REVIEW

by Associate Professor Dr. Antoaneta Miteva Mlachkova, Ph.D.
Medical University, Faculty of Dental Medicine, Department of Periodontology, Sofia

of dissertation for awarding the educational and scientific degree 'doctor'

professional field **7.2.Dental medicine; 7.Health and sports.**

doctoral program: **Periodontology and oral diseases**

Author: Dr. Ivan Venkov Nachkov

Form of doctoral studies: regular / independent preparation

Department: Periodontology and diseases of the oral mucosa

Topic: "Laser-assisted therapy of periimplantitis with Er: YAG laser"

Scientific adviser: 1. Associate Professor Dr. Georgi Tomov, MD; MU-Plovdiv, FDM; 2. Prof. Dr. Plamen Zagorchev, Ph.D.; MU-Plovdiv

1. General presentation of the procedure and the doctoral student

The presented set of materials on electronic media is in accordance with Article 70 (1) of Section I. Acquisition of educational and scientific degree "DOCTOR" and scientific degree "DOCTOR OF SCIENCES" in MU-Plovdiv; Regulations of MU-Plovdiv from 28.01.2021 and includes the following documents:

- application to the Rector of MU-Plovdiv for disclosure of the procedure for defense of the dissertation
- curriculum vitae in European format with the signature of the doctoral student
- notarized copies of the diploma for higher education
- orders for enrollment in doctoral studies, interruption of studies (due to maternity) and for continuation of studies; for deductions with the right of defense
- an order for conducting an examination from the individual plan and a respective protocol for passing an exam or a doctoral minimum in the specialty
- minutes of the department council for preliminary discussion of the dissertation and the decisions taken to open a procedure for deduction with the right to defense and for the composition of a scientific jury
- dissertation work
- abstract
- list and copies of scientific publications on the topic of the dissertation
- copies of scientific publications
- list of participations in scientific forums
- list of noticed citations
- declaration of originality and authenticity of the attached documents

– other documents related to the course of the procedure

The doctoral student has attached **3 publications.**

Notes and comment on the documents:
The presented set of materials on paper is in accordance with the requirements of the Regulations for the development of the academic staff of MU - Plovdiv.

2. **2. Brief biographical data about the doctoral student**

Dr. Ivan Nachkov was born on January 31, 1977, in the town of Svishtov. He graduated in dental medicine in 2004, at the Faculty of Medicine, Medical University of Plovdiv. He graduated in human medicine in 2013. in MU-Plovdiv. Assistant in the Department of Periodontology and oral diseases at FDM Plovdiv. Works in MHAT "St. Panteleimon - Plovdiv EOOD. Acquired a degree in Maxillofacial Surgery in 2011.

3. Relevance of the topic of the dissertation and expediency of the set goals and objectives

The topic is relevant and in recent years has become established in dentistry. Dental implantology is becoming more and more widespread in clinical practice and occupies an increasing volume of the activity of the dentist. The risks of complications of local and local-complex nature, such as: inflammation, dystrophic and general diseases, impaired metabolism and reduced immunity, as well as poor orthopedic planning, often cause complications, and one of the possibilities for their management and treatment is the use of different types of laser technology. The problem of determining the indications, the methods for their application and reporting the treatment results are of great interest for medicine and in particular for dentistry.

From this point of view, the chosen topic and the expediency of the set goal and the set tasks for its realization are of exceptional interest for dental medicine and dental implantology, both from a scientific and practical point of view.

The goal is formulated correctly and is of interest to dental science and practice. The methodologies for its achievement are purposeful and well selected. Sufficient modern technologies are used to prove the set goal.

4. Knowledge of the problem

In the presented literature review Dr. Nachkov shows that he is thoroughly acquainted with the latest advances in dental implantology and the development of laser technology for

medical purposes. The review covers a large volume of authors and developments from recent years. In the review, Dr. Nachkov traced and analyzed the indications, contraindications and methods used in modern dental implantology. He also pointed out the reasons leading to complications. He analyzed the possibilities of different types of laser technologies and their possibilities to be used in dental practice. After a critical analysis of the literature data and on the basis of the existing diversity in the opinions of the individual authors, on the basis of unsolved problems, he builds his concept and defines his scientific goal.

5. Research methodology

The research methods are performed correctly. The results are reliably reported and are subjected to in-depth statistical and clinical analysis, which allows to adequately respond to the tasks to be solved in the dissertation submitted to me for review.

6. Characteristics and evaluation of the dissertation

Results obtained from Task 1.

The obtained results give grounds to conclude that the Er: YAG laser fully satisfies the requirements for stability. The observed surface areas obtained from the diode laser treatment create a problem for the osteointegrative abilities of the tissues due to resolidification and cracking of the surfaces. The titanium oxide layer is damaged, which is a problem of stabilization. This shows that the energy values of the laser treatment must be in unfocused mode, low energy and under water cooling to avoid the described changes. The non-contact mode protects the surface and performs detoxification and decontamination, as well as ablation of granulations in soft tissues.

Results obtained from Task 2.

The results of the implementation of the first part of Task 2 "Study of temperature changes using thermocouples" are presented after treatment with T-test and Kruskal - Wallis when working with diode, CO2 and Er: YAG laser in different modes in different areas, which show statistically significant differences between the values in the groups at a significance level $p < 0.05$. The data are shown in the study graphs in the different areas of the implant interface. The obtained data show that the temperature values above the biological limit of 47°C are in the mode of operation with CO2 and diode laser. There is a slight rise above the outlet temperature or a slight decrease only with the Er: YAG laser.

The results of the implementation of the second part of task 2 "Investigation of temperature changes using a thermal camera" show the values when working with Er: YAG laser, obtained with thermocouples, conducted under natural conditions in the oral cavity. An infrared thermal camera was used for this purpose. Four factory modes of operation were used, necessary for laser - assisted therapy of periimplantitis. The analysis revealed a

statistically insignificant difference at different energies and durations. The results show that the interaction between the laser light and the metal surfaces is determined by the degree of absorption and reflection, which depends on the specific wavelength. In the interaction of laser radiation with matter, the main processes are reflection, transmission, absorption and scattering. While preserving the biological environment, the energy is equal to the difference between the emitted laser energy and its components. The absorbed energy depends on the fluorescence, photothermal and thermal effects. Poor permeability and deep absorption focuses on the reflectivity of the titanium implant. **The actual measurement of temperature changes during laser exposure is a significant contribution to the choice of methodology for the treatment of periimplants and contributes to the prognosis in the long run. The selection of infrared laser types, due to their specific interaction with the titanium implant, represents a significant contribution to the treatment tactics for the treatment of periimplants.** The establishment of the best physico-biological parameters in the Er: YAG laser, the established temperature changes and the water cooling with which the device works, allows for thermal relaxation of the tissues. Described operating modes: CR (calculus removal); BR (bone remodeling); GTA (granulation tissue ablation) and PPD (periodontal pocket debridement) provide safe intervention both on the soft tissues of the implant interface and on the implant itself during treatment procedures.

Results obtained from Task 3.

The results of the first part of task 3, on determining the main periodontal pathogens from the periimplant pocket of patients by Real-time-PCR reaction, show that in patients diagnosed with periimplantitis there is a certain distribution of MO by type and amount in the pathological pocket.

The results of the second part of task 3, related to the comparison of the decontaminating ability of Er: YAG laser on periodontopathogenic microorganisms and the decontaminating ability of ultrasonic Teflon tips -Implant-clean Type 1, show that mechanical means are less effective in processing the titanium surface in terms of debridement, decontamination and detoxification. The preservation of intact metal micro- and macrostructure of the implant body during machining is compromised, and this disrupts future processes of reosteointegration. When the colonies of microorganisms were treated with a laser (4 ± 1.24), a statistically significant strong decrease was obtained in comparison with their treatment with an ultrasonic tip (59.2 ± 18.15, $p < 0.0001$). **It has been experimentally proven that the Er: YAG laser, which works in non-contact mode under continuous water cooling, gives it an advantage in the treatment of highly contaminated and complex architectural surfaces,**

such as implants. Laser energy also has a direct damaging effect on the MO. This action of the laser, in addition to reducing their pathogenic potential, leads to a violation of their adhesive ability, which makes it much easier to wash and mechanically remove.

Results obtained from Task 4.

The results of task 4, related to clinical research with Er: YAG laser in laser-assisted periimplant therapy, show that based on laboratory and electron microscopic examinations, a **laser-assisted surgical protocol for the treatment of periimplantitis can be proposed.** From the conducted clinical study, statistical models were derived for the degree of dependence on the basis of sex, smoking, heart disease, age of implants, periodontal parameters and the obtained treatment result. 4 main operating modes of the laser with factory settings are used to achieve effective tissue debridement, decontamination, bone remodeling, tissue ablation and titanium surface treatment. The features of a visibly cleaned implant surface (qualitative reflection of the implant surface) are fully achieved when treated with Er: YAG laser. The supraosal part of the pathologically exposed implant surface can be treated by using an Er: YAG laser as close as possible to the factory set engineering parameters of the implant body in order to achieve biologically and chemically clean, unmodified implant surfaces.

7. **Contributions and significance of development for science and practice**

Characterization of the main achievements in the dissertation: In the made work, the dissertation establishes the following facts having practical applicability:

1. The observed surface areas of resolidification and cracks obtained during diode laser treatment create major problems for the osteointegrative abilities of tissues due to anodizing of the implant surface due to the applied laser energy, which disrupts the titanium layer, which is crucial for secondary stabilization of the implant.

2. The energy values of the laser treatment must be in unfocused mode, low energy and always under water cooling in order to avoid surface changes due to high temperature.

3. Visualization of the temperature distribution in and around the titanium implant during ER: YAG laser irradiation in the various factory operating modes does not lead to extreme thermal rise above the physiological threshold for 1, 3 and 5 minutes.

4. The data obtained from the thermal chamber fully confirm those obtained from the study with thermocouples. This justifies the ER: YAG laser being safely included in therapeutic protocols for the treatment of periimplantitis in different regimens and with different durations depending on clinical indications and conditions.

5. Subject to the conditions of the present study: (inclination of the tip of the laser device 15-20 ° to the root surface; energy determined by the modes of factory settings; continuous movement of the tip during operation; continuous water cooling) receives an increase in temperature in a 60-second time interval in the implant body and the tissues of the implant interface during ER: YAG laser instrumentation, which determines the possibility of long-term and safe clinical work.

6. The obtained laboratory results and statistical analysis show a comparative characteristic between the decontaminating properties of the Er: YAG laser and the widely used ultrasonic Teflon tip. Due to the peculiarities of the implant surface, which has micro- and macro-retentions, which are extremely important for the primary stability and osseointegration, its cleaning is very difficult and can even be defined as impossible. These facts define mechanical agents to be ineffective in treating the titanium surface in terms of debridement, decontamination and detoxification. .

7.Er:YAG laser works in contactless mode under continuous water cooling, features that give an advantage when processing heavily contaminated and with complex architecture surfaces. Laser energy also has a direct damaging effect on the MO. This, in addition to reducing their pathogenic potential, also leads to a violation of their adhesive ability, which makes them easier to wash off

and mechanically remove. In addition, an excessive decrease in their quantity and quality would help increase the effectiveness of the additional chemicals used to decontaminate the operative field during surgical treatment.

8. The observed in vitro changes define the Er: YAG laser as the only means of providing maximum cleaning and decontamination of the metal surfaces involved in the peri-implant pocket.

9. On the basis of laboratory and electron microscopic examinations, a laser-assisted surgical protocol for the treatment of PI has been proposed. Statistical models have been developed for the degree of dependence based on sex, smoking, heart disease, implant age according to periodontal parameters and treatment outcome. 4 main menu modes with factory settings are used to achieve effective tissue debridement, decontamination, bone remodeling, tissue ablation and titanium surface treatment. Scars on a visibly cleaned implant surface can be fully achieved by Er: YAG laser treatment.

Scientific and / or scientific-applied contributions of the dissertation:

1. For the first time an electron microscopic examination of implant surfaces treated with ER: YAG laser was performed.
2. The coefficient of reflection from the titanium surface during the laser treatment is precisely determined.
3. For the first time, the temperature changes in the operative field of a thermostated biological model were observed, which most closely resembles the physiological conditions in the oral cavity.
4. For the first time, temperature changes were recorded in real time by irradiation through a thermal camera.
5. The bactericidal potential of the ER: YAG laser detected by a scanning electron microscope was studied for the first time.
6. Based on the results of laboratory and clinical studies, a surgical protocol for ER: YAG laser-assisted therapy of periimplantitis has been proposed.

Contributions and significance of the development for science and practice (what are the scientific and / or scientific-applied and applied contributions in the dissertation). Implementation in practice.

The contributions made in the dissertation are significant for dental science and practice and offer a new therapeutic approach and modern methods for the treatment of periimplantitis.

8. Evaluation of publications related to the dissertation

3 publications are presented, one of them is in a referenced international journal, one is in English, 2 of the publications are published in national journals.The publications related to the dissertation work fully reflect the achieved results of the dissertation work, interpret problems from the scientific development and meet the requirements of the regulations of MU and LDASRB.The publications have been published in renowned scientific journals.

9. Personal participation of the doctoral student

Dr. Ivan Nachkov has directly participated in the development of the scientific paper presented to me for review. The performed clinical studies and the applied methods for the use of laser - assisted therapy of periimplantitis with Er: YAG laser were performed by the dissertation under his direct clinical supervision.

10. Abstract

The abstract presented to me is made in full compliance with the requirements in terms of content and quality. The abstract fully reflects the main results achieved in the dissertation.

11. Critical remarks and recommendations.

I have no critical remarks on the final version of the dissertation.

12. Personal impressions

I am familiar with the work of Dr. Ivan Nachkov as an assistant in the Department of Periodontology and oral diseases, especially in recent years, when I reviewed research projects in which he participated, also in relation to our joint work with the Department in writing a textbook on Clinical Periodontology . In general, my impressions of Dr. Nachkov are that he is an excellent specialist, strictly fulfilling his duties as a lecturer and researcher, which is confirmed by the dissertation submitted to me for review.

13. Recommendations for future use of dissertation contributions and results

Regarding the future use of the scientifically applicable contributions of the dissertation research, I would recommend the dissertation to build a clear algorithm for laser application - assisted periimplant therapy with Er: YAG laser, which can be easily used in the clinical practice of dental professionals.

CONCLUSION

The dissertation contains scientific, scientific-applied and applied results, which represent an original contribution to science and meet all the requirements of the Academic Staff Development Act in the Republic of Bulgaria (LDASRB), the Regulations for implementation of LDASRB and the Regulations of MU - Plovdiv. The presented materials and dissertation results correspond to the specific requirements adopted in connection with the Regulations of MU – Plovdiv.

The dissertation shows that the doctoral student Dr. Ivan Venkov Nachkov has theoretical knowledge and professional skills in the scientific specialty "Periodontology and oral diseases" and has the qualities and skills for independent research.

Due to the above, I confidently give my positive assessment of the research presented by the above-reviewed dissertation, abstract, results and contributions, ***and I offer the esteemed scientific jury to award the educational and scientific degree 'Doctor' to Dr. Ivan Venkov Nachkov in a doctoral program in "Periodontology and Oral diseases. '***

22.11. 2021 г.
Sofia

Reviewer: Assoc. Prof. Dr. Antoaneta Mlachkova, Ph.D.