

REVIEW

by Prof. Dr. Emilia Karova, PhD
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regarding the dissertation on the topic
"Study of the Influence of Certain Factors on Tooth Whitening"
for awarding the educational and scientific degree "Doctor"
in the doctoral program "Therapeutic Dental Medicine"
in the professional field 7.2 Dental Medicine
from the area of higher education 7. Healthcare and Sports

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Form of Doctoral Studies: Full-time

Department: Conservative Dentistry and Oral Pathology, FDM, MU – Varna Scientific

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The review is prepared in accordance with Order No. R-109-200/15.07.2024 by the Rector of MU-Varna and Protocol No. 1/01.08.2024 by the Scientific Jury.

General Presentation of the Procedure and the Doctoral Student

The presented set of materials on an electronic medium complies with the requirements of the Law for the Development of the Academic Staff in the Republic of Bulgaria (ZRASRB), the Regulations for the Implementation of the ZRASRB, and the Regulations for the Conditions and Procedures for Acquiring Academic Degrees and Occupying Academic Positions at MU – Varna. It includes: Order No. R-109-463/03.11.2020 for enrollment as a full-time doctoral student in the Department of Conservative Dentistry and Oral Pathology, FDM – Varna, with scientific supervisor Prof. Dr. Vladimir Panov, PhD; Extract from protocol No. 33/25.06.2024 from the meeting of the Department Committee with a positive decision for readiness for defense; Order No. R-109-200/15.07.2024 for discharge with the right to defend within one year; European format CV signed by the doctoral student; Protocol from conducted exams in the specialty and in English (doctoral minimum); List of publications related to the dissertation, signed by the doctoral student; Copy of the diploma for the educational qualification degree "Master"; Copy of the diploma for the recognized specialty "Operative Dentistry and Endodontics"; Dissertation; Printed abstract; Declaration of authenticity of the submitted documents for defense; Declaration of originality under Art. 27, para. 2 of the Regulations for the Implementation of the ZRASRB; Official note on similarity No. 72/17.06.2024; Declaration for registration of profiles in scientific databases and academic transcript for the presence of scientific profiles.

Dr. Silvia Stankova was born in 1978 in Vidin. In 1997, she completed her secondary education in Vidin, and in 2003, she graduated from the Faculty of Dental Medicine (FDM) at MU – Plovdiv. She has worked as a dental practitioner in Vidin and Varna, and since 2008, she has been an assistant in the Department of Conservative Dentistry and Oral Pathology at FDM – Varna. In 2012, she obtained a specialty in "Operative Dentistry and Endodontics."

She participates in teaching pre-clinical and clinical courses in conservative dentistry and in the state internship program for students. She is proficient in English and has an intermediate level of Russian.

Structure of the Dissertation

Dr. Silvia Stankova's dissertation is properly structured and includes the necessary sections required by the Regulations for the Conditions and Procedures for Acquiring Academic Degrees and Occupying Academic Positions at MU – Varna. It consists of 190 pages, distributed as follows: table of contents (2 pages), list of abbreviations (1 page), introduction (1 page), literature review (45 pages), objectives and tasks (1 page), materials and methods (17 pages), results and discussion (82 pages), conclusions (2 pages), summary (1 page), contributions (1 page), bibliography (20 pages), publications related to the dissertation (1 page), and 4 appendices.

The evidential material is illustrated with 30 tables, 94 figures, and 4 appendices. The bibliography includes 424 literary sources, of which 23 are in Cyrillic and 401 in Latin.

Relevance of the Topic

Modern dental medicine aims to develop and establish treatment procedures and materials that not only ensure good therapeutic results but also achieve high aesthetics in restorations and complete rehabilitation of the oral cavity. Increasingly, clinicians are focusing on creating high aesthetic standards, of which the color of the teeth is a part.

Tooth whitening is the simplest, most cost-effective, and often sought-after non-invasive method for removing tooth discolorations and lightening the color of vital and devitalized teeth. It is very successful with properly selected patients and suitable means and work protocols. Tooth whitening improves the patient's smile, appearance, and quality of life.

The growing demand for ways to improve tooth color requires a good understanding of the possible adverse reactions and effects in order to limit them, as well as the search for more conservative but equally effective whitening methods. Some of the most common adverse effects after whitening vital teeth include the development of tooth hypersensitivity, changes in the structure and properties of the tooth enamel (changes in topography and roughness, increased permeability, reduced surface microhardness, dissolution of hydroxyapatite crystals, and release of calcium, phosphorus, and fluoride), increased intrapulpal temperature, diffusion of the whitening agent into the hard dental tissues, diffusion into the dental pulp of ions, radicals, and molecules of the residual whitening agent, changes in the properties of restorative composite materials, and their adhesion strength to the hard tooth tissues.

The application of highly concentrated whitening agents in the office has been the subject of long-term scientific research, not only in terms of their whitening effect but also concerning potential side effects on the hard dental tissues, dental pulp, and soft tissues. These studies explore the relationship between the type and concentration of whitening agents, their pH, frequency and duration of application, and the use of additional means to activate the whitening agent. Various physical and chemical factors that have the potential to increase the effectiveness of professional whitening agents while reducing the risk of adverse side effects during their application are also being researched. The results and conclusions of the experiments and observations conducted are contradictory regarding the effects of peroxide-containing products on the quality of enamel and dentin. Efforts are being made to modify conventional procedures for whitening vital teeth to ensure the desired aesthetic effect while reducing the risk of enamel demineralization, changes in the tooth surface, and damage to the dental pulp.

The topic of the doctoral candidate's research is suitable for a dissertation, relevant, and important both for the development of science in this field and for clinical practice. It aligns with contemporary trends and meets patient expectations for maximum aesthetics during dental procedures. The results obtained and the conclusions drawn will assist dental practitioners in choosing appropriate methods and means for effective and safe whitening of vital teeth.

Understanding the Problem – Literature Review

The literature review is focused and sequentially examines the types of tooth discolorations, the chemical composition of whitening agents, and the methods of their application for vital and devitalized teeth.

The mechanism of tooth whitening, based on oxidation-reduction reactions involving hydrogen peroxide and pigment molecules, is analyzed in detail.

Methods for assessing tooth color, which must be reliably registered before, during, and after the whitening procedure, are critically examined. Special attention is paid to published literature data regarding changes in the whitening effect of hydrogen peroxide under the influence of various physical and chemical means, such as: increasing the temperature of the whitening agent through high-intensity light (LED lamps, lasers); including photosensitive compounds in the whitening product; applying ultrasonic energy; and including metal salts and plant extracts (enzymes) as catalysts for the chemical reaction.

A critical analysis of the possible adverse effects following the whitening of vital teeth is made, based on a thorough analysis of literature data on the occurrence of tooth hypersensitivity, changes in the structure and properties of tooth enamel, increased intrapulpal temperature, diffusion of the whitening agent into the hard dental tissues, and more. The contradictions in the cited studies logically lead to the conclusion that opportunities should be sought to modify conventional procedures for whitening vital teeth and to develop new clinical protocols that not only ensure the desired aesthetic result but also reduce the adverse effects of the applied agents on hard dental tissues and pulp.

Objectives and Tasks

The objective of the dissertation is to investigate the experiences of dental practitioners and patients regarding tooth whitening methods and to examine the influence of certain physical and chemical factors on the whitening mechanism and the effects of whitening products on teeth.

Four planned tasks aim to: 1. Survey dental practitioners and patients opinions and experiences regarding tooth whitening; 2. Investigate the impact of LED light and electric current (2mA) on the decomposition rate and whitening effect of hydrogen peroxide in whitening products using chemical methods and UV-VIS spectroscopy; 3. Study the potential of metal salts and enzymes to activate whitening products with varying concentrations of hydrogen peroxide and compare the accuracy of tooth color determination using standard shade guides and a spectrophotometer during the whitening procedure; 4. Examine the morphology and roughness of enamel on teeth subjected to whitening with different products, with or without chemical activation.

It is recommended that the second part of task 3 (3.2), related to the study of the accuracy of tooth color determination using standard shade guides and a spectrophotometer, be separated into an independent task, as it addresses a different aspect of the whitening procedure and does not correspond to the general formulation of the task.

Research Methodology

The research material is sufficient in volume to obtain reliable results and conclusions. Dr. Stankova uses various research methods in her studies, which are appropriate for the tasks set, ensure objectivity and reliability of the results obtained, and are described in detail for each task. The studies were conducted independently by the doctoral candidate.

The experiences and opinions of dental practitioners and patients regarding tooth whitening were investigated through a survey of 150 practicing dentists and 122 patients. The results were processed and analyzed using descriptive statistics and graphical methods (tables and diagrams) with MS Excel 2019 and SPSS 20.0.

In task 2.1, thirty samples were divided into three equal groups, based on the presence or absence of activation with LED light or electric current. The concentration of hydrogen peroxide was determined dynamically through titration. In task 2.2, five groups of ten samples each had their optical density measured using a Boeco UV-VIS Spectrophotometer S-26 at intervals of one minute over a period of 0 to 10 minutes.

The study for task 3 was conducted on 43 extracted upper and lower incisors, canines, and premolars, which were divided into one control and five experimental groups, depending on the concentration of hydrogen peroxide and added catalysts. Two methods were used to register the color immediately before and after the experiment: a standard shade guide for visual determination of tooth color by VITA and a spectrophotometer VITA Easyshade V.

The subjects of the study in task 4 were the teeth from the previous task, distributed in the same groups. The surface microroughness of the vestibular surface in the gingivo-incisal direction

of the tooth samples was examined before and after the application of the whitening agents using a microroughness measuring device.

Characterization and Evaluation of the Dissertation

The dissertation was personally conducted by the candidate under the guidance of her scientific advisor. The results of the conducted studies are presented accurately and comprehensively and are excellently illustrated in tables and figures. The analysis is based on objective statistical methods.

Results for Task 1.1 are presented descriptively and in the form of 14 figures and 6 tables, while for Task 1.2, the results are shown in 24 figures and 8 tables. It was found that dental practitioners often perform tooth whitening, preferring procedures with light activation. They believe that in-office procedures have a better effect compared to those applied at home. There is no clear consensus on the registration of hypersensitivity in whitened teeth.

Patients prefer in-office whitening, with toothpaste being the most commonly used product for home use. The majority of patients use whitening procedures to improve their appearance rather than solely on the recommendation of a dental practitioner. The percentage of those dissatisfied with the results is low.

The data from the studies in Task 2 indicate that the application of physical factors (blue light - 450 nm and electric current) as activators of whitening products leads to an initial increase in the concentration of hydrogen peroxide, peaking at the fifth minute, followed by a gradual decline without returning to the initial values. This result allows for changes in the clinical protocols for in-office whitening of vital teeth concerning the initial concentration and amount of the whitening agent, as well as the number of applications to improve the speed and efficiency of the procedure. The application of electric current as an activator needs further research to determine the risk of damage to pulp cells and the preservation of their vitality. The influence of physical factors on the whitening potential in *in vitro* conditions can also be assessed through spectrophotometry. The final whitening effect achieved on black tea extract after the application of a whitening agent with or without blue light activation is the same but occurs almost twice as fast after activation.

Comparative research on the potential of samples with a lower concentration of hydrogen peroxide, activated by adding metal salts and enzymes, shows an increased whitening effect, most pronounced with horseradish peroxidase. However, this product's effectiveness is weaker compared to using whitening agents with a higher concentration of hydrogen peroxide. Optimization of the amount of activator is necessary, along with additional thermometric studies of changes in intrapulpal temperature, as these products cause a rapid and intense exothermic reaction on the tooth surface. No statistical difference is found between the visual and spectrophotometric methods for determining tooth color.

The results of Task 4 are presented comprehensively in tables and figures, excellently illustrating the observation of the surface microroughness of enamel on teeth subjected to whitening with agents of different hydrogen peroxide concentrations with/without chemical

activation. An increase in average surface roughness after whitening procedures is recorded, most pronounced in the catalase activator group. For a more objective characterization of each examined surface, measuring the average surface roughness Ra should be accompanied by measuring the average roughness depth Rz.

The discussion of the results is done in a good scientific style and is based on comparing the candidate's results with those of other contemporary scientific studies. The candidate's accurate interpretations and critical attitude towards the obtained data indicate a deep understanding of the main problems of the chosen topic.

Findings and Recommendations

Each task concludes with findings that correspond to the evidence material within them. The summarized findings after the discussion of the results practically repeat those made after each task. It is necessary to reduce their number here and systematize and highlight the main conclusions reached by the candidate as a result of the experiments conducted.

The dissertation ends with a brief conclusion.

Contributions

Dr. Stankova categorizes the contributions of her scientific work into two groups: scientific-applied and applied. Among the scientific-applied contributions, 4 are confirmatory, and 3 are original:

- A thorough analysis of the awareness, experience, and various aspects of conducting whitening procedures among dental practitioners and patients has been conducted.
- The potential of physical factors such as blue LED light and electric current to activate whitening agents containing hydrogen peroxide has been compared.
- For the first time, the microroughness parameters Rq, Rsk, and Rku, as well as BAC and ADC curves of the surface profile of teeth subjected to whitening *in vitro*, have been determined.

One of the applied contributions is original and of significant practical importance, proving the good capabilities of the visual method for evaluating tooth color during the whitening procedure when the technique is correctly performed. Another applied contribution confirms that physical and chemical factors allow changes in the clinical protocols for in-office whitening of vital teeth.

Evaluation of Publications Related to the Dissertation

In connection with the developed dissertation, 3 publications in Bulgarian have been presented, in which Dr. Stankova is the sole author. Their number is sufficient and meets the requirements of the Regulations for the conditions and procedures for acquiring scientific degrees and holding academic positions at MU - Varna.

Abstract

The abstract corresponds to the content of the dissertation and complies with the requirements adopted by MU - Varna. On 64 pages, the goal, tasks, material, research methods, and obtained results, presented in tables and color figures, are discussed. The findings, contributions, and publications related to the dissertation are also included.

Conclusion

Dr. Silvia Evtimova Stankova presents a relevant dissertation with original scientific-applied and applied results. Based on sufficiently extensive experimental material, she presents results and draws conclusions useful for dental practitioners.

The planned and completed experimental setups demonstrate Dr. Stankova's ability to conduct successful scientific research independently. The remarks made do not diminish the scientific value of the presented dissertation.

Considering the scientific work and the criteria for obtaining the educational and scientific degree "Doctor," as specified in the Law on the Development of Academic Staff, its application regulations, and the regulations of MU - Varna, **I give a positive evaluation of the dissertation "Study of the Influence of Certain Factors on Tooth Whitening" and confidently vote for Dr. Silvia Evtimova Stankova to be awarded the educational and scientific degree "Doctor" in the scientific specialty 03.03.01 Therapeutic Dental Medicine.**

September 7, 2024
Sofia

Reviewer:


Prof. Dr. Emilia Karova, PhD