Patronage of Committee of Rehabilitation, Physical Education and Social Integration of the Polish Academy of Sciences

Acta Balneologica

Published since 1905

ISSN 2082 - 1867

JOURNAL OF THE POLISH BALNEOLOGY AND PHYSICAL MEDICINE ASSOCIATION

2023 SEPTEMBER-OCTOBER VOL. LXV NUMBER 5 (177)

● HEALTH-RESORT MEDICINE ● PHYSICAL MEDICINE ● BIOCLIMATOLOGY

INDEXED IN EMERGING SOURCES CITATION INDEX THOMSON REUTERS

CONTENTS

ORIGINAL ARTICLES

REVIEW ARTICLES

Acta Balneol. 2023;VOL.LXV,5(177):314-318

ORIGINAL ARTICLE

DOI: 10.36740/ABAL202305109

EFFICACY OF DENTAL BLEACHING WITH DIODE LASER, LED IRRADIATION AND CHEMICAL ACTIVATION SYSTEM: A COMPARATIVE STUDY

Nataliia G. Gadzhula, Mariia M. Shinkaruk-Dykovytska, Anastasiia V. Povsheniuk, Tetiana O. Rekun, Nataliia M. Isakova

NATIONAL PIROGOV MEMORIAL MEDICAL UNIVERSITY, VINNYTSIA, UKRAINE

ABSTRACT

Aim: To compare the effectiveness and safety of various methods of professional teeth bleaching using light and chemical activation systems in an in vivo study.

Materials and Methods: Teeth whitening was performed on 48 patients aged 20 to 35, divided into 4 groups. In patients of group 1 for dental bleaching a diode laser activation was used, group 2 – LED/gel activation, group 3 – chemical whitening with the following remineralization therapy, group 4 – chemical whitening without remineralization therapy. The study of the effect of bleaching systems on the hard tooth tissues was carried out by index assessment, determination of biochemical parameters of an oral fluid.

Results: Laser bleaching of the vital teeth was significantly more effective than the other methods with 95% confidence level and did not affect the structure of hard dental tissues and mineral exchange of the oral fluid. LED irradiation has a high whitening effect, but leads to dentin hypersensitivity and a decrease in phosphorus and alkaline phosphatase of oral fluid. Chemical bleaching causes a decrease in enamel resistance, the occurrence of tooth sensitivity, violation of mineral exchange of oral fluid, therefore; it requires combined use with local remotherapy.

Conclusions: Laser teeth bleaching is the effective and safe method in management of discolored teeth. A positive result of its use can be considered an improvement of color change of the teeth by 3.33 shades compared to chemical bleaching, enamel stability, low values of dental hypersensitivity indices, no changes in biochemical parameters of the oral fluid.

KEY WORDS: laser teeth bleaching, tooth discoloration, oral fluid, mineral metabolism

INTRODUCTION

A change in the color of the teeth, or tooth discoloration, leads to a violation of smile aesthetics and, as a result, adversely affect a person's self-esteem, social adaptation, and psychological state. Tooth discoloration is divided into congenital and acquired, extrinsic (temporary) and intrinsic (permanent). Most of them are successfully removed using one method, for others there is a need for the combined use of different methods. Despite the high demand for teeth bleaching, the safety issue of various methods for removing tooth depigmentation has not been completely resolved. A significant disadvantage of bleaching systems, especially with a high concentration of hydrogen peroxide (HP) and a low pH value, is their side effect on the dental hard tissues, which leads to demineralization and dehydration of tooth tissues, a decrease of the enamel microhardness, the release of macro- and microelements from the superficial enamel layer, and a decrease of resistance to abrasion, occurrence of dentin hypersensitivity [1, 2]. According to the results of numerous studies, peroxide agents used in office tooth bleaching systems can affect not only the enamel, dentin and pulp of the tooth, but also can change the mineral metabolism and the activity of some enzymes in the oral fluid [3], although in publications about this there are conflicting data.

Light or heat sources are used to accelerate the oxidation-reduction reaction of the bleaching gel due to faster decomposition of HP and the formation of free radicals. One of the methods of activation during professional bleaching of discolored teeth is power bleaching with high-intensity light [4]. Implementation of laser systems into dental practice [5-7], which are also actively used in the bleaching algorithm of discolored teeth, occupies an important place in the development of effective and safe bleaching methods [1, 8]. Currently, there are conflicting reviews about laser bleaching efficiency and its effect on the tooth, that needs additional research.

AIM

To compare the effectiveness and safety of various methods of professional tooth bleaching using light and chemical activation systems in an in vivo study.

MATERIALS AND METHODS

Tooth bleaching was performed in 48 patients aged 20 to 35 years. The inclusion criteria were the following:

discolored teeth of various etiology, age-related changes in the color of tooth enamel, aesthetic preferences of the patient. The exclusion criteria were: the presence of dental hypersensitivity, carious cavities, exposed necks and roots of the teeth, periodontal diseases and oral mucosal diseases, a wide pulp chamber, orthopedic and orthodontic appliances, significant loss of enamel as a result of pathological or age-related tooth wear, taking light-sensitive medicines, oncological and endocrine diseases, bronchial asthma, pregnancy.

Before the start of the bleaching procedure, all patients underwent professional oral hygiene, the enamel remineralization index and enamel resistance test (TER-test), as well as parameters of the mineral exchange of oral fluid, were determined. Participants of the study were divided into 4 groups with a similar dental status of 12 patients in each with the same distribution of colors according to the VITA scale ("VITA Zahnfabric", Germany). In group 1 the teeth were bleached with diode laser Picasso 7Wt "AMD Lasers, USA" with a power of 1.6 W and a wavelength of 808 nm (the standard fourth program of the pulsed radiation mode of the device) after a single applying of JW Power Bleaching NEXT gel ("Heydent", USA) with 30% HP content. Patients of group 2 underwent light-emitting diode (LED) bleaching with a wavelength of 470 nm using the Bleach'n smile AUTOMIX system (Schutz Dental, Germany) with 35% HP content. In patients of groups 3 and 4, in-office teeth whitening was performed chemically with the use of Opalescence Extra Boost gel ("Ultradent", USA) with 40% HP three sessions for 20 minutes. After bleaching, in patients of group 3 a remineralization therapy lasting 20 minutes daily for 10 days was carried out with applying of two-component gel which includes calcium phosphate salts and fluorides.

The evaluation of the efficiency of dental bleaching was carried out on the 10th day in visual analysis according to the expanded VITA shade guide. The study of the effect of the bleaching systems on the hard tooth tissues was evaluated immediately and in 10 days after the bleaching procedure according to TER-test, enamel remineralization index, prevalence and intensity of tooth sensitivity indices, Schiff test.

The content of calcium (Ca), phosphorus (P), magnesium (Mg) and alkaline phosphatase (AP) in the oral fluid was determined before vital tooth bleaching, right after the bleaching procedure and in 10 days by the photometric method using a KONE "Specific Basic" biochemical analyzer (Konelab Corporation, Finland) with the standard sets of reagents and control serumes Abtrol, Nortrol and "SERODOS plus HUMAN" (Germany). Ca concentration was determined by Arsenazo III method, P content was measured by Molybdate method, magnesium – by Xylidyl Blue I. AP activity was determined using diethylamine buffer (SCE).

The study was approved by the Biomedical Ethics Committee of National Pirogov Memorial Medical University, Vinnytsya (protocol No. 4 dated May 18, 2023) and complies with Declaration of Helsinki (2013). All patients gave their written voluntary informed consent to research their data.

The statistical data analysis was carried out using the methods of variation statistics with "Statistica 6.1" software (serial number BXXR901E246022FA) and Microsoft® Excel 2017 for Mac (corporate license, product ID: 02984-001-000001, device code: 86C36D0C-8F15-59CA-A81E-B1D889205F71). For descriptive statistics, average arithmetic and relative mean values and standard errors of the mean (M±m), (P±m), standard deviation (σ) and the significance of differences (p-value) were used. The reliability of the obtained results was assessed by Student's t-test; the differences were considered statistically significant in $p<0.05$.

RESULTS

The obtained results of the clinical study showed that all bleaching systems were effective in removing of discolored vital teeth. Thus, color change of the teeth in group 1 occurred by 7.58±0.73 shades, in group 2 – by 5.92±0.80 shades, in group 3 – by 4.25±0.39 shades, in group 4 – by 4.08±0.44 shades (Table 1).

As a result of the study of the structural and morphological composition of superficial layer of enamel after tooth bleaching, it was seen that in patients of groups 1 and 3, TER-test scores did not differ significantly from the initial values (3.71±0.18; 3.80±0.17, $p>0.05$). In participants of group 2, an increase of TER-test values to 4.45±0.19 ($p<0.01$) was observed. The maximum average statistical values of TER-test were revealed in patients of group 4 – 4.65±0.20 ($p<0.01$), which indicates a decrease in enamel resistance after tooth bleaching without the involvement of remineralization therapy. In 10 days of follow-up, the value of the test decreased to 3.94±0.19 in group 2 ($p>0.05$) and to 4.22±0.20 in group 4, but did not reach the baseline ($p_1<0,01$).

The index of enamel remineralization in participants of groups 1 and 3 did not change statistically significantly compared to baseline ($p>0.05$). In group 2 after LED/gel activated the index values increased from 2.72±0.09 to 3.17±0.13 scores in $p<0.05$. In group 4 after chemical bleaching without prior and subsequent remotherapy, the index values increased significantly compared to the initial data and the values of other groups to 3.28±0.13 scores in $p<0.01$.

Evaluation of clinical symptoms after the bleaching procedure revealed increased tooth sensitivity in all groups of examined patients. In participants of groups 1 and 3 were revealed the significantly ($p<0.001$) lower values of the prevalence and intensity index of hypersensitivity than in groups 2 and 4. The highest degree of teeth sensitivity lasting 24 hours was observed after LED/gel activated. In this group, an increase in enamel permeability was accompanied by increased tooth sensitivity: 17,02±3,58% and 2.03±0.06 scores immediately after bleaching and 5,50±1,71% and 1.34±0.05 scores in 10 days after the end of the procedure. In patients of group 4 localized tooth sensitivity of the 2nd degree prevailed, the prevalence index of hyperesthesia increased to 15,89±2,87%. Similar tendency was observed when determining the intensity

Table 1. The effect of various methods of professional tooth bleaching on the hard tooth tissues

Indices	Before bleaching	Group 1 n=12	Group 2 n=12	Group 3 n=12	Group 4 n=12
Color change, shades		7.58±0.73	5.92±0.80	4.25±0.39**	4.08±0.44**
TER-test	3.62±0.18	3.71±0.18	4.45±0.19*	3.80±0.17	4.65±0.20*
TER-test in 10 days		3.66±0.17	3.94±0.19	3.60±0.18	4.22±0.20*
Index of enamel remineralization	2.72±0.09	2.78±0.11	3.17±0.13*	2.83±0.12	3.28±0.13*
		2.70±0.12	2.95±0.13	2.65±0.11	3.25±0.12*
Index of prevalence of hyperesthesia, %	0	3.94±1.67*	17.02±3.58*	4.46±1.63*	15.89±2.87*
		1.04±0.73	5.50±1.71*	1.59±0.87	4.98±1.48*
Intensity index of hyperesthesia, scores	0	0.92±0.07*	2.03±0.06*	1.14±0.06*	1.67±0.05*
		0.09±0.06	1.34±0.05*	0.11±0.09	1.14±0.05*
Schiff index, scores	0	1.08±0.16*	2.75±0.19*	1.0±0.18*	2.50±0.20*
		0.08±0.09	1.33±0.15*	0.17±0.12	1.67±0.23*

*Note: * – significance of the difference between the baseline values and parameters after tooth bleaching; ** – significance of the difference between group 1 and other groups.*

index of tooth sensitivity: the values increased to 1.67±0.05 scores. In 10 days, the index values decreased to 4,98±1,48% and 1.14±0.05 scores, but did not reach the baseline and according to the qualitative assessment corresponded to "localized tooth sensitivity of the 1st degree".

The average value of Schiff's sensitivity digital rating scale in group 1 was 1.08±0.16 scores immediately after laser whitening (11/12) and 0.08±0.09 scores (1/12) on the 10th day of follow-up. During the patients' examination of group 2, the Schiff index was 2.75±0.19 scores (12/12), during the repeated examination – 1.33±0.15 scores (10/12), mainly in the frontal group of teeth ($p<0.001$). In group 3, where chemical whitening was performed in combination with remotherapy, the Schiff score was 1.0±0.18 (10/12) immediately after whitening; 10 days later slight tooth sensitivity was diagnosed in 2 patients (0.17±0.12). In patients of group 4 with chemical bleaching in the absence of remineralization therapy, the Schiff score was 2.50±0.20 (12/12) after the bleaching procedure and 1.67±0.23 (11/12) during final examination.

The dynamics of Ca, P, Mg and AP in mixed saliva during vital tooth bleaching were within normal limits (Table 2). The highest values of Ca concentration in the oral fluid were registered in participants of group 4 after chemical bleaching (1.29±0.03 mmol/l, $p<0.05$). At the same time, a significant reduction of P content was observed to 5,19±0,20 mmol/l in group 2 and to 5,09±0,20 mmol/l in group 4 compared to baseline ($p<0.05$). A change in the concentration of the main mineral components of oral fluid, necessary for physical and chemical exchange in enamel, contributed to a significant increase in the Ca/P ratio in mixed saliva. However, the reliability of the difference in the Ca/P ratio was revealed only in patients of group 4 ($p<0.05$).

Ca level returned to baseline in 10 days. There was no significant difference in the changes in Ca after tooth bleaching procedure between all groups. A decrease in P content was observed immediately after tooth bleaching, and 10 days later, the P level returned to baseline. The ratio of Ca/P in the oral fluid increased right after tooth bleaching procedure and returned to baseline values 10 days later, reflecting the changes of Ca and P content in oral fluid. After professional tooth whitening, the concentration of Mg in group 4 significantly decreased compared to baseline ($p<0.05$). In groups 2 and 4 there was a significant reduction ($p<0.01$) of AP activity: 3.25±0.23 EU/l and 2.92±0.22 EU/l. Obviously, a significant decrease of Mg concentration in group 4 leads to a compensatory reduction in the activity of AP.

Table 2. Dynamics of biochemical parameters of the oral fluid after vital tooth bleaching

Biochemical parameters	Before tooth bleaching	Group 1 n=12	Group 2 n=12	Group 3 n=12	Group 4 n=12
Ca, mmol/l	1.19±0.02	1.20±0.02	1.22±0.03	1.18±0.02	1.29±0.03*
P, mmol/l	5.90±0.21	5.85±0.22	5.19±0.20*	5.98±0.20	5.09±0.20*
Ca/P ratio	0.210±0.006	0.211±0.009	0.235±0.011	0.198±0.07	0.255±0.010*
Mg, mmol/l	0.53±0.05	0.51±0.05	0.41±0.04	0.55±0.05	0.35±0.04*
AP, EU/l	4.17±0.26	4.02±0.25	3.25±0.23*	4.11±0.26	2.92±0.22*

*Note: * – significance of the difference between the baseline values and parameters after tooth bleaching.*

Thus, as can be seen from the given data of oral fluid research, we have the opportunity to note significant changes in the content of Ca, P, Mg and AP in group of patients who underwent chemical bleaching ($p<0.05$), which was clinically confirmed by dental hypersensitivity of the 2nd degree and high TER-test values. The level of biochemical parameters of the oral fluid returned to baseline values on the 10th day of follow-up. The stability of Ca, P, Mg and AP content during all stages of follow-up can be considered a positive result of the use of remineralization therapy in study participants of group 3.

DISCUSSION

Laser bleaching was the most effective method, chemical bleaching had a minimally pronounced whitening effect, and LED/gel activated occupied an intermediate position. In the scientific studies [9, 10], it was found that tooth bleaching did not improve when using additional light sources (halogen lamps, LED lamps, laser), but the results of our study showed that the light-activated system provides better whitening efficiency, than chemical activation system. Our data are consistent with the study [1, 4], in which is listed that in laser bleaching absorption by the bleaching gel is directed to the ionization of HP, and this depends on the specific wavelength required for direct photolysis or photooxidation of chromophores in dentin.

Various scientists have studied the effect of bleaching agents on enamel surface roughness. The obtained results regarding the safety of the bleaching procedure with the use of a diode laser were confirmed in studies [1], in which the unchanged enamel surface after whitening and the absence of changes in the dentine structure were demonstrated, and no significant differences in the enamel microhardness before and after treatment were seen.

The results of our study showed high values of the remineralization index and TER test in the groups after chemical bleaching and LED/gel activation, indicating a decrease in enamel resistance due to the demineralizing effect of the bleaching gel on the dental tissues.

Increased tooth sensitivity after the professional bleaching procedure was revealed in all groups of the examined. The highest degree of dental hypersensitivity was observed after photobleaching, which necessitates the use of remineralizing therapy. The lowest tooth sensitivity occurred in the group of patients after laser tooth bleaching. Our data are consistent with the study of Mondelli et al. [9], in which a comparative analysis of teeth whitening with the a diode laser (810 nm, 37% HP), LED activation (400-500 nm, 38% HP) and without light activation (38% HP). According to the reports of authors, the lowest sensitivity was seen for diode laser usage, which decreased in 24 hours after bleaching and returned to normal in 7 days.

Demineralization and Ca loss from the tooth surface usually occurs in organic tissues and hydroxyapatite crystals during bleaching. It has been established that under the influence of various bleaching systems and methods, the organic matrix of inter-enamel prisms is discolored, as well as a slight releasing of Ca and P, due to which the pores expand in the superficial and deep enamel layers [11]. Research of the effects of tooth bleaching systems has shown that the concentration of some parameters of mineral metabolism and the activity of AP changes in the oral fluid. The most pronounced increase of Ca concentration, as well as a decrease in the level of P, Mg and AP activity in the oral fluid after bleaching occurred when using a chemical activation system with 40% HP. The studied parameters in 10 days stabilized and were not significantly differ from the baseline, which can be explained by the gradual mineral recovery of hard tooth tissues due to the remineralizing potential of saliva.

The analysis of oral fluid parameters after chemical bleaching with the following remineralization therapy in patients of group 3 showed that the use of remineralizing agents provides the stability of the content of Ca, P, Mg and higher activity of AP in mixed saliva than in other groups of the examined. Along with this, when using laser bleaching, changes in levels of Ca, P, Mg and AP in the oral fluid were also not seen. The obtained results agree with literature data of Parreiras et al. [12], in which it was confirmed that no significant differences in Ca and P concentration were observed after 830 nm laser bleaching.

CONCLUSIONS

1. Laser teeth bleaching is the effective and safe method in management of discolored teeth. A positive result of its use can be considered an improvement in tooth color change by 3.33 shades compared to chemical bleaching, enamel stability, low values of dental hypersensitivity indices, no changes in biochemical parameters of the oral fluid.
2. LED irradiation contributes to a high improvement in the brightness of teeth, but leads to a significant decrease of enamel resistance, the occurrence of dentine hypersensitivity, a significant reduction in the level of P and AP in the oral fluid.
3. An increase in enamel resistance, low values of the prevalence and intensity of tooth sensitivity indices, stability of Ca, P, Mg and higher activity of AP in oral fluid were revealed in the group of patients when vital tooth bleaching was combined with remotherapy usage.
4. Elimination of tooth discoloration by a chemical method causes violation of the mineral content of oral fluid, a decrease of enamel resistance, the occurrence of dental hyperesthesia, therefore it requires mandatory combined use with local remineralizing therapy at all stages of bleaching.

REFERENCES

1. De Moor RJ, Verheyen J, Verheyen P et al. Laser teeth bleaching: evaluation of eventual side effects on enamel and the pulp and the efficiency *in vitro* and *in vivo*. Scientific World Journal. 2015;2015:835405. doi: 10.1155/2015/835405.
2. Maran BM, Matos TP, de Castro ADS et al. In-office bleaching with low/medium vs. high concentrate hydrogen peroxide: A systematic review and meta-analysis. Journal of dentistry. 2020;103:103499. doi:10.1016/j.jdent.2020.103499.
3. Dvornyk AV, Dvornyk VM, Vodoriz YY et al. Clinical features of influence of different groups of bleaching agents in the oral cavity at different periods after the end of the treatment. World Med Biol. 2022;2(80):56-60. doi: 10.26724/2079-8334-2022-2-80-56-60.
4. Shahabi S, Assadian H, Mahmoudi NA, Nokhbatolfoghahaei H. Comparison of tooth color change after bleaching with conventional and different light-activated methods. J Lasers Med Sci. 2018;9(1):27-31. doi:10.15171/jlms.2018.07.
5. Gadzhula NG, Shinkaruk-Dykovytska MM, Cherepakha OL et al. Efficiency of using the diode laser in the treatment of periodontal inflammatory diseases. Wiad Lek. 2020;73(5):841-845. doi:10.36740/WLek202005101.
6. Gadzhula NG, Barylo OS, Furman RL, Rekun TO. The use of magnetic-laser therapy in the rehabilitation period for patients with infraorbital nerve damage. Acta Balneol. 2021;3(164):165-169. doi:10.36740/ABAL202103106.
7. Gorai MA, Kurdysh LF, Gadzhula NG et al. Experience of the use of photodynamic therapy in the treatment of chronic traumatic lesions of oral mucosa. Acta Balneol. 2022;5(171):417-421. doi:10.36740/ABAL202205107.
8. Ahrari F, Akbari M, Mohammadpour S, Forghani M. The efficacy of laser-assisted in-office bleaching and home bleaching on sound and demineralized enamel. Laser Ther. 2015;24(4):257-264. doi:10.5978/islsm.15-OR-15.
9. Mondelli RF, Azevedo JF, Francisconi AC et al. Comparative clinical study of the effectiveness of different dental bleaching methods – two-year follow-up. Appl Oral Sci. 2012;20(4):435-43. doi: 10.1590/s1678-77572012000400008.
10. Fonseca AM, Tunas I, Vidal F et al. Dental bleaching with and without LED/Laser association: a split-mouth controlled study. Revista Brasileira de Odontologia. 2016;73(4):267 doi:10.18363/rbo.v73n4.p.267.
11. Heshmat H, Ganjkar MH, Miri Y, Fard MJ. The effect of two remineralizing agents and natural saliva on bleached enamel hardness. Dent Res J (Isfahan). 2016;13(1):52-57. doi:10.4103/1735-3327.174713.
12. Parreiras SO, Vianna P, Kossatz S et al. Effects of light activated in-office bleaching on permeability, microhardness, and mineral content of enamel. Operative Dentistry. 2014;39(5):E225-30. doi: 10.2341/13-031-L.

The work is a fragment of the research project "Modern trends and the latest technologies in the diagnosis and treatment of odontopathology, periodontal diseases and oral mucosal diseases", state registration № 0118U005471.

ORCID AND CONTRIBUTIONSHIP*

Nataliia G. Gadzhula: 0000-0003-0016-2264[A,B,D]
Mariia M. Shinkaruk-Dykovytska: 0000-0002-0747-4247[E,F]
Anastasiia V. Povsheniuk: 0000-0002-6799-9627[B,E]
Tetiana O. Rekun: 0000-0003-1183-7028[B,E]
Nataliia M. Isakova: 0000-0002-3037-9651[B,C]

ADDRESS FOR CORRESPONDENCE

Nataliia G. Gadzhula
National Pirogov Memorial Medical University
56 Pyrohov St., 21018 Vinnytsia, Ukraine
e-mail: gadzhula@vnmu.edu.ua

CONFLICT OF INTEREST

The Authors declare no conflict of interest

RECEIVED: 09.06.2023
ACCEPTED: 10.09.2023

* Contribution: A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval.