REVIEW

of Prof. Dr. STEFAN IVANOV SIROMASHKI, PhD

of Dissertation for awarding the educational and scientific degree "Doctor", professional direction: Dental medicine, Doctor's program: "Prosthetic Dentistry" - Varna,

on the topic:

„ Application of temporary restorations obtained by 3D printing with a laser stereolithographic printer"

Of Dr. Delyan Krasimirov Georgiev

Scientific Supervisor: **Assoc. Prof. Stoyan Katsarov, DMD, PhD**

Dr. Georgiev presents all the necessary administrative documents according to the rules for awarding educational and scientific degree "Doctor" (PhD), doctor's program "Prosthetic Dentistry".

The review was prepared in accordance with the requirements of the Law on the Development of the Academic Staff of the Republic of Bulgaria and the Regulations for the Development of the Academic Staff of the Medical University - Varna.

Dr. Georgiev presents Dissertation on 140 pages as follows:

Content - 1 page	Used abbreviations - 1 page
Introduction - 2 pages	Literary review - 41 pages
Analysis of literary review - 1 page	Purpose and tasks - 1 page
Materials and methods - 22 pages	Results and discussion - 45 pages
Conclusion - 1 page	Conclusions - 1 page
Inferences - 1 page	Tables – 3 Figures -85
Publications – 1 page	Bibliography – 19 pages

Citations – 270 of them – 7 in Cyrillic and – 263 in Latin.

Declaration of originality – 1 page.

Short CV data of d-r Delyan Krasimirov Georgiev

He was born on 21.04.1989 in Plovdiv. He graduated "Ivan Vazov" Language High School in Plovdiv with English and Russian languages. In 2014 he graduated Dental Medicine in MU - Plovdiv. 2015 - 2018 he specialized in the Faculty of Dental Medicine – Varna. In 2018 Dr, Georgiev starts working as an Assistant Professor in the Department of Dental materials and Prosthetic Dentistry, FDM, MU – Varna.

The language knowledge of Dr. Georgiev is as follows:

	reading	speaking	writing
English	B_2	B_1	B_1
Russian	B_1	B_1	B_1
Turkish	C_2	C_1	C_1
German	B_1	B_1	B_1

Dr. Georgiev has good computer literacy. He participates in various courses and seminars.

Literature review

Dr. Georgiev with great competence performs an in-depth historical review of dental materials from their appearance to the present day. In different epochs of human history, materials for fixed restorations change their origin and technological process. At the beginning of the literary review, Dr. Georgiev made an extensive review of factory made removable crowns (metal crowns, Aluminum, Tin, Chrome – Nickel and temporary crowns of polycarbonate resin). Temporary restorations should be made of low-grade materials, easy to process and repair. The Acrylic resins meet these requirements. They are most commonly used materials for dental restorations.

Dr. Georgiev describes in detail the most used resins in dental medicine (Polymethyl metacrylic resins, Polyethyl metacrylic resins, Bis-acrylic resins, Urethane dimethacrylate resins (UDMA)). Along with the description of different types of resins use in dentistry, the dissertation describes conventional methods for making temporary restorations (direct method, indirect method, direct-indirect method, Egg-shell technique). Dr. Georgiev describes complications and errors related to conventional methods (inflammation of the dental pulp, fractures of temporary restorations, inconsistency between the preparation border and crown edges and stability of the color).

The science and the practice continue to be improved with a long list of innovations. The era of the first digital revolution came with the introduction of the CAD/SAM technology. Dr. Georgiev pays in-depth attention to the new subjective method creating a scheme of CAD/CAM methods for manufacture of temporary restorations. He describes the advantages and disadvantages of making temporary restorations through the method of removing of material. He describes the manufacturing of dental restorations through the additive method. This process is opposite to the method by removing material, the object is made by joining materials layer by layer.

The dissertation describes in detail the technological process with its advantages and disadvantages. For layer-by-layer technique most often are used 6 of them: Steriolithography (SLA), Production of details by layering (FDM), Selective electron beam melting (SEBM), Selective laser melting (SLM), Selective laser sintering (SLS) and Inkjet printing (IJP).

The literature review describes the standards of the world organization ISO. In them are written the qualities that dental materials should have. In the characterization of colors is mentioned that each color has three dimensions:

- Color tone (color name);
- Saturation (density);
- Bleaching (brightness).

The accurate determination of the tooth color is important for the aesthetic success of the prosthetic restoration. In dentistry, the color determination is done visually by a dentist or dental technician using shade guides. An analysis of the color system was made by Dr. Georgiev, describing in detail the dental color standards and shade guides based on them.

According to their purpose they are: ceramic, metal-ceramic, composite and resin. When we determining the color of the tooth with the help of shade guides, errors of a subjective nature could be made. To eliminate them recently (2013) in dentistry appears the digital determination

of the tooth color. The digital cameras are most modern devices for determination the color of the teeth. They deserved their place in the dissertation development.

Analysis of the literature review

In the found literature there is no information about the influence of the egg-shell restorations. There is insufficient information about the creation of wider range of colors for temporary restorations. There is no information about the modification and strengthen of the temporary restorations. All this gives us reason to conduct in-depth research in this area, setting the following aim and tasks.

The aim of the present work is to study the possibilities for application of temporary restorations made by printing a laser stereographic printer. In order to achieve the set aim, Dr. Georgiev solves it with the help of four tasks:

Task 1. Study the influence of color on printed preprints egg-shell type restorations made of transparent polymer.
Task 2. Development of recipes for resins related to the theory of color formation.
Task 3. Comparative analysis of bending strength.
Task 4. Creating a methodology for increasing the bending strength.

Materials and methods

Task 1. For the needs of the research under task 1, 2 types of test samples with veneer design and vestibular side thickness of 0.5 mm and 0.8 mm were made by 3D printing, which fit on the color standards of VITA shade guide.

Task 2. This task is dedicated to the development of a standard for the regular formation of color standards for printing temporary restorations. Dr. Georgiev uses three types of resins in different combinations and proportions between them - similar to the individual color characteristics: bleaching, saturation, density, transparency. Three types of combinations of composite resins were obtained, each divided into nine subgroups for making of test samples.

Task 3. From the received color combinations ten have been selected, in accordance with the correspondences of the color tone according to the shade guide of VITA Classic and VITA 3D Master. 300 test samples were made, the prototypes of which were made with the help of a specialized software product. The shape of the specimens is a cylinder with a length of 45 mm and a diameter of 3.75 mm. An experimental setup has been made to study the strength properties of the samples through a specialized device.

Task 4. The hypothesis of the technological possibility is being tested, to develop a method for strengthening the skeleton of the printed constructions. Two types of restorations have been made, respectively for the upper and lower jaw, as defects have been created on a phantom model of Frasaco. Dr. Georgiev has been prepared for the production of fixed prosthetic restorations. He uses for its experimental staging software products for simulation, as well as various digital methods used in dental practice.

Results and discussion

Task 1. The results of the analysis show that the biggest difference compared to the color shade guide was reported in A4, B4, C3 and D4. The most distant from the main color in this indicator are; A1, B 1, C1 and D4. C4 and D3. The smallest differences in color tone are found in B2, C2, C 4, and D4, such as A3.5, A4 and D2.

From the results obtained it follows that the use of egg-shell is not recommended for the restorations in the aesthetic area. Apply it only in the distal areas.

Task 2. The results of the study - to determine the color of the obtained test specimens, confirm that the different combinations of the three starting resins affect the final color and cover a wide range of possible colors. High quality of the restoration is guaranteed. The tests and analyzes show that the colors B1, B4 and C4 can be reproduced without any problems from the obtained resins for temporary restorations, while the colors A4, B2, B3 and D4 are significantly deviate from the permissible norm. The limitations of the newly created resins are due to the fact that they cannot reproduce a greater variety of colors.

Task 3. From the comparative analysis of the change in bending strength at different concentrations of White Resin, shows significant differences in bending strength at different concentrations. In combination with White Resin: Dental L.T. Clear Resin in a ratio of 4/6 corresponds to color B1. With this ratio is obtained a resin suitable for use in both the frontal and distal areas of the dentition.

Task 4. During the masticatory act. the greatest load in the bridge restorations is obtained at the boundary between the pontic and the retainers. The highest values of loads are obtained in this zone (strength and periodontal resistance). In order to reduce the fractures of the bridge prostheses. Dr. Georgiev proposes a method for creating a hollow space in the pontic, which can be filled with another heterogeneous material. The presence of material in the hollow space will increase the mechanical strength of the bridge restorations. This leads to a reduction in its breakage.

Conclusions

Conclusion 1.

The use of egg-shell printed temporary crowns by Dental LT Clear Resin affects the colors used. so they can only be applied to the distal area of the dentition.

Conclusion 2.

Tests and analyzes show that the different combinations of the three starting resins White Resin, Model Resin and Dental LT Clear Resin affect the final color and provide a range of 7 possible colors.

Conclusion 3.

The production of temporary non-removable restorations in the frontal area achieves combinations with high concentrations Dental LT Clear Resin or only Model Resin are suitable for restorations in the distal area.

Conclusion 4.

The high aesthetic and mechanical characteristics of the combination White Resin, Dental LT Clear Resin in a ratio of 4/6, corresponds to B1.

Conclusion 5.

The concentration of White Resin is responsible for achieving one of the most preferred by patients color, corresponding to the color of bleached teeth B1.

Conclusion 6.

The concentration of Dental LT Clear Resin up to 60% is associated with the transparency of the natural dentition, contributing to the imitation of tooth enamel.

Conclusion 7.

All combinations between the three starting resins - White Resin, Model Resin and Dental LT Clear Resin, show bending strength above the minimum international limit.

Conclusion 8.

The created software modification of digital files allows the formation of a significant space, which can be filled with material with different fiber structure or to be injected material with higher mechanical and strength characteristics.

Conclusion 9.

Critical areas for fractures - in the area of the connections of the pontic with the retainers, the replacement with heterogeneous material with higher bending strength would increase the overall strength of the restorations.

Conclusion

The color formation of the provisional restorations is the result of the action of a number of factors, such as the physical properties of the starting resins - their color tone, density and bleaching. In task number 1, it was proved that the egg-shell application printed temporary restorations from Dental LT Clear Resin is only suitable for the distal areas of the dentition.

The dissertation develops recipes for resins to cover a wider range of color standards. The mechanical and strength properties of the newly obtained resins for 3D printing of temporary restorations was established by a specially created experimental setup that they fully meet the requirements for bending strength set in international standards ISO 10477. High concentrations of White Resin lead to lower flexural strength, while Model Resin and Dental LT Clear Resin increase strength.

In order to create conditions for increasing the mechanical and strength qualities of the temporary restorations of these resins for the needs of long-term temporary prosthetics, a software modification of the digital files was created.

CONTRIBUTIONS

Contributions of scientific and applied nature

1. For the first time in our country the printed temporary restorations from Dental LT Clear Resin on the colors of the underlying structures are registered and documented on egg-shell.
2. For the first time White Resin, Model Resin and Dental LT Clear Resin in order to create recipes for resins that reproduce proportionally and regularly color standards.
3. The flexural strength of the newly obtained resins according to the international standards ISO 10477 and ISO 4049 has been proven.

The author adds two contributions that have an original character for our country.

Publications and participations related to the dissertation

Dr. Georgiev presents four publications related to the dissertation. Three of them are published in the International Journal of Science and Research. In the above publications, Dr. Georgiev occupies the first position. The fourth publication is in Clinical Oral Implants Research, in which he ranks second.

Conclusion

The dissertation is an original contribution to science and responds to all the requirements of the law for the development of the academic staff in the Republic of Bulgaria. In the dissertation Dr. Georgiev considers for the first time in our country some little known, unexplored material in prosthetic dentistry. He is the first dentist to discover the little-known technologies. The dissertation is mostly a personal work of Dr. Georgiev, creates his own methodologies, resorted to collaboration with close specialists in the field of engineering, structural engineers and other specialists. To prove the reliability of the obtained results he uses the following static methods: dispersion analysis, comparative analysis, correlation analysis, graphic and tabular method. Actively participates in scientific, dental and dental conferences with independent reports in which his competence on the treated problem is evident.

The dissertation responds to all the mandatory conditions of the science criteria for awarding the title **"Philosophy Doctor (PhD)".** Due to the above, I confidently give my **positive assessment** of the research and scientific contributions in the field of dentistry. As a member of the esteemed jury, I will vote convincingly **"YES"** for the award of educational and scientific degree **"DOCTOR"** to **Dr. Delyan Krasimirov Georgiev.**

18.01.2022
Plovdiv

Reviewer:
/Prof. Stefan Siromashki, DMD, PhD/