of chlorine, magnesium, silicon and aluminum.

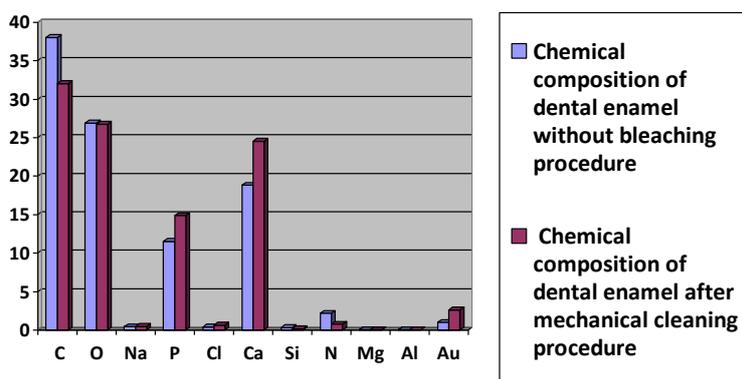


Fig. 3. Features of the chemical composition of dental enamel after carrying out the mechanical cleaning protocol (before and after the cleaning procedure).

Evaluating the obtained indices, we can note that no significant difference in the chemical composition of the studied groups in relation to carbon and oxygen was obtained, which may indicate surface alterations in the dental enamel without affecting the crystal lattice.

The ratio of trace elements in the dental enamel after carrying out the mechanical cleaning protocol are presented in fig. 3.

The next study concerned the use of 44 % carbamide peroxide complex for the clinical teeth bleaching procedure. The number of elements with differences in the use of carbamide peroxide is increasing, which, in our opinion, can lead to more pronounced clinical manifestations and complications (table 4).

Table 4

The difference in the chemical composition of dental enamel in the normal conditions and when using bleaching agents with 44 % carbamide peroxide ($p < 0.05$) between the study indices

Studied trace elements	Group I (n=19)	Group II (n=56)	p
C	38.04±0.88 32.02±1.79	36.19±0.91 44.92±1.90	0.000
O	26.91±0.46 23.74±1.2	27.96±0.46 20.74±1.008	0.000
Na	0.45±0.02 0.7±0.2	0.52±0.026 0.2246±0.028	0.000
P	11.55±0.28 14.88±0.84	11.67±0.31 12.11±0.51	0.549
Cl	0.38±0.029 0.62±0.14	0.44±0.032 0.19±0.057	0.001
Ca	18.81±0.48 24.53±1.55	19±0.53 19.86±0.87	0.490
Si	0.30±0.07 0.19±0.12	0.32±0.081 0.16±0.098	0.367
N	2.17±0.25 0.76±0.52	2.20±0.27 1.54±0.47	0.302
Mg	0.04±0.007 0.047±0.018	0.035±0.006 0.1±0.03	0.001
Al	0.05±0.01 0.017±0.01	0.035±0.01 0.11±0.037	0.009
Au	1±0.3 2.63±1.8	1.33±0.36 0.0000±0.00000	0.101

The differences between indices relate to data on carbon, oxygen, sodium, chlorine, magnesium and aluminum. The study showed a significant decrease in the amount of carbon, oxygen, sodium, chlorine, magnesium and aluminum.

In most cases, specialists first use mechanical brushing to improve the results, which usually allows you to perform the whitening procedure much better.

Therefore, comparing statistical indicators in the experimental groups, we found a difference in carbon levels with changes in values from 40.03 on the surface, which was not treated, to 0.87 when using 44 % carbamide peroxide-based bleaching agents. There were also changes in the oxygen amount from 25.24 to 0.44, sodium content from 0.46 to 0.02, a decrease in the phosphorus amount from 11.32 to 0.3 and a significant calcium content decrease from 18.4 to 0.52.

We also observed a decrease in the nitrogen amount from 2.4 to 0.27 and in the magnesium content – from 0.05 to 0.008. Changes in these indices will significantly affect changes in the values of the clinical indices and clinical manifestations and will depend on the characteristics of functional and structural resistance of dental enamel.

Thus, such elements as sodium, phosphorus and calcium play a special role in the structure of dental enamel, changes in their amount causes changes in the dentine structure, which is directly related to the morphological features of their structure.

If we take dental enamel with the ideal formula $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ as a current standard, it is possible to assume changes in the ideal hydroxyapatite formula with the possibility of replacing calcium ions with magnesium or sodium ions or exchanging $\text{PO}_3\text{-4}$ for $\text{CO}_2\text{-3}$ and $\text{HPO}_2\text{-4}$. We can make assumptions about the substitution of the carbon compounds with oxygen, fluorine, chlorine or water molecules in the hydroxyl group. In the case of dental enamel decalcification caused by the organic acids attack, there is a change in the shape, size and orientation of the hydroxyapatite crystals [9].

Conclusion

Depending on the etiology and depth of enamel and dentin damage, there are discolorations, which are divided into external and internal ones and may be limited only by the tooth surface or penetrate deeper into the hard tooth tissues, in particular dentin.

With discolorations, both external and internal, it is possible to use both mechanical cleaning methods and chemical preparations. This study compared the chemical composition of the tooth enamel surface during the professional hygiene and the use of carbamide peroxide as a chemical component of the clinical teeth bleaching system.

Because of the performed studies, we found a difference in carbon levels with changes in values from 40.03 on the surface, which was not treated, to 0.87 when using 44 % carbamide peroxide-based bleaching agents. There were also changes in the oxygen amount from 25.24 to 0.44, sodium content from 0.46 to 0.02, a decrease in the phosphorus amount from 11.32 to 0.3 and a significant calcium content decrease from 18.4 to 0.52. We also observed a decrease in the nitrogen amount from 2.4 to 0.27 and in the magnesium content – from 0.05 to 0.008.

The change in these indices will significantly affect the change in the values of oral parameters, in particular the oral fluid composition in patients, the salivary glands activity, as well as the functional and structural resistance of the hard tooth tissues.

After performing laboratory tests and establishing the discrepancy of the main elements, we have the opportunity to justify clinically the remineralizing drugs application with a given number of chemical elements and chemical characteristics of their composition depending on the choice of bleaching component.

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PECULIARITIES OF ANTENATAL AND POSTNATAL PERIODS OF CHILD DEVELOPMENT WITH INFLAMMATORY MAXILLOFACIAL LOCALIZATION PROCESSES

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For the period of 7 years, 537 children with acute purulent odontogenic and non-odontogenic processes of maxillofacial area were examined. Acute purulent lymphadenitis (29 %) and adenoflegmon and odontogenic osteomyelitis, which accounted for 18 %, were found to be predominant in their structure. Noteworthy is the fact that a large number of children and their relatives seek specialized care behind time and are often treated for the wrong diagnosis. There are also certain age differences depending on the nosological form of the disease. Analysis of pregnancy showed that in this period, in the examined children's mothers cases of acute infectious diseases, the presence of pathological conditions were quite frequently observed, and this has reflected in childbirth. It is also noteworthy that infants who were in artificial and mixed feeding from the age of one month and six months were more likely to fall ill. This situation indicates the need to include these children to the risk group in order to timely recover, which can negate the impact of adverse factors that they have experienced in both the ante- and post-natal periods of their development.

Key words: children, developmental periods, lymphadenitis, adenophlegmon, osteomyelitis.

П.І. Ткаченко, С.О. Білоконь, Н.М. Лохматова, О.Б. Доленко, Ю.В. Попело, Н.М. Коротич **ОСОБЛИВОСТІ АНТЕНАТАЛЬНОГО І ПОСТНАТАЛЬНОГО ПЕРІОДІВ РОЗВИТКУ ДІТЕЙ З ЗАПАЛЬНИМИ ПРОЦЕСАМИ ЩЕЛЕПНО-ЛИЦЕВОЇ ЛОКАЛІЗАЦІЇ**

За 7 років обстежено 537 дітей з гострими гнійними одонтогенними і неодонтогенними процесами щелепно-лицевої ділянки. Встановлено, що в їх структурі превалювали гострий гнійний лімфаденіт (29 %) та аденофлегмона і одонтогенний остеомиєліт, на долю яких припадало по 18 %. Аналіз перебігу вагітності засвідчив, що в цей період у матерів обстежених дітей досить часто простежувалися випадки гострих інфекційних захворювань, наявність патологічних станів і це певною мірою відображалось на пологовій діяльності. Характерним є також те, що діти, які знаходилися на штучному та змішаному вигодуванні з місячного та шестимісячного віку частіше хворіли. Така ситуація вказує на необхідність включення цих дітей до групи ризику з метою своєчасно оздоровлення, що може звести на нівець вплив несприятливих чинників, дію яких вони відчували як в анте- так і постнатальному періодах їх розвитку.

Ключові слова: діти, періоди розвитку, лімфаденіт, аденофлегмона, остеомиєліт.

The work is a fragment of the research project "Integrative-differentiated substantiation of the choice for optimal methods of surgical interventions and volume of therapeutic measures in surgical pathology of the maxillofacial area", state registration No. 0116U003821.

The source of many infectious origin diseases are often the circumstances of the child's living. Due to the pregnancy course features, the nature of childbirth in mothers and their development in the postnatal period, certain adaptive-protective mechanisms of the body are formed, which directly or indirectly affect the occurrence and course of all types of nosological disease forms, and sometimes their consequences. The same age-related anatomical and physiological features of the child as a whole, including the breast feeding period, in particular, cause easy involvement of the whole body into the process with the infection focal point generalization accompanied by metabolic, immune and endocrine disorders with the resulting consequences [2, 4, 6, 7, 8, 11].

Significant changes in the clinical course of acute odontogenic and non-odontogenic inflammatory diseases of the maxillofacial area in children necessitate the generalization of epidemiological, experimental, clinical observations and taking into account modern scientific developments regarding the effects of adverse exogenous and endogenous factors on the child's body at all phases of its development [1, 3, 4, 12].