PROSPERITAS VESTRA FINIS NOSTRA!

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APPLICATION OF TEMPORARY RESTORATIONS OBTAINED THROUGH 3D LASER STEREOLITHOGRAPHIC PRINTER

ABSTRACT

of PhD thesis for awarding educational and scientific degree

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The dissertation contains 140 standard pages and is illustrated with 3 tables and 85 figures, and contains 1 applciation. The literary reference contains 270 literary sources, of which 7 are written in the Cyrillic alphabet and 263 in the Latin alphabet.

The dissertation was discussed and directed to the defense of the Department Council of the Department of Dental Materials Science and Propaedeutics of Prosthetic Dentistry at MU "Prof. Dr. Paraskev Stoyanov "- Varna on November 29, 2021.

Note: The numbers for the tables and figures in this abstract do not match the numbers in the dissertation.

TABLE OF CONTENTS

ABBREVIATIONS USED

PMMA	Polymethyl methacrylate
PEMA	Polyethyl methacrylate
UDMA	Urethane dimethacrylate
STL	Standard Tessellation Language
CAD/CAM	computer-aided design and computer-aided manufacturing
SLA	Stereolithography
SLM	Selective Laser Melting
FDM	Fused Deposition Modeling
IJP	Inkjet Printing
SEBM	Selective Electron Beam Melting
SLS	Selective Laser Sintering
N	Newton
MPa	Megapascal
ΔE	Color deviation

I. INTRODUCTION

In modern prosthetic dental medicine temporary fixed prosthetic restorations – crowns and bridges – find wide application. The prepared hard dental tissues of the natural teeth, be they still vital or devitalized, have decreased prophylactic, functional and esthetic qualities.

A variety of methods and tools exists for the construction of temporary restorations, direct and indirect methods with which it is possible to make the temporary restorations either in the dental office or in a dental laboratory.

The advancement of CAD/CAM technology in the dental practice leads to their more frequent usage for the making of both final and temporary restorations. In the last few years, the subtractive method for their manufacture through machine milling has been widely represented.

The additive method, with which the restoration is manufactured through layered application of material through 3D printing, has been studied less and is less represented.

Color determination is a particularly important stage in the process of manufacturing a given restoration, since picking the wrong color can ruin a perfectly made, from a technical standpoint, prosthetic restoration, and lead to dissatisfaction and disappointment on the side of the patient, regarding the prosthetic treatment.

Temporary restorations are a prototype of their future definitive versions. On the basis of their form, size, placement and color, they can give an idea of the definitive restoration and a chance to discuss any corrections with the patient.

While the physical parameters of a provisional restoration – shape, size and placement - can be defined and set using CAD/CAM software based on the model present in the dental laboratory, determining the color is done in the dental office, in presence of the patient. Determining the color can be subjective - done by comparing the color of the natural teeth with a set of color standards (dental colorings) - or objective, with the help of color determination devices, which allow for accurate determination of the color of both the dentition, as well as restorations manufactured in the dental laboratory.

The widely represented subjective color determination often leads to inaccuracies in the color picked and its parameters: hue, chroma, and value, under the influence of different internal and external factors like physical and mental tiredness on the side of the dental practitioner, the different levels of lighting in the dental office, an improperly picked color standard and more.

The need for an in-depth objective study of the relationship between temporary restorations and the accurate selection of their color, determines and argues the need to create this dissertation.

II. GOAL AND TASKS

1. Goal

The aim of the present work is to study the possibilities for application of temporary restorations made by 3D printing on a laser stereolithographic printer.

2. Tasks

In order to achieve the set goal, the following tasks need to be solved:

1. Investigation of the influence of the color of printed, provisional restorations type *egg shell* made from transparent resin Dental LT Clear ®, at different wall thicknesses.
2. Development of recipes for resins, reproducing proportionally and lawfully the color standards, logically related to the theory of color formation.
3. Comparative analysis of bending strength of the newly obtained resins under the second task.
4. Creating a method for increasing the bending strength of printed temporary restorations through software modification of digital files.

III. MATERIALS AND METHODS

III.1. Materials and methodology for task 1

One of the widespread techniques for rapid fabrication of temporary restorations is the use of thermovacuum-formed PVC foil on a pre-cast model. In order to obtain the restoration, it is only necessary to fill the cradle with material for temporary restorations based on PMMA or on a composite base and to place them on the already prepared tooth stumps. As both materials do not have a chemical bond with the material from which the cradle is pulled, it can be easily removed after the material has hardened. The method is relatively low cost, but has a number of disadvantages and limitations in its mass application, because it can be downloaded only on plaster or 3D printed model. In cases where there is a diagnostic model, it is necessary to duplicate the wax model and cast it from plaster or to scan and print a model of heat-resistant resin, which in any case would prolong and increase the cost of the laboratory process, and ultimately the only goal is to get a shape that fits on the prepared teeth. The use of the egg shell technique can be used as an alternative, but in most cases the materials for cutting provisional restorations are based on PMMA and in cases where their use is necessary, it is advisable to use a material that is from the same basis, as to ensure a chemical connection between the shell and the correcting material. This is a key point in terms of structural stability. The crowns used to make the egg shell by the subtractive CAM method remain connected after rebasing as part of the structure, thus forming the characteristic appearance of the final structure after using the appropriate colors of materials for their rebasing.

In this line of thought, it is logical to examine the hypothesis that it is appropriate, in order to improve the shortcomings of the thermovacuum extraction technique, to export an STL file and print a transparent resin shell used for printing bruxism splints. This will speed up the laboratory process and eliminate the restrictions on the use of this technique, which were discussed above. However, this hypothesis hides an important feature and that is that the rebasing of the printed shell with the appropriate color composite material for temporary structures will chemically bond to the inner surface of the rail. Thus, like the crowns used to make an egg shell using the subtractive CAM method from PMMA, this bar will be part of the optical environment that will affect the color reproduction of the final design. But unlike them, it is transparent.

In order to check the expediency of the use of such a method, we prepared the following experimental setup, in which we investigated the potential influence of splints with different thicknesses on color standards. The range of crown wall thicknesses in egg shell varies between 0.5 and 0.8 mm. In order to develop a universal benchmark for color comparison, a virtual model was first created by scanning with a laboratory scanner D850® (3Shape ™) **(Fig. 1)** on a VITA color benchmark. With the help of specialized software 3Shape Dental System® veneers were modeled on it in 2 thicknesses, the same on their entire vestibular surface 0.5 mm and 0.8 mm **(Fig. 2).**

Sample making technology

For the needs of the research under **task 1**, two types of restorations with veneer design and vestibular wall thickness of **0.5 mm and 0.8 mm**, respectively, were made for testing via 3D printing, which fit the color standards for determining the color with VITA tooth shade guide.

Figure 1. *Extraoral laboratory scanner D850® from the manufacturer 3Shape ™. The device provides scanning of physical models with scanning accuracy up to 7 µm.*

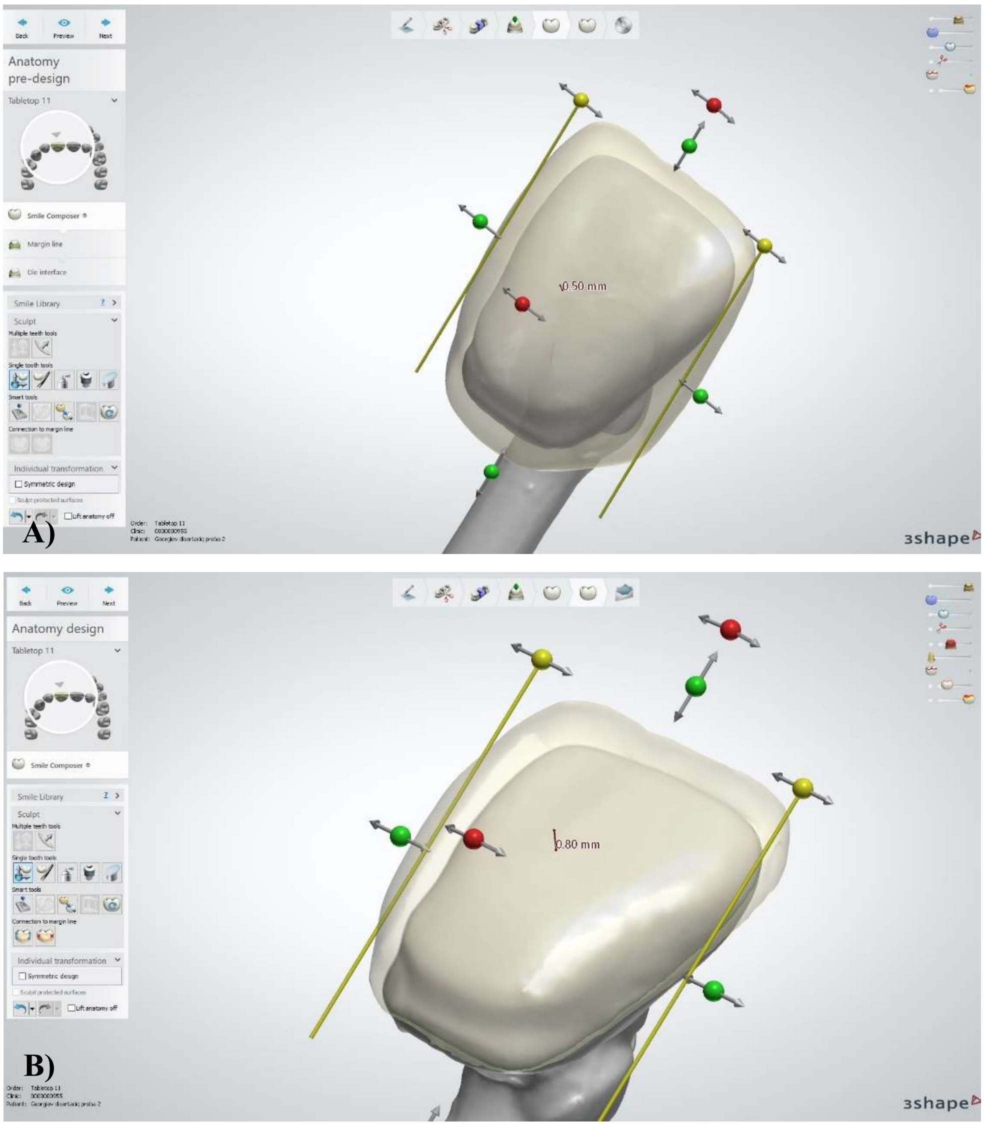


FIG. 2. *Virtual modeling of the veneers on the scanned color standard. The vestibular wall is formed with the same thickness over its entire surface.*
A) *0.5mm thickness;* ***B)*** *0.8mm thickness.*

The digital prototypes were created as .stl files and transferred to PreForm® (Formlabs ™) prepress software **(Figure 3).**

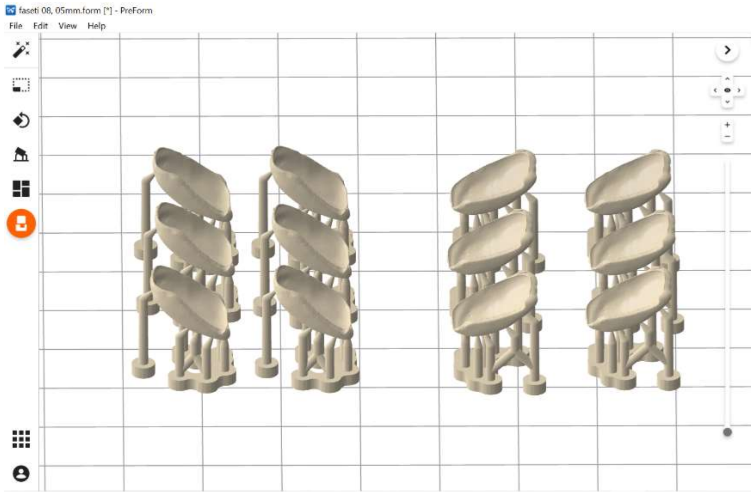


Fig. 3. Organizing and arranging the veneers on the workspace for 3D printing using the software PreForm® (Formlabs™) - orientation of the virtual models, placement of the pad and supports.

The samples were printed using the method of selective laser polymerization ustilisng a 3D printer Form 2® (Formlabs ™) **(Fig. 4)** from Dental LT Clear Resin® resin (Formlabs ™) **(Fig. 5).**

A) **B)** **C)**

Fig. 4*. Formlabs 3D printing kit ™ consisting of:*

A) *Form 2® stereolithographic 3D printer with a laser beam diameter of 140 µm and a print resolution along the axis plane of 25 µm, 50 µm and 100 µm:*

B) *Form Wash®. The device is used to remove unpolymerized resin from printed objects, working by soaking them in a solvent-isopropyl alcohol.*

C) *Form Cure®. Apparatus for additional polymerization up to 60 ° C and light with a wavelength of 405 nm.*

Fig. 5. *Composite resin with high transparency Dental LT Clear Resin® (Formlabs™).*

Each of the thus obtained veneers **(Fig. 6)** was applied to all VITA Classic® and VITA 3D Master® color standards **(Fig. 7).**

Fig. 6*. The printed veneers in 2 thicknesses - 0,8 mm and 0,5 mm.*

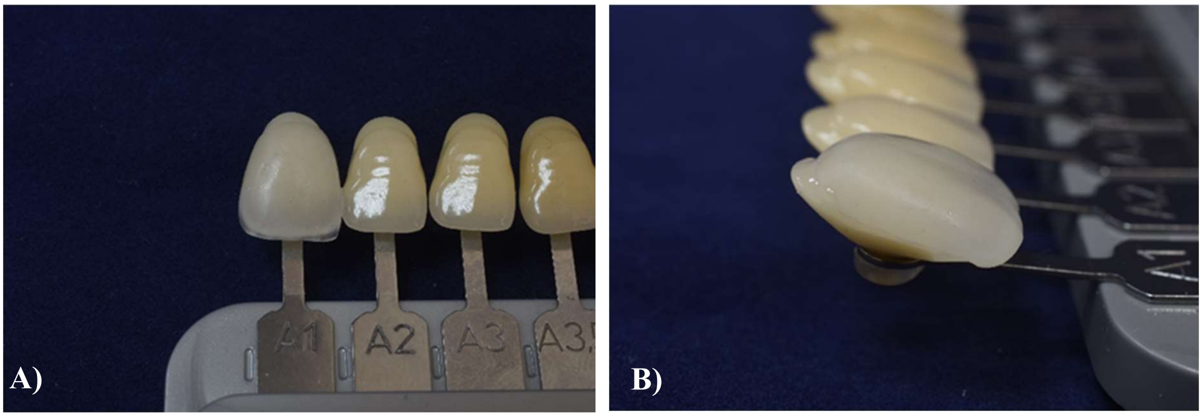


Fig. *7. Veneer with a thickness of 0.8 mm placed on a standard of VITA Classic® colors:*
A) *Front view;* ***B)*** *Side view .*

To eliminate the air environment that may affect the objective determination of the color by the device and the accuracy of the reported results, we used 2 types of liquid in all measurements - colorless ultrasound gel and Try-In paste Transperent from the set for adhesive cementation Variolink® II (Ivoclar Vivadent ™) **(Fig. 8).**

Fig. 8*. Applying Try-In paste color-Transperent Variolink® II (Ivoclar Vivadent () on the inner surface of the veneer.*

With the help of the VITA Easyshade® V device (Fig. 9) we performed measurements of each color during its "masking" with both thicknesses. The color of the standard without veneer was also measured as a control. The nozzle of the apparatus was positioned in the middle third of the vestibular surface to achieve uniform conditions for estimating the values **(Fig. 10).**

Fig. 9. *VITA Easyshade® V digital spectrophotometer for determining the color of natural teeth and aesthetic restorative materials.*

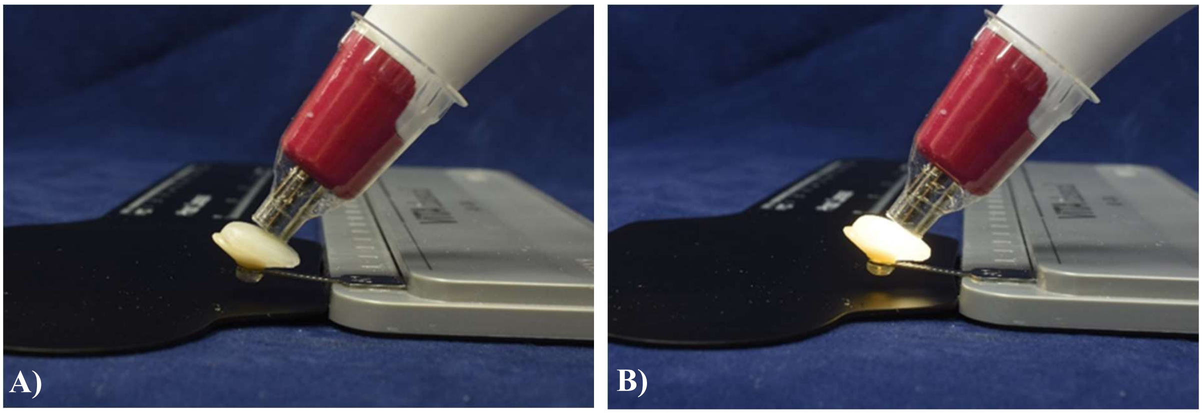


Fig. 10. A) *Positioning of the device;* ***B)*** *Measurement of the color of the standard with the veneer applied on it.*

The influence of the two veneer thicknesses was reported on the color deviation scale-ΔE, which is generated by the device itself. We measured both the total deviation and the individual components - hue, value, chroma **(Fig. 11).**

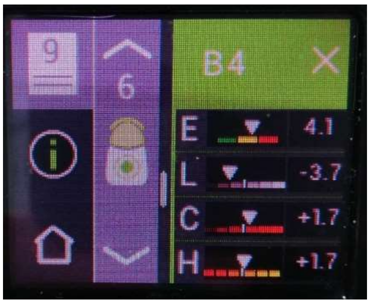


Fig. 11. *Screenshot of the device showing the color and deviation ΔE. The letter E indicates the total deviation ΔE; with L-value; C- chroma; H- hue.*

III.2. Materials and methodology for task 2

Based on the conclusions made from the results of the first task and their analysis, it is logical to examine the following hypothesis. It is known that the color of temporary restorations is determined by the type of material used for their printing. When combining different resins with different color and mechanical strength properties for 3D printing, we consider it necessary to look for the presence of regularity, in proportion to the production of colors. It is logical to assume that the use of different concentrations of resins would give us the opportunity for regular formation of color standards for printing provisional restorations. During the selection of combinations Munsell's theory for three-dimensional colorforming can be applied.

For the purpose of the study we used the following resins White Resin® (FormlabsTM), Model Resin® (FormlabsTM) and Dental LT Clear Resin® (FormlabsTM) in different combinations and proportions - similar to the individual color characteristics: value, chroma, density and transparency.

To investigate the hypotheses in this problem, 3 types of composite resins were combined in different proportions. For this purpose we divided them into 3 groups:

- White Resin® – Model Resin®;
- White Resin® - Dental LT Clear Resin®;
- Model Resin®- Dental LT Clear Resin®.

We divided each group into 9 subgroups depending on the ratio of concentrations in them. The proportions were equated to a total volume of 2 ml as follows:

White Resin® – Model Resin®:

- White Resin / Model Resin - in a ratio of 9/1 (1.8ml to 0.2ml);
- White Resin / Model Resin - in a ratio of 8/2 (1.6ml to 0.4ml);
- White Resin / Model Resin - in a ratio of 7/3 (1.4ml to 0.6ml);
- White Resin / Model Resin - in a ratio of 6/4 (1.2ml to 0.8ml);
- White Resin / Model Resin - in a ratio of 5/5 (1.0ml to 1.0ml);
- White Resin / Model Resin - in a ratio of 4/6 (0.8ml to 1.2ml);
- White Resin / Model Resin - in a ratio of 3/7 (0.6ml to 1.4ml);
- White Resin / Model Resin - in a ratio of 2/8 (0.4ml to 1.6ml);
- White Resin / Model Resin - in a ratio of 1/9 (0.2ml to 1.8ml).

White Resin®- Dental LT Clear Resin®:

- White Resin / Dental LT Clear Resin - in a ratio of 9/1 (1.8ml to 0.2ml);

• White Resin / Dental LT Clear Resin - in a ratio of 8/2 (1.6ml to 0.4ml);
• White Resin / Dental LT Clear Resin - in a ratio of 7/3 (1.4ml to 0.6ml);
• White Resin / Dental LT Clear Resin - in a ratio of 6/4 (1.2ml to 0.8ml);
• White Resin / Dental LT Clear Resin - in a ratio of 5/5 (1.0ml to 1.0ml);
• White Resin / Dental LT Clear Resin - in a ratio of 4/6 (0.8ml to 1.2ml);
• White Resin / Dental LT Clear Resin - in a ratio of 3/7 (0.6ml to 1.4ml);
• White Resin / Dental LT Clear Resin - in a ratio of 2/8 (0.4ml to 1.6ml);
• White Resin / Dental LT Clear Resin - in a ratio of 1/9 (0.2ml to 1.8ml).

Model Resin®- Dental LT Clear Resin®:

• Model Resin / Dental LT Clear Resin - in a ratio of 9/1 (1.8ml to 0.2ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 8/2 (1.6ml to 0.4ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 7/3 (1.4ml to 0.6ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 6/4 (1.2ml to 0.8ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 5/5 (1.0ml to 1.0ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 4/6 (0.8ml to 1.2ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 3/7 (0.6ml to 1.4ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 2/8 (0.4ml to 1.6ml);
• Model Resin / Dental LT Clear Resin - in a ratio of 1/9 (0.2ml to 1.8ml).

For precise dosage of the proportions for the experimental samples we used an automatic pipette with variable volume Plastomed VARI 3000 W (**Fig. 12**). The resulting mixture was stirred until the color of the resins homogenized and the mixture was placed in a transparent plastic blister mold (**Fig. 13** and **Fig. 14**). The test specimens were placed in a Form Cure® apparatus for 60 min at 60 ° C for photopolymerization (**Fig. 15**).

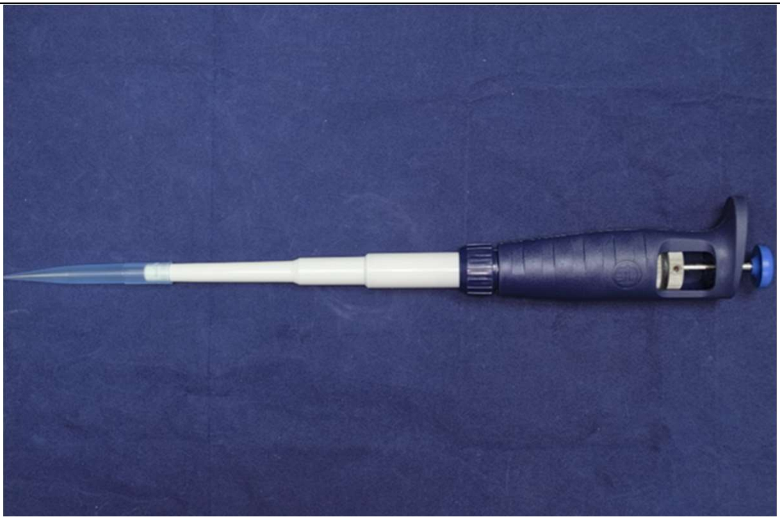


Fig. 12. *Automatic pipette Plastomed VARI 3000 W with variable volume up to 1ml.*

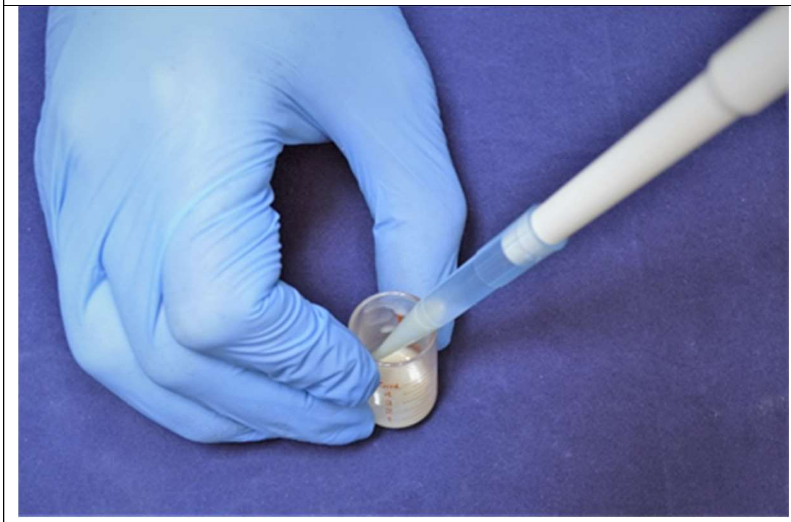


Fig. 13. *Dosing and homogenization of the mixture obtained from composite resins*

Fig. 14*. Transfer of the composite resin to blister form.*

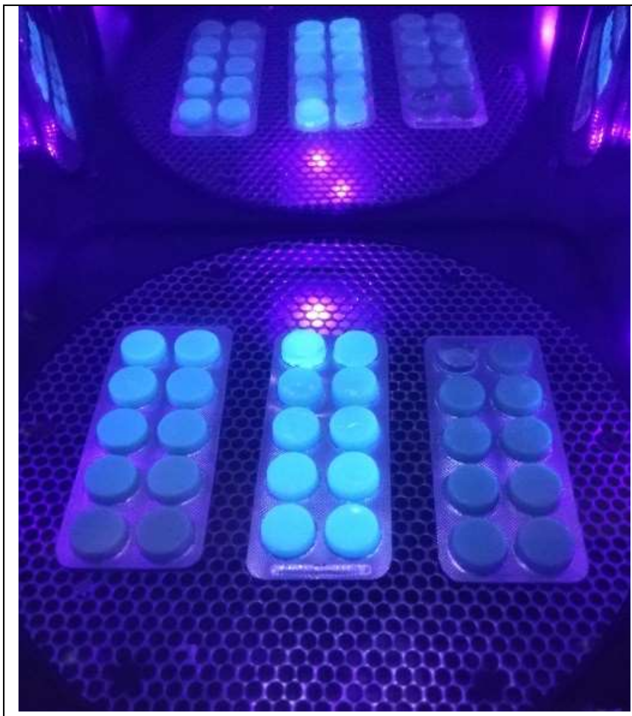


Fig. 15. *Light polymerization of the test samples in the apparatus Form Cure®*

After completion of the polymerization process (**Fig. 16**), the color of each sample was measured using a VITA Easyshade® V apparatus. The obtained data was registered, recorded and subjected to statistical processing (**Fig. 17).**

Fig. 16. *Test samples after completion of the polymerization process.*

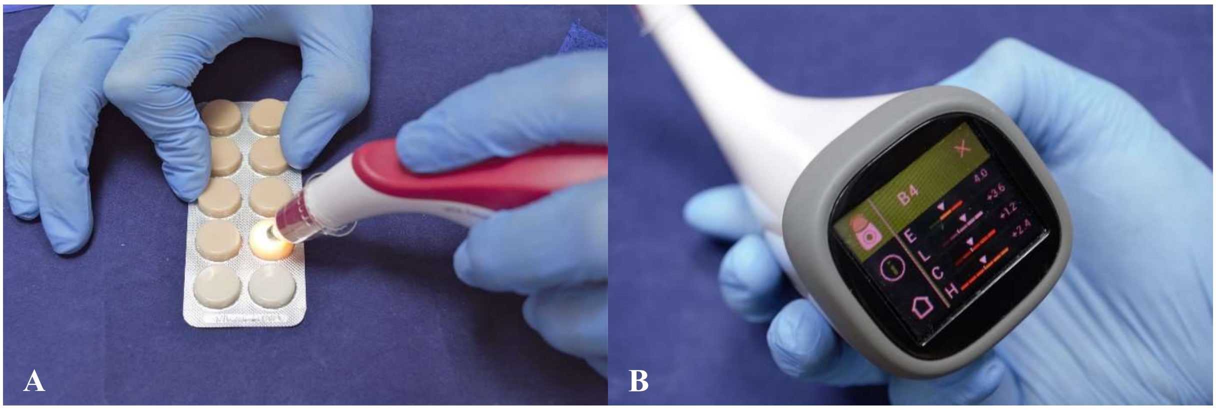


Fig. 17. A) *Measurement of test specimens with the VITA Easyshade® V apparatus.*

B) *Reading the results on the display of the device.*

III.3. Materials and methodology for task 3

After analyzing the results of task 2, it is logical to check to what extent the successful samples in color ratio would mechanically meet the strength requirements for this type of construction, specified in the international standards ISO 10477 and ISO 4049.

10 color combinations were selected, corresponding to the respective hue of the VITA Classic or VITA 3D Master color scheme:

1. White Resin / Model Resin - in a ratio of 9/1, corresponding to color B2;
2. White Resin / Model Resin - in a ratio of 8/2, corresponding to color B3;
3. White Resin / Model Resin - in a ratio of 7/3, corresponding to color B4;
4. White Resin / Model Resin - in a ratio of 6/4, corresponding to color B4;
5. White Resin / Model Resin - in a ratio of 1/9, corresponding to color A4;
6. White Resin / Dental LT Clear Resin - in a ratio of 9/1, corresponding to color B1;
7. White Resin / Dental LT Clear Resin - in a ratio of 4/6, corresponding to color B1;
8. White Resin / Dental LT Clear Resin - in a ratio of 3/7, corresponding to color 3M1 (according to VITA 3D Master);
9. White Resin / Dental LT Clear Resin - in a ratio of 2/8, corresponding to color 4M1 (according to VITA 3D Master);
10. Model Resin / Dental LT Clear Resin - in a ratio of 5/5, corresponding to color B4.

To accomplish **Task 3**, digital prototypes of the testing bodies were created using specialized 3D design and optimization software (Autodesk Meshmixer®). The design of the experimental bodies has a cylindrical shape with a length of 45 mm and a diameter of 3.75 mm (**Fig. 18**).

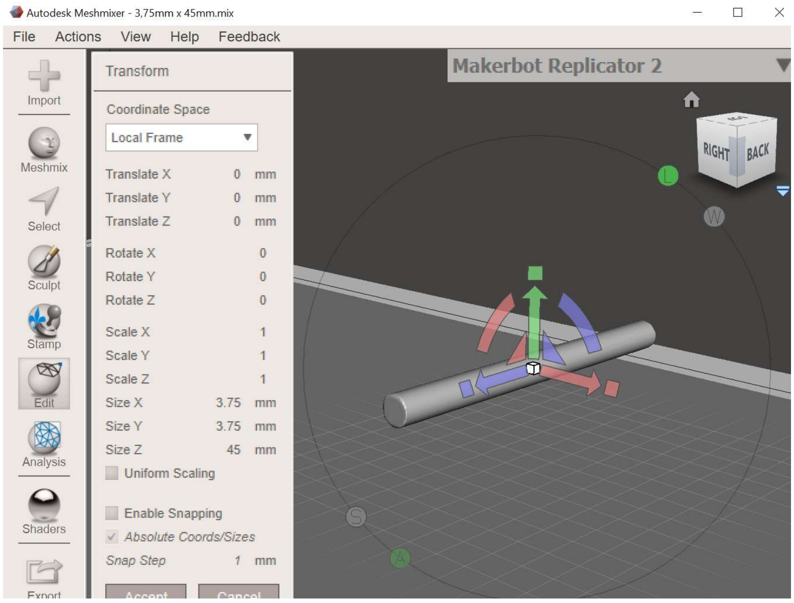


Fig. 18. *Creating the virtual model of the test samples using Autodesk Meshmixer® software.*

The completed .stl file was transferred to materialization preparation software (PreForm® 3.5, FormlabsTM). The testing bodies were printed using the method of selective laser polymerization, utilising a 3D printer Form 2® (Formlabs TM), **300** cylindrical test specimens were made. The test specimens were divided into **10 groups** of **30** in each, depending on the color obtained from the recipes in task 2 (**Fig. 19**).

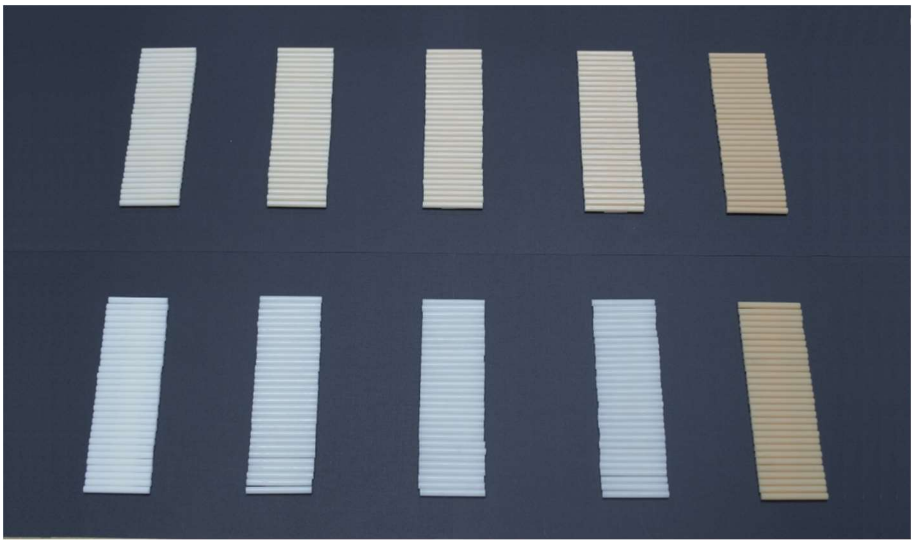


Fig. 19. *Printed experimental bodies, divided into groups of 30 pieces*

In the experimental setup for the testing the specimen's bending strenght, we used an LMT 100 micro-tensile and micro-pressure tester (LAM Tehnologies, Italy) (**Fig. 20**).

Fig. 20. *Apparatus for compressive and tensile strength LMT 100 (LAM Tehnologies, Italy).*

A fastening and loading element were fixed into the chamber of the apparatus to test the bending strength. They were made individually for the needs of the experimental setup, because the device does not have universal ones (**Fig. 21** and **Fig. 22**).

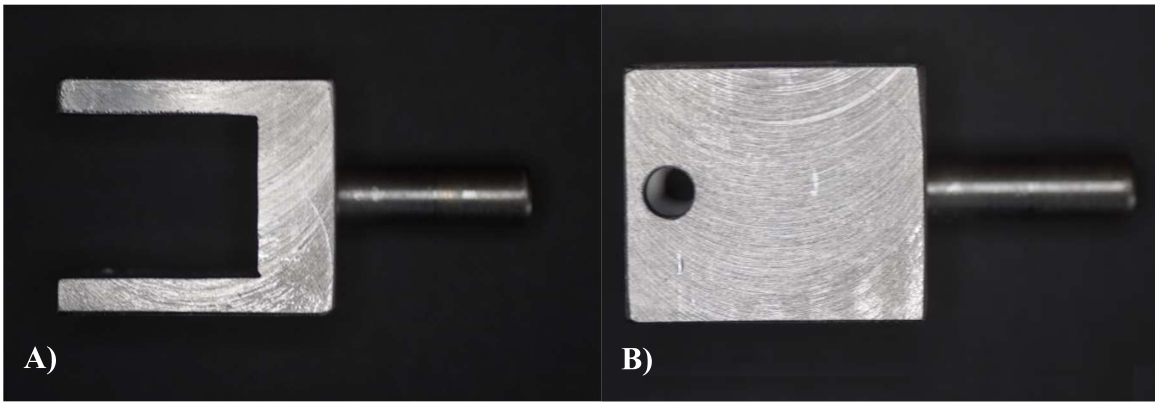


Fig. 21. *Retaining element:* ***A)*** *top view;* ***B)*** *side view.*

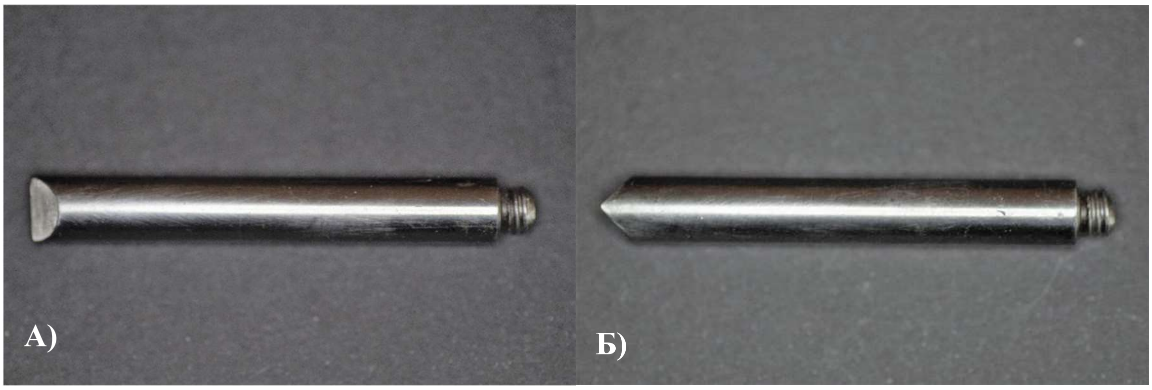


***Fig. 22.** Load element**: A)** top view; **B)** side view.*

The results were registered, processed and recorded using specialized software LMT1xx Ver 1.12 (LAM Tehnologies, Italy) (**Fig. 23**). In the computer program, when testing each test body, a graph is displayed showing the bending force in each position of the fastening and loading mechanism. For the starting position we indicated a distance of 10 mm between them and a movement speed of 0.5 mm / sec (**Fig. 24**).

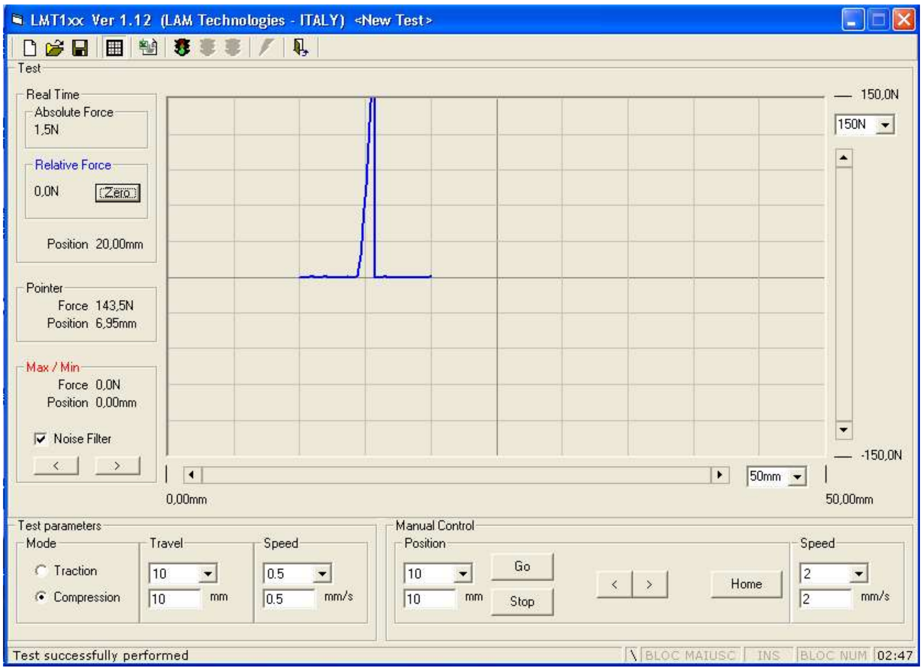


***Fig. 23.** Screenshot when working with LMT1xx software Ver 1.12 (LAM Technologies, Italy).*

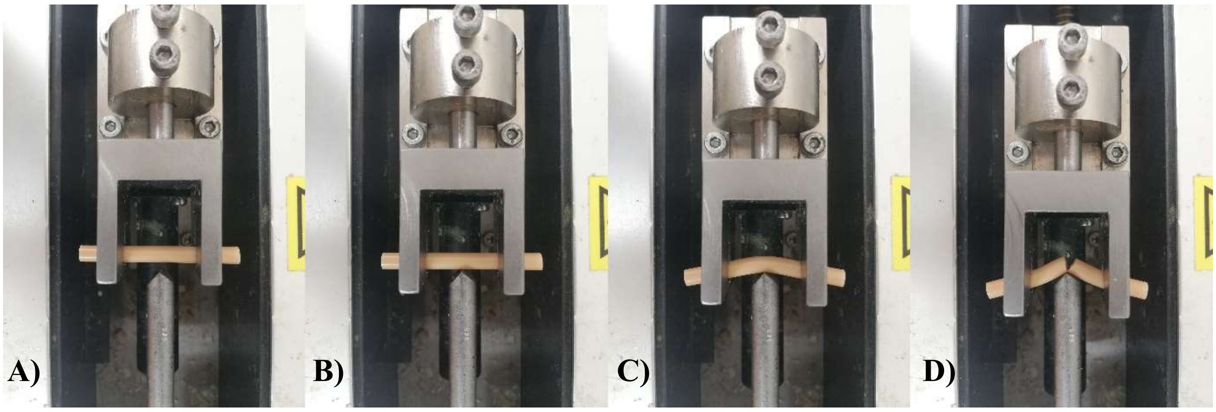


***Fig. 24. A)** Starting position of the elements; **B)** Initiation of pressure on the test body;*
***C)** Continuation of pressure and initial deformation in the prototype;*
***D)** Fracture of the test body and end of the experiment.*

The bending strength is calculated by the formula (MPa):

$$\sigma = (8.F.l) /\pi.d3$$

where: F- applied force (N);

l - the length between the support points of the retaining element (20 mm);

d - diameter of the test body (3.75 mm)

III.4. Materials and methodology for task 4

After analyzing the results arising from the discussion on task 3, we believe that it is logical to test the hypothesis of whether it is technologically possible to develop a method for strengthening the existing printed restorations.

With the mechanical properties of the resins being a constant, specified by the manufacturer, the only alternative to solve the problem is to look for methods to increase the strength by further strengthening the skeleton with materials of another kind. For this purpose, it is necessary to modify the planned restoratios so that it is possible to materialize them in objects that provide space for reinforcement with the help of heterogeneous material.

A defect of missing teeth 12,11,21,22 was created on the FrasacoTM training model of the upper jaw and the defect of missing 45 and 46 was created on the FrasacoTM training model for the lower jaw. Using a "shoulder" type finish line the following abutment teeth were prepared: for the upper model teeth 13 and 23 and respectively for the lower model teeth 44 and 47. The models were scanned using a laboratory scanner D850® from the manufacturer 3Shape™. Using the specialized 3Shape Dental System® software, two bridges were modeled between the respective abutments 13 and 23 (Fig. 25) and between 44 and 47 (**Fig. 26**).

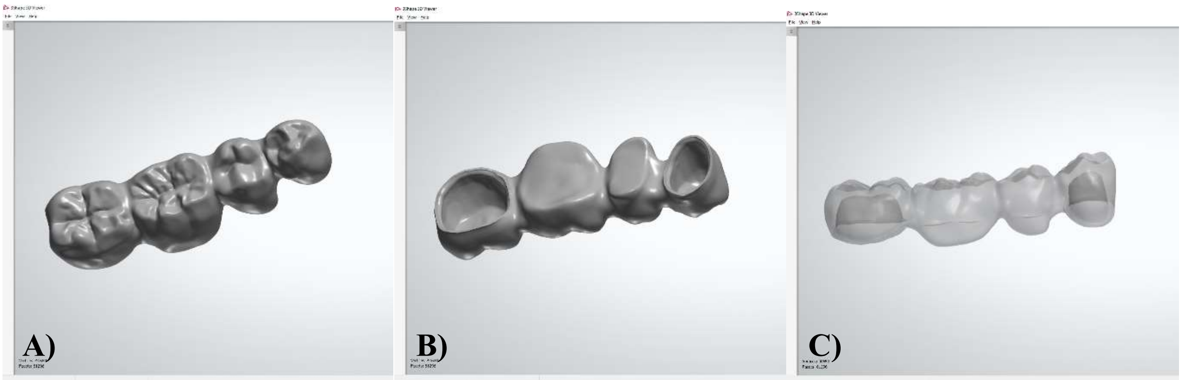


Fig. 25. A) *Occlusal view of bridge 44-47;* ***B)*** *Gingival view of bridge 44-47;* ***C)*** *Side view of the bridge showing the density of the bridge bodies.*

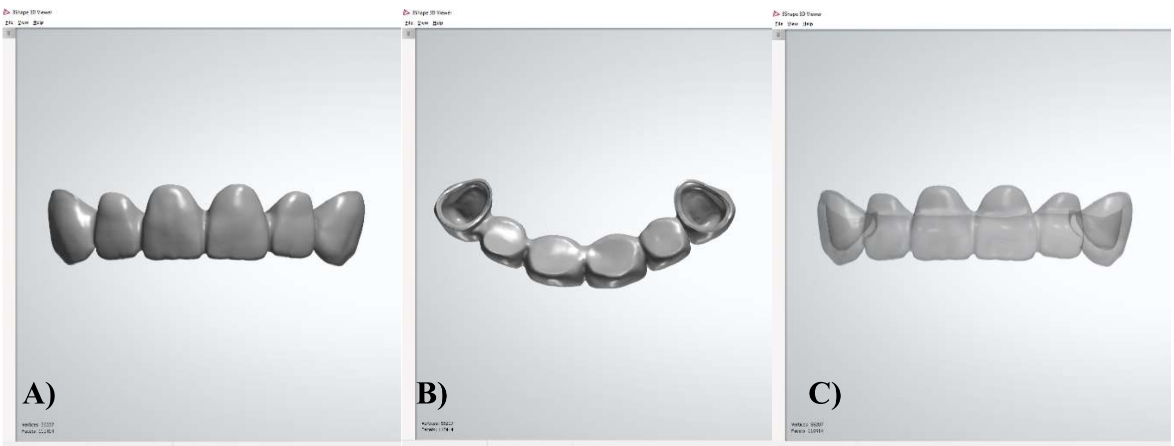


Fig. 26. A) *Occlusal view of bridge 13-23;* ***B)*** *Gingival view of bridge 13-23;* ***C)*** *Side view of the bridge showing the density of the bridge bodies.*

Because the standard STL formats generated by the 3Shape Dental System® CAD system do not allow freedom of access to alternative means of modeling the finished file, we imported the corresponding prototype bridges into specialized Meshmixer® spatial modeling software (**Fig. 27**).

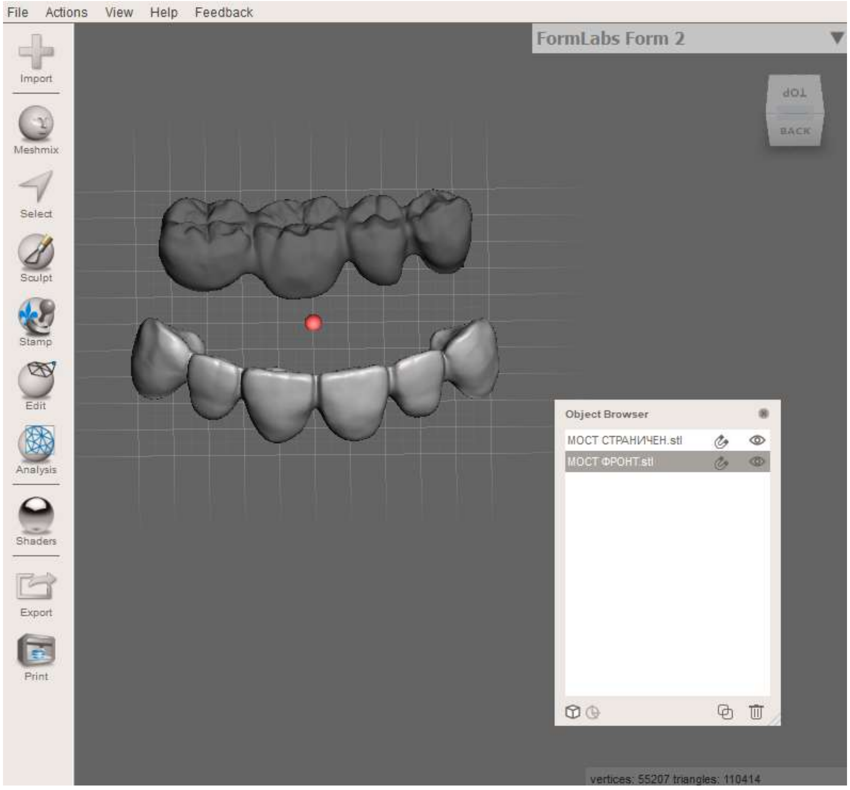


Fig. 27. Digital prototypes imported into Meshmixer®.

A cylindrical object was created from the program menu using the "meshmix" button (**Fig. 28**).

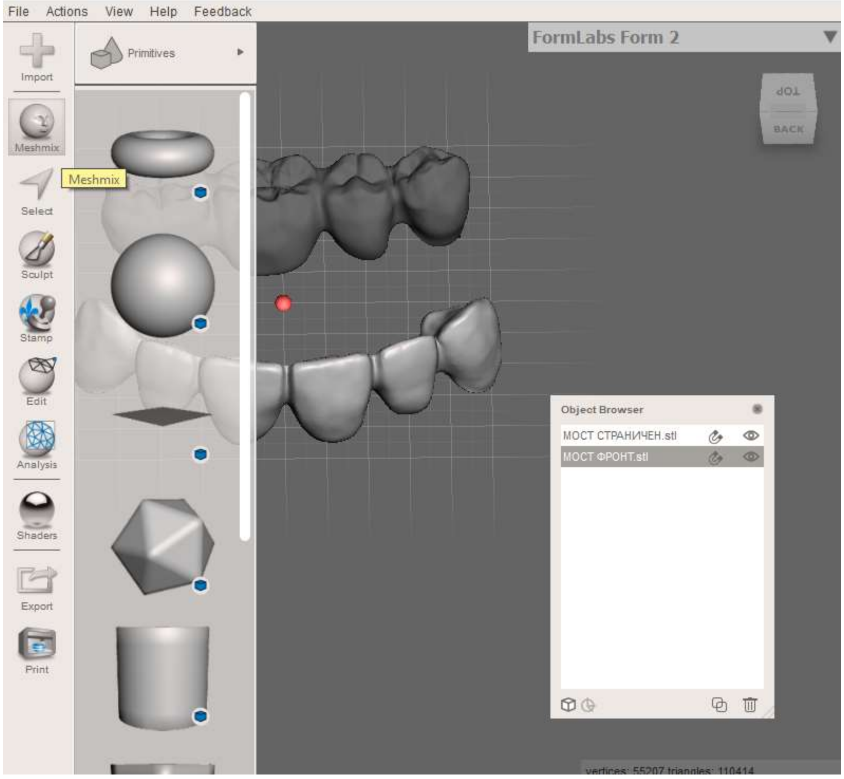


Fig. 28. Create the additional cylindrical object from the menu.

Using the "transform" function, the newly created cylindrical body was modified in shape and size so that it can fit in the volume of the bridge restoration without protruding anywhere except in the area of the retainers (**Fig. 29** and **Fig. 30**).

With the help of the "magnet tool" precise control of the positioning of the cylindrical body is achieved, because for the purpose of the tasks it is important to achieve optimal position and possibly create an elliptical shape of the body with a dominant diameter directed in the occlusal direction. 31).

Then, using the ”boolean function”, the volume occupied by the created elliptical body was removed from the total volume of the restoration, leaving a cavity corresponding to the set dimensions. (**Fig. 32** and **Fig. 33**).

Analogous to the already described methodology, in the bridge restoration 13-23 several cylindrical bodies were created and arranged independently along the length of the pontics and united in one object.Then the volume occupied by them was also extracted from the pontics to form a canal along the bridge (**Fig. 34**).

Finally, the modified bridges were exported as a stl file and analyzed using 3Shape 3D Viewer®.

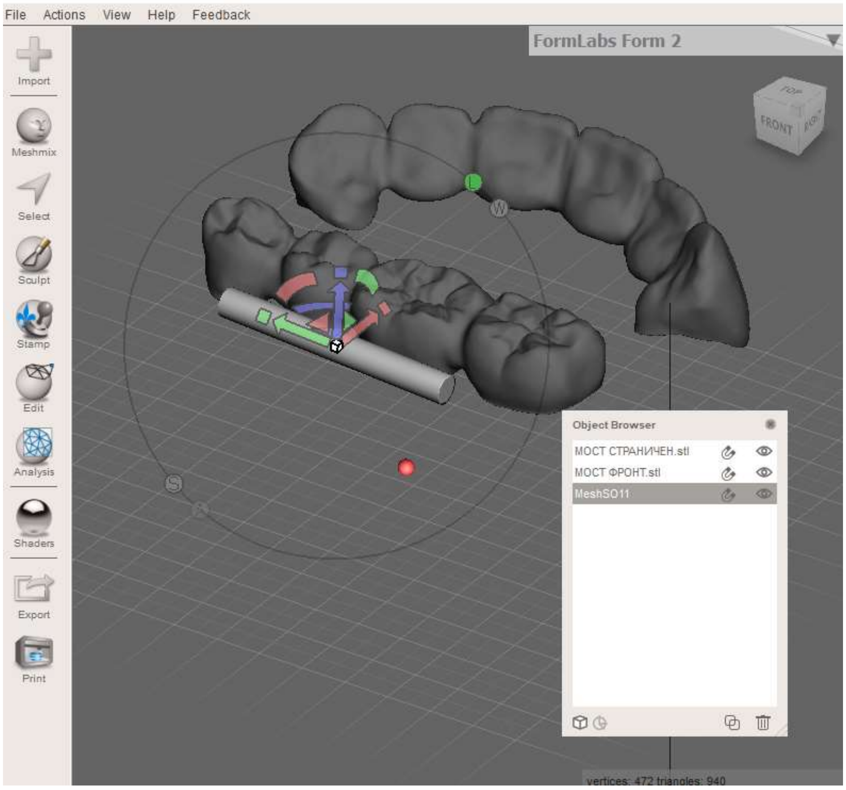


Fig. 29. *Adaptation of the cylinder according to the length of the bridge bodies*

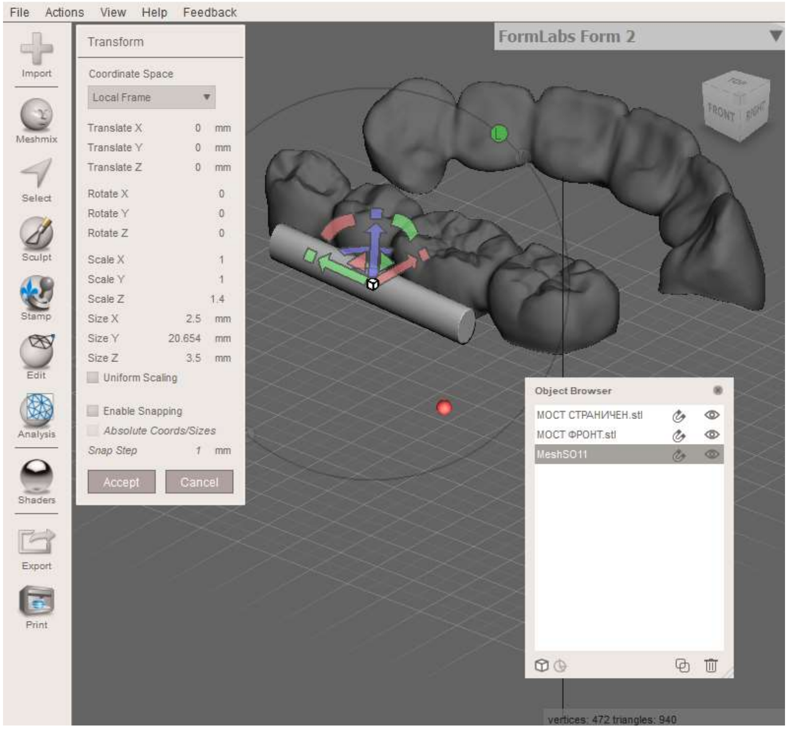


Fig. 30. *Adapting body dimensions through control options.*

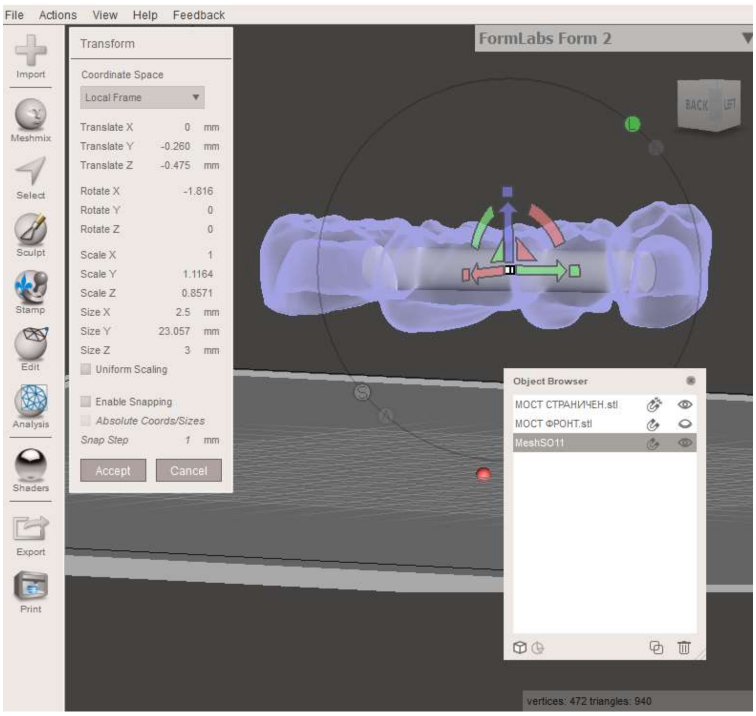


Fig. 31. *Precise adaptation of the dimensions of the elliptical body in a special visualization.*

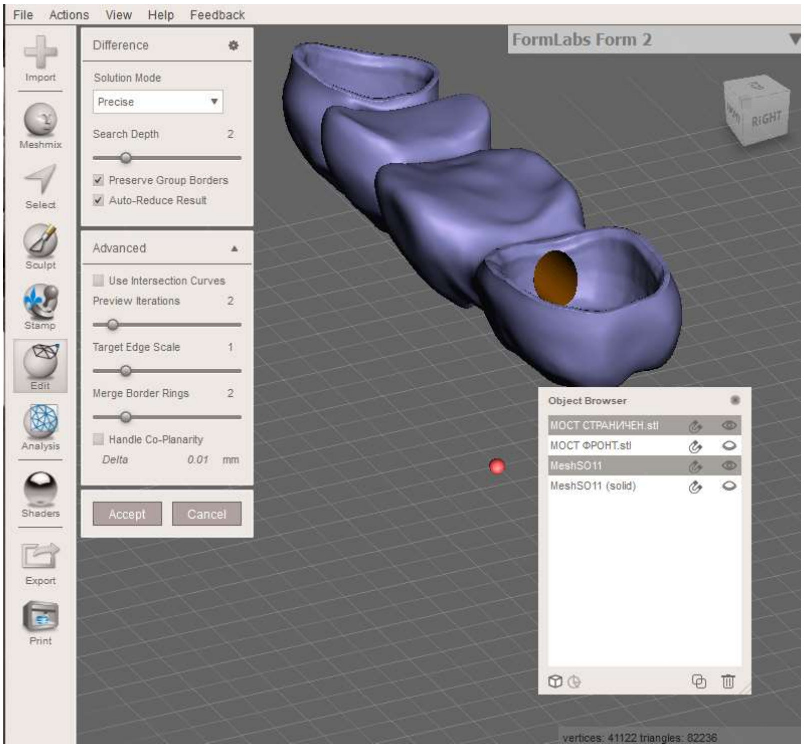


Fig. 32. *Modified bridge prototype created before export (bridge view 47).*

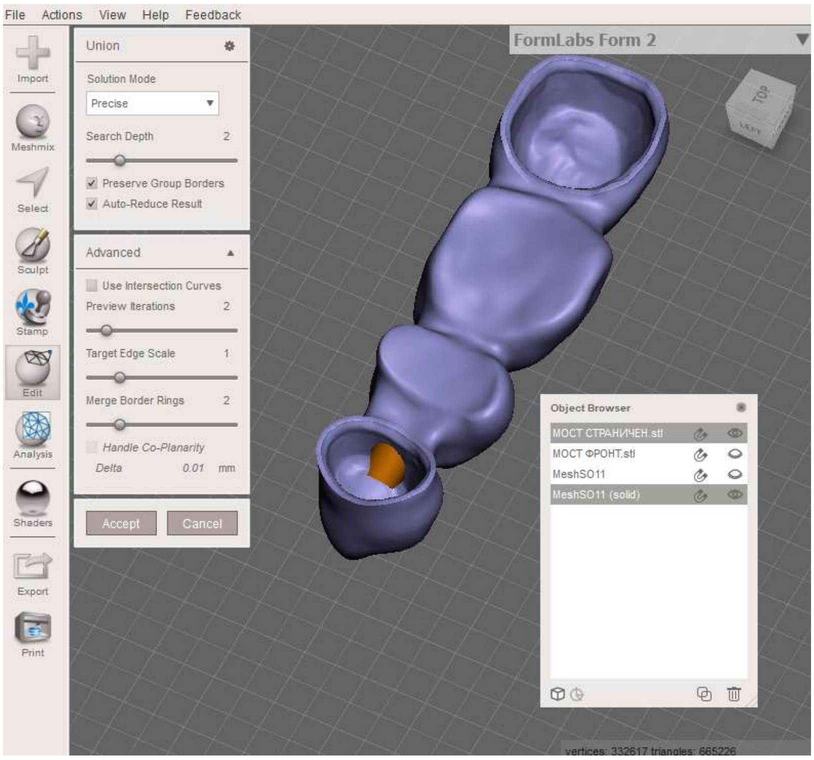


Fig. 33. *The created modified bridge prototype before export*

(view from retainer 44).

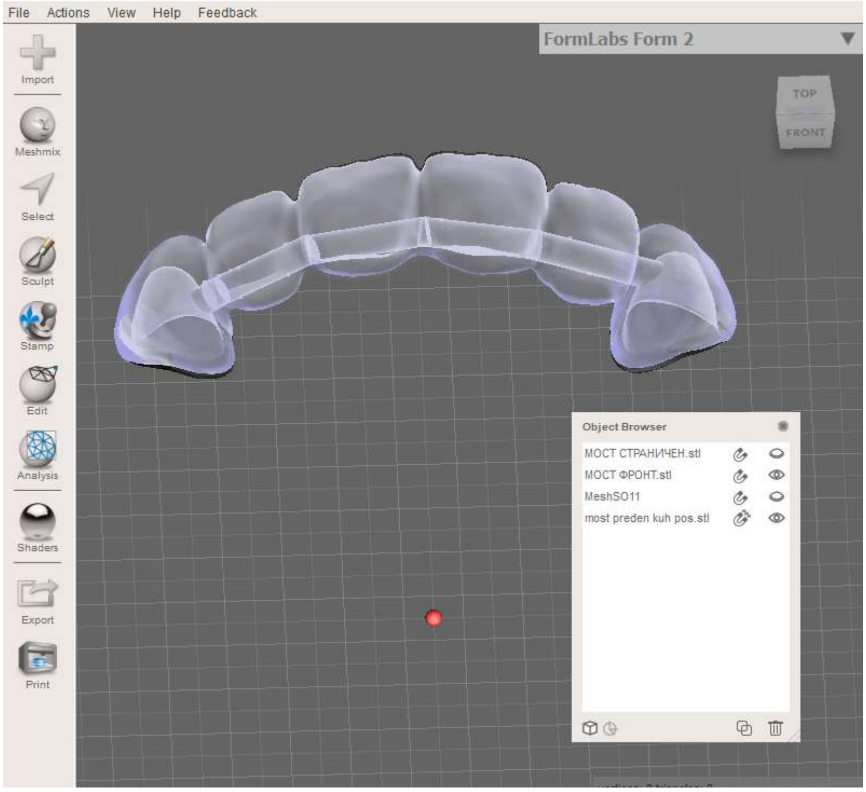


__Fig. 34__. Created canal along the bridge bodies in bridge construction 13-23.

III.5. Statistical methods

The data from the conducted studies was processed with SPSS v. 20.0 for Windows, using the following analyzes:

- Dispersion analysis;
- Comparative analysis;
- Correlation analysis;
- Graphic and tabular method for visualizing the results.

For a level of significane we assume $p < 0.05$ at 95% confidence interval.

IV. RESULTS AND DISCUSSION

IV.1. Results and discussion on task 1

In **fig. 35** the color change according to the measured indicators of the VITA Classic color is shown. The results of the analysis show that the largest difference in color gamut is reported for A4, B4, C3 and D4 (p <0.001).

When assessing the change in value according to color, a significant difference was also found (p <0.001), which shows a tendency to increase the deviation in value with increasing chroma of the dominant colors. The furthest from the main color in this indicator are A1, B1, C1 and D4, and the closest are A3.5, A4 and C4.

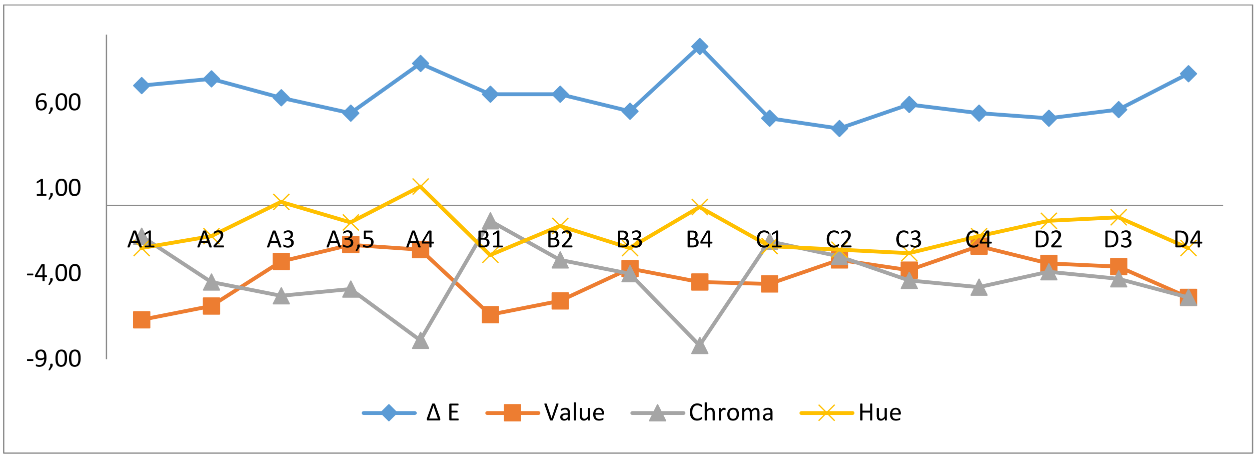


Fig. 35. *Color change according to the measured indicators according to VITA Classic.*

The analysis of chroma revealed significant deviations from the color gamut (p <0.001), with the smallest in A1, B1 and C1, and the largest in A4 and B4.

The analysis of the hue revealed several differences: In group A and group B several peaks and dips in the values (p <0.01) were found. In group C, as a whole, there is an increase in the values of the deviation of the hue. In group D the curve acquires a U-shape.

The analysis of the color change with the combination with 0.5 mm veneer and *Try-in transparent paste* also revealed a significant difference in the color deviation from the baseline values, with the largest deviation being B4 and D4 (p <0.01). An interesting result is that the color deviation from C1 to D3 is significantly less than from A1 to B3 (p <0.01) (Fig. 36).

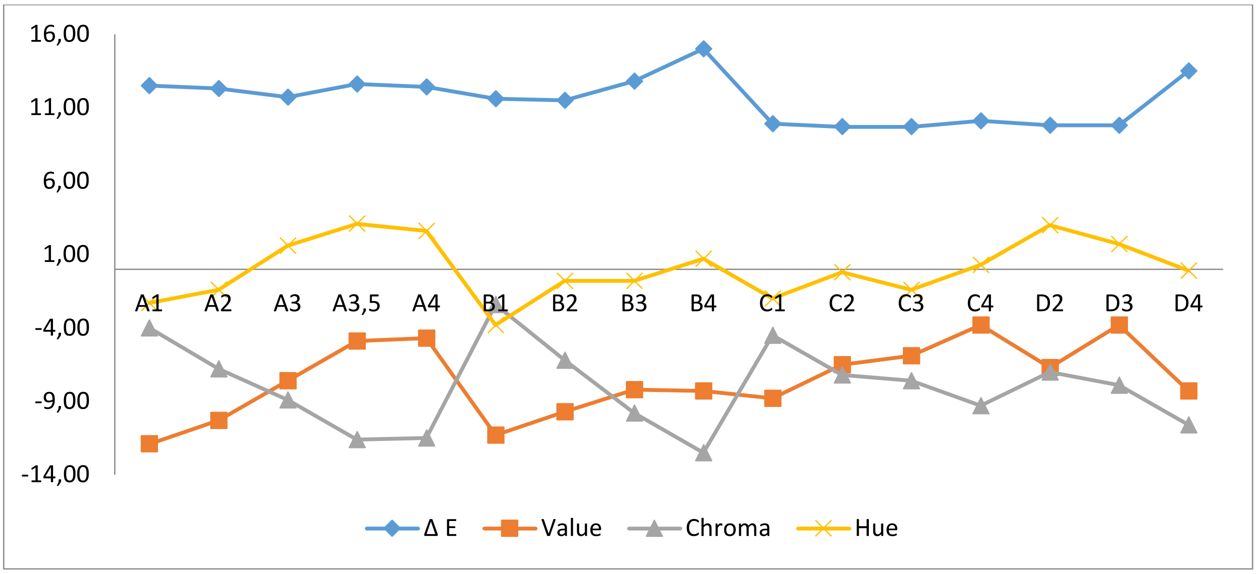


Fig. 36. *Color change according to the measured indicators according to VITA Classic with veneer 0.5 mm and Try-in paste transparent.*

When assessing the change in value, a significant difference was found in the entire color space of the color (p <0.001). The largest deviation is in A1, B1 and C1, and the smallest in A3.5 and A4, C4 and D3.

The color deviation shows minimal deviations in B1 and C1, with the largest being in A3.5 and A4, as well as in B4 (p <0.01)

The smallest differences in hue were found in B2, C2, C4 and D4, while in A3.5 and A4 and D2 the deviation was significant (p <0.001).

The analysis of the color change with the combination with a veneer of 0.5 mm and gel also revealed a significant difference in the color deviation from the baseline values, with the largest deviation being from A1 to B4 and D4 (p <0.01). The results show that there is a grouping of data from A1 to B4 and from C1 to D3 (Fig. 37).

When assessing the change in value, a significant difference was found in the entire color space of the color (p <0.001). The largest deviation is in A1, A2, B1 and B2, and the smallest in A3.5 and A4 and C4.

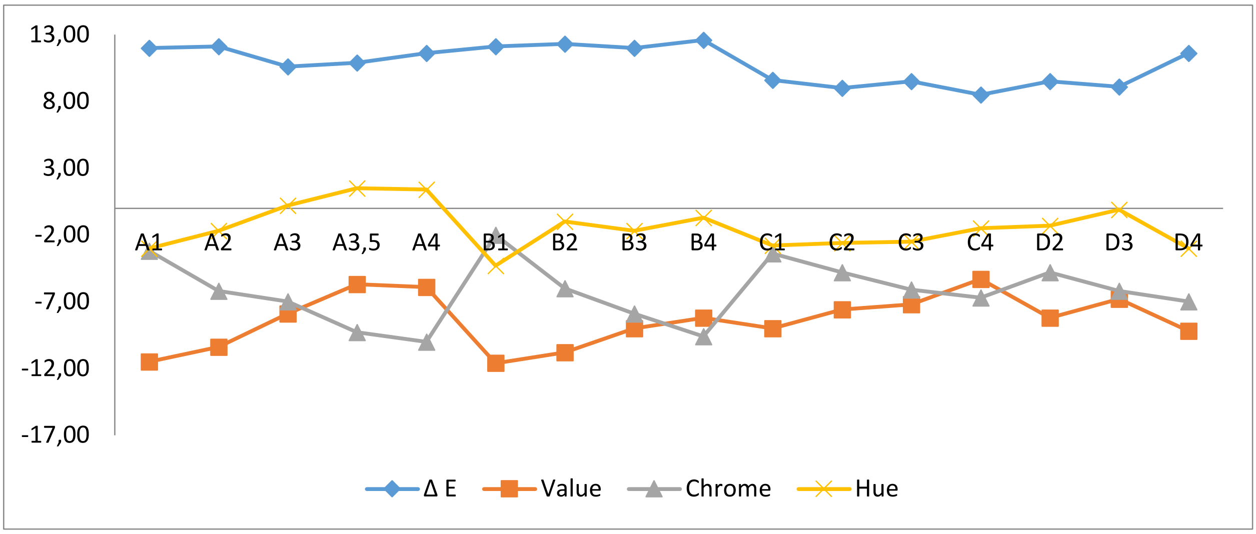


Fig. 37. *Color change according to the measured indicators according to VITA Classic with 0.5 mm veneer and ultrasound gel.*

Chroma shows minimal deviations in B1, with the largest deviations in A4, as well as in B4 (p <0.01)

The smallest differences in hue were found in A3 and D3, while in B1 and D4 the deviation was significant (p <0.001).

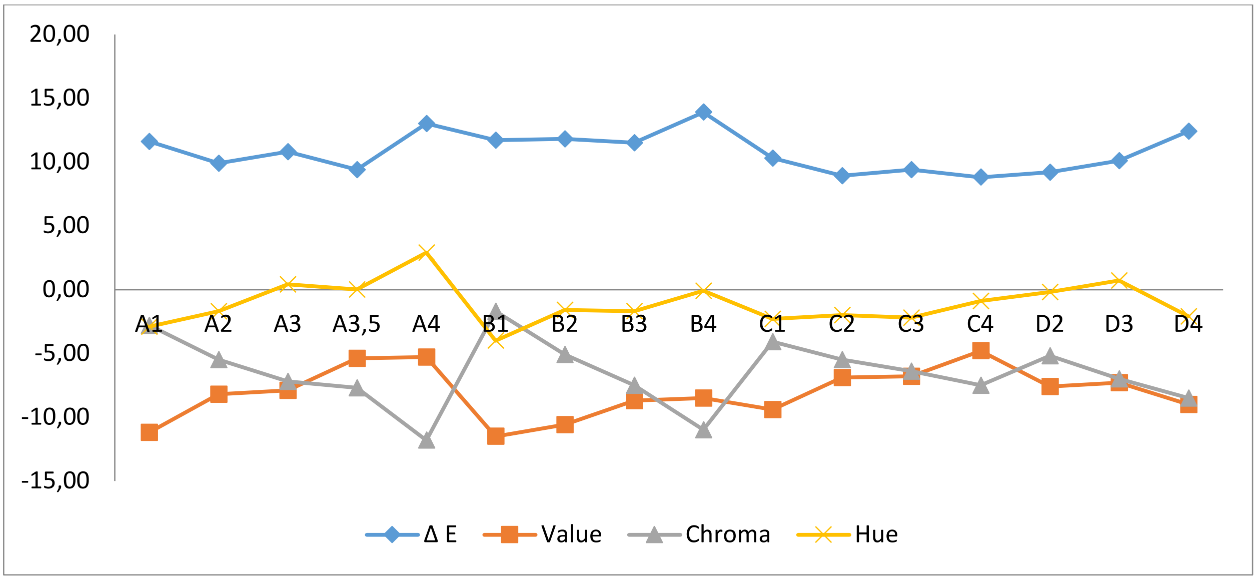


Fig. 38. *Color change according to the measured indicators according to VITA Classic with 0.8 mm veneer and Try-in transparent paste.*

The analysis of the color change with the combination with 0.8 mm veneer and *Try-in transparent paste* also revealed a significant difference in the color deviation from the baseline values, with the largest deviation being in A4, B4 and D4 ($p < 0.01$) (**Fig. 38**).

When assessing the change in value, a significant difference was found in the entire color space of the color ($p < 0.001$). The largest deviation is in A1, B1 and B1, and the smallest in C4.

The color deviations show minimal deviations in B1 and A1, with the largest deviations being B4 ($p < 0.01$).

In A3.5 there is no deviation from the hue, minimal differences are observed in A3, B4, D2 and D3 and in A4, B1, C1, C2, C3 and D4 the deviation is significant ($p < 0.001$).

The analysis of the color change with the combination with 0.8 mm veneer and gel also revealed a significant difference in the color deviation compared to the baseline values, with the largest deviation being at A1, B4 and D4 ($p < 0.01$) (**Fig. 39**).

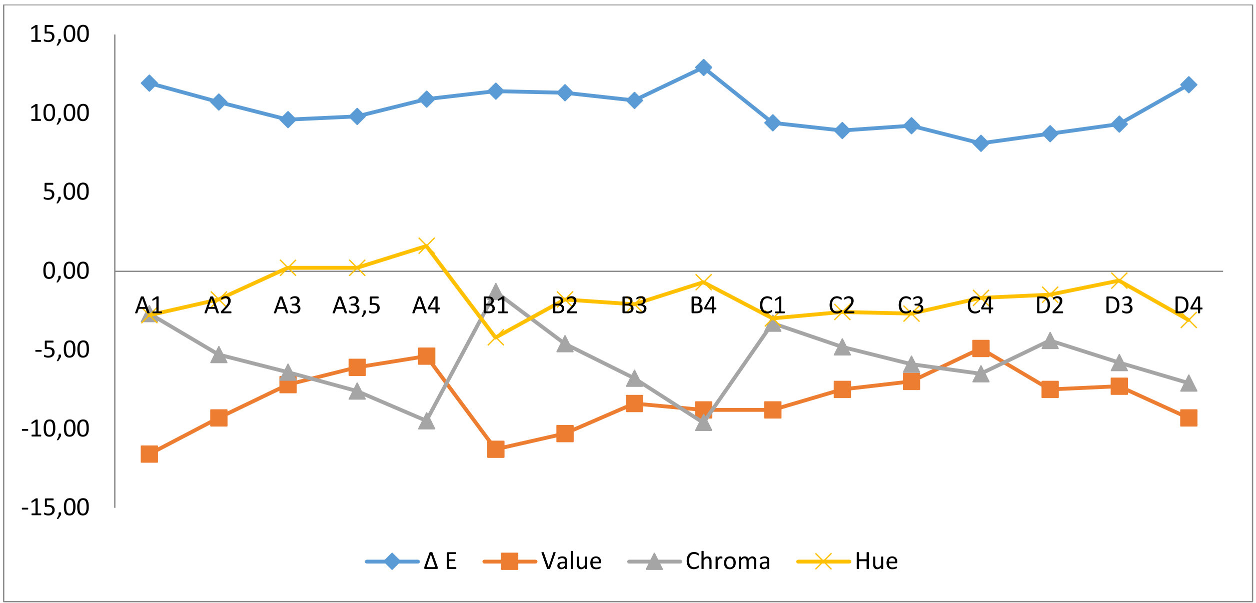


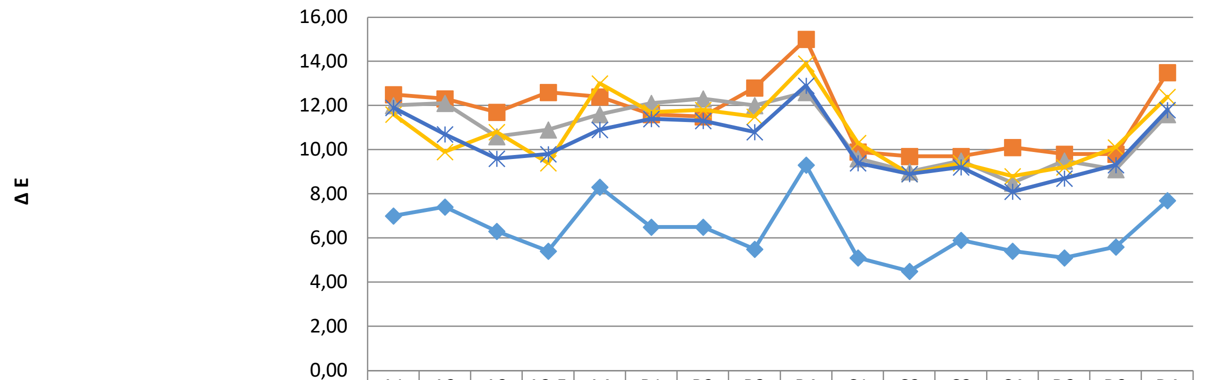
***Fig. 39.** Color change according to the measured indicators according to VITA Classic with 0.8 mm veneer and ultrasound gel.*

When assessing the change in value, a significant difference was found in the entire color space of the color ($p < 0.001$). The largest deviation is in A1 and B1, and the smallest in A4 and C4.

The chroma showed minimal deviations in B1 and A1, with the largest deviations being A4, B4, C4 and D4 ($p < 0.01$).

In A3 and A3.5 there is a minimal deviation from the hue, and in A4, B1, C1, C2, C3 and D4 the deviation is significant ($p < 0.001$).

Fig. 40 presents a comparative analysis of the color difference ΔE in the initial position, using a veneer with dimensions of 0.5 mm and 0.8 mm and Try-in paste transparent or gel.



	A1	A2	A3	A3,5	A4	B1	B2	B3	B4	C1	C2	C3	C4	D2	D3	D4
Δ E	7,00	7,40	6,30	5,40	8,30	6,50	6,50	5,50	9,30	5,10	4,50	5,90	5,40	5,10	5,60	7,70
veneer 0.5 mm and Try-in paste transparent	12,50	12,30	11,70	12,60	12,40	11,60	11,50	12,80	15,00	9,90	9,70	9,70	10,10	9,80	9,80	13,50
veneer 0.5 mm and gel	12,00	12,10	10,60	10,90	11,60	12,10	12,30	12,00	12,60	9,60	9,00	9,50	8,50	9,50	9,10	11,60
veneer 0.8 mm and Try-in paste transperent	11,60	9,90	10,80	9,40	13,00	11,70	11,80	11,50	13,90	10,30	8,90	9,40	8,80	9,20	10,10	12,40
veneer 0.8 mm and gel	11,90	10,70	9,60	9,80	10,90	11,40	11,30	10,80	12,90	9,40	8,90	9,20	8,10	8,70	9,30	11,80

***Fig. 40.** Comparative analysis of color difference according to VITA Classic.*

There was a significant difference in the measured values for color difference ΔE according to the VITA Classic color scheme both with regard to the application of veneers with a thickness of 0.5 mm ($p < 0.01$) and with regard to the application of veneers with a thickness of 0.8 mm ($p < 0.05$) relative to baseline values. Although there is a deviation in the color difference values according to the use of Try-in transparent or gel paste, it is not statistically significant.

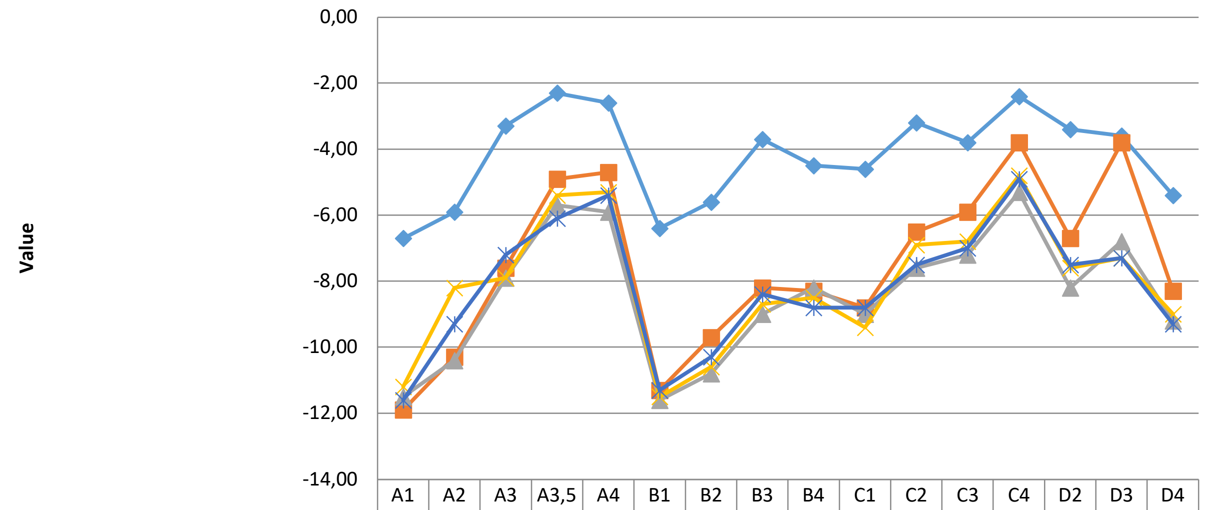
The use of 0.5 mm thick veneer and Try-in transparent paste does not come close to any of the main colors of VITA Classic.

The use of a 0.5 mm thick veneer and gel showed the best results for B4, D3 and D4.

The use of 0.8 mm thick veneer and Try-in transparent paste shows the best results in terms of A1, A2, A3.5 and C2.

The use of veneers with a thickness of 0.8 mm and gel shows the best results in most primary colors according to VITA Classic - A3, A4, B1, B2, B3, C1, C3, C4 and D2.

FIG. 41 presents a comparative analysis of value at baseline using a 0.5 mm and 0.8 mm facet and a Try-in transparent transparent or ultrasound gel.

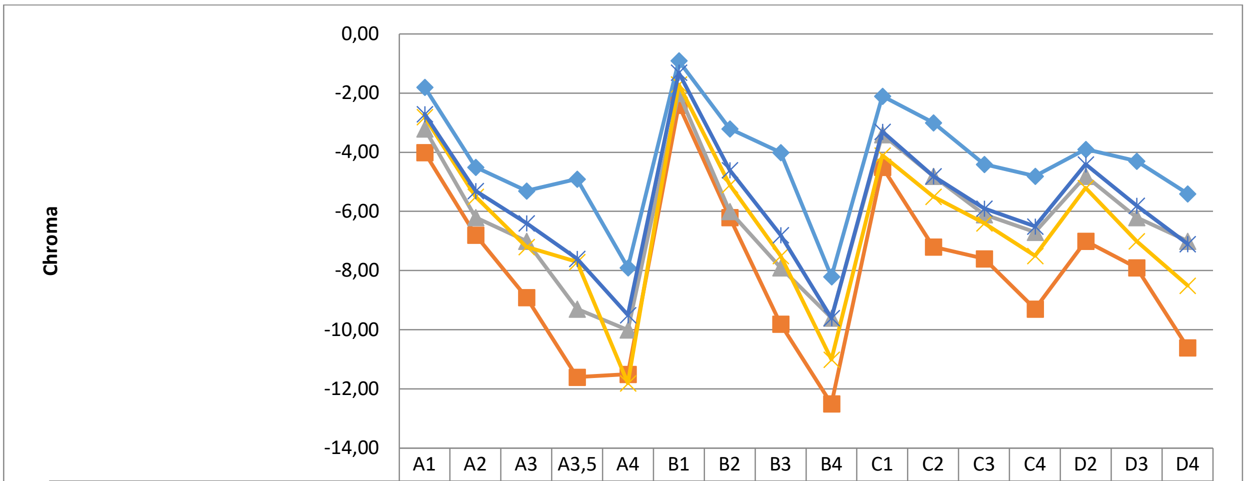


	A1	A2	A3	A3,5	A4	B1	B2	B3	B4	C1	C2	C3	C4	D2	D3	D4
Value	-6,70	-5,90	-3,30	-2,30	-2,60	-6,40	-5,60	-3,70	-4,50	-4,60	-3,20	-3,80	-2,40	-3,40	-3,60	-5,40
veneer 0.5 mm and Try-in paste transparent	-11,90	-10,30	-7,60	-4,90	-4,70	-11,30	-9,70	-8,20	-8,30	-8,80	-6,50	-5,90	-3,80	-6,70	-3,80	-8,30
veneer 0.5 mm and gel	-11,50	-10,40	-7,90	-5,70	-5,90	-11,60	-10,80	-9,00	-8,20	-9,00	-7,60	-7,20	-5,30	-8,20	-6,80	-9,20
veneer 0.8 mm and Try-in paste transparent	-11,20	-8,20	-7,90	-5,40	-5,30	-11,50	-10,60	-8,70	-8,50	-9,40	-6,90	-6,80	-4,80	-7,60	-7,30	-9,00
veneer 0.8 mm and gel	-11,60	-9,30	-7,20	-6,10	-5,40	-11,30	-10,30	-8,40	-8,80	-8,80	-7,50	-7,00	-4,90	-7,50	-7,30	-9,30

Fig. 41. *Comparative analysis of value according to VITA Classic.*

Unlike ΔE, the thickness of the veneer and the air-eliminating material are related to value. The thinner veneer (0.5 mm) and Try-in transparent paste showed the best results for all VITA Classic primary colors except A1 and A2, where the best results compared to the initial value were obtained when using a 0.8 mm veneer and Try-in paste transparent. For A3, the best results on value are achieved with a 0.8 mm veneer and ultrasound gel. It is impressive that B1 and C1 achieve equally good results when using a 0.5 mm veneer and Try-in transparent paste and 0.8 and veneer veneer.

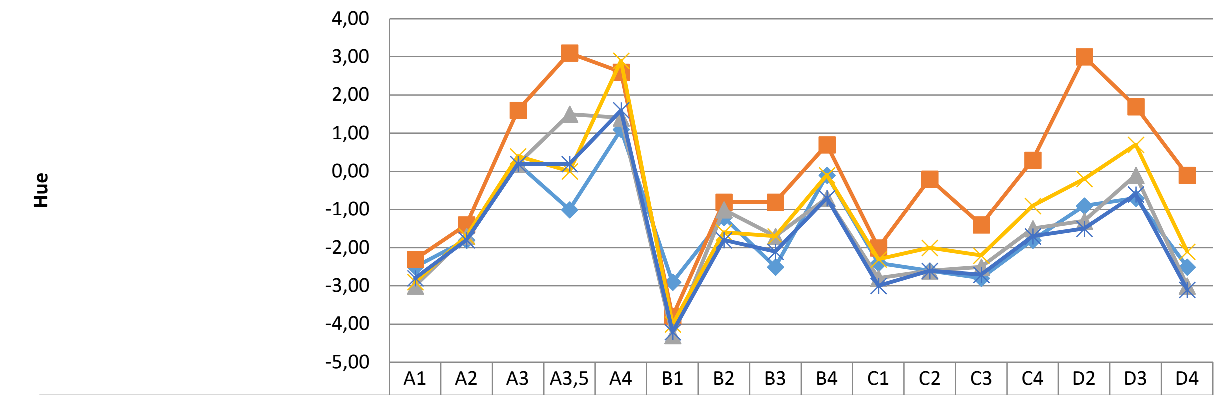
Fig. 42 presents a comparative analysis of chroma at a baseline using 0.5 mm and 0.8 mm facets with Try-in transparent paste or ultrasound gel. A significant difference was found between the studied groups (p <0.01). On the other hand, the closest values to the initial ones for chroma are obtained when using a facet 0.8 and gel. Exceptions are B4 and C2, where identical results are achieved when using veneer 0.5 and gel. With D4, the best results are achieved when using a 0.5 veneer and gel.



	A1	A2	A3	A3,5	A4	B1	B2	B3	B4	C1	C2	C3	C4	D2	D3	D4
Chroma	-1,80	-4,50	-5,30	-4,90	-7,90	-0,90	-3,20	-4,00	-8,20	-2,10	-3,00	-4,40	-4,80	-3,90	-4,30	-5,40
Veneer 0.5 mm and Try-in paste transparent	-4,00	-6,80	-8,90	-11,60	-11,50	-2,40	-6,20	-9,80	-12,50	-4,50	-7,20	-7,60	-9,30	-7,00	-7,90	-10,60
Veneer 0.5 mm and gel	-3,20	-6,20	-7,00	-9,30	-10,00	-2,00	-6,00	-7,90	-9,60	-3,40	-4,80	-6,10	-6,70	-4,80	-6,20	-7,00
Veneer 0.8 mm and Try-in paste transparent	-2,80	-5,50	-7,20	-7,70	-11,80	-1,70	-5,10	-7,50	-11,00	-4,10	-5,50	-6,40	-7,50	-5,20	-7,00	-8,50
Veneer 0.8 mm and gel	-2,70	-5,30	-6,40	-7,60	-9,50	-1,30	-4,60	-6,80	-9,60	-3,30	-4,80	-5,90	-6,50	-4,40	-5,80	-7,10

***Fig. 42.** Comparative analysis of chroma according to VITA Classic.*

Fig. 43 presents a comparative analysis of the hue in the starting position, using veneers with dimensions of 0.5 mm and 0.8 mm and Try-in paste transparent or gel. Regarding the hue, no statistically significant difference was found between the studied groups.



	A1	A2	A3	A3,5	A4	B1	B2	B3	B4	C1	C2	C3	C4	D2	D3	D4
Hue	-2,50	-1,80	0,20	-1,00	1,10	-2,90	-1,20	-2,50	-0,10	-2,40	-2,60	-2,80	-1,80	-0,90	-0,70	-2,50
Veneer 0.5 mm and Try-in paste transparent	-2,30	-1,40	1,60	3,10	2,60	-3,80	-0,80	-0,80	0,70	-2,00	-0,20	-1,40	0,30	3,00	1,70	-0,10
Veneer 0.5 mm and gel	-3,00	-1,70	0,20	1,50	1,40	-4,30	-1,00	-1,70	-0,70	-2,80	-2,60	-2,50	-1,50	-1,30	-0,10	-3,00
Veneer 0.8 mm and Try-in paste transparent	-2,90	-1,70	0,40	0,00	2,90	-4,00	-1,60	-1,70	-0,10	-2,30	-2,00	-2,20	-0,90	-0,20	0,70	-2,10
Veneer 0.8 mm and gel	-2,80	-1,80	0,20	0,20	1,60	-4,20	-1,80	-2,10	-0,70	-3,00	-2,60	-2,70	-1,70	-1,50	-0,60	-3,10

***Fig. 43.** Comparative analysis of hue according to VITA Classic.*

When using a 0.5 mm veneer and Try-in transparent paste for A1, A2, B1, B2, B3, C1, C2, C3 and C4, the obtained results are lower than the initial values. For A3 the use of 0.8 mm veneer and gel, and for B4 the use of 0.8 mm veneer and Try-in paste transparent, the results are the same as the initial values. For A3.5 and D2 the use of 0.8 mm veneer and Try-in transparent paste shows lower values for hue compared to the initial values. For A4, D3 and D4, the use of a 0.5 mm veneer and gel also results in lower than the original hue values. On the other hand, some colors achieve the same values as the original:

- A2 when using 0.8 mm veneer and gel;
- A3 when using a 0.5 mm or 0.8 mm veneer and gel;
- B4 when using 0.8 mm veneer and transparent try-in paste;
- C2 when using a 0.5 mm or 0.8 mm veneer and gel;
- D3 when using a 0.8 mm veneer and Try-in transparent paste

Fig. 44 shows the color change according to the measured indicators according to VITA 3D Master.

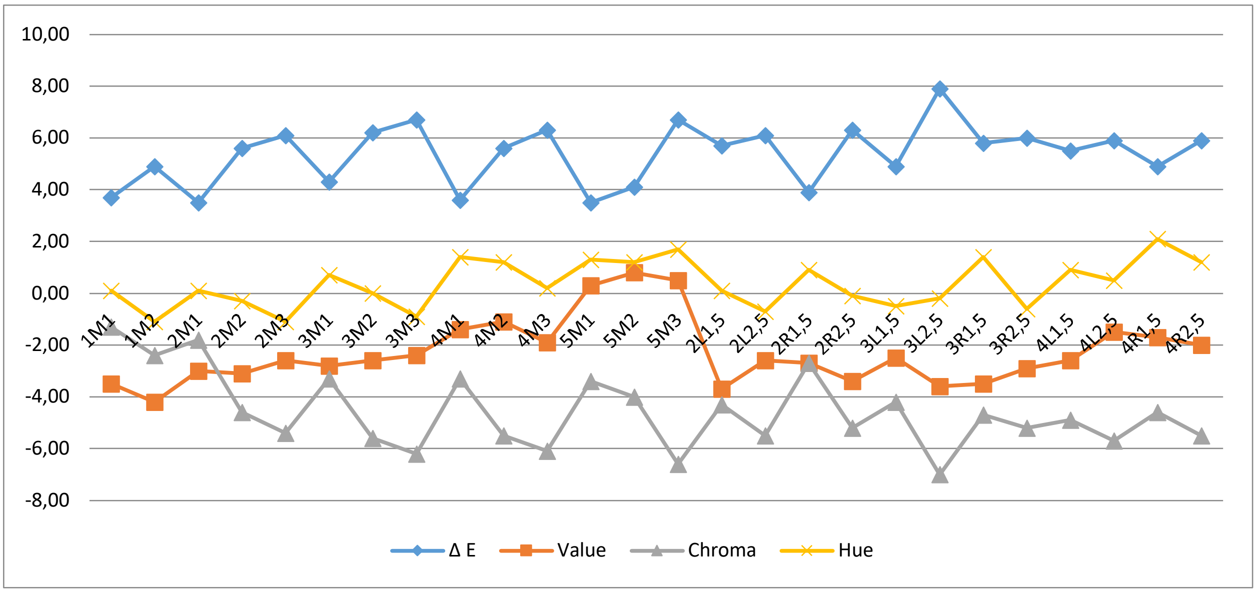


Fig. 44. *Color change according to the measured indicators according to VITA 3D Master***.**

Fig. 45 presents the color change according to the measured indicators according to VITA 3D Master when using veneer 0.5 and Try-in paste transparent. There was a significant difference in terms of color deviation, value, chroma and hue compared to the main color according to VITA 3D Master (p <0.001).

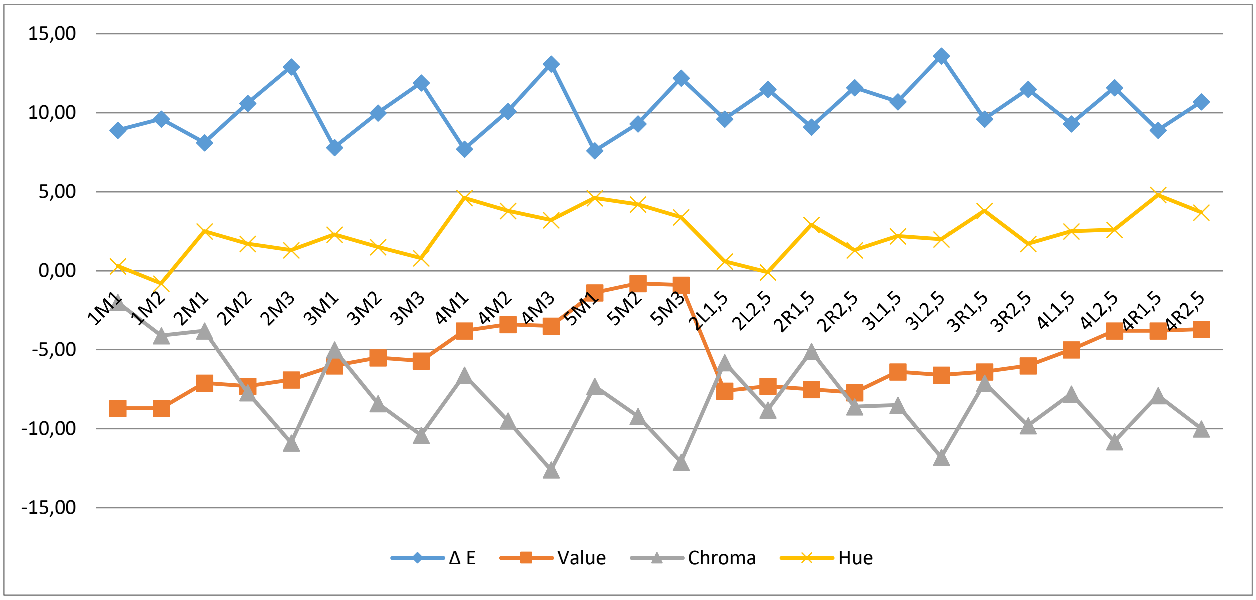


Fig. 45. *Color change according to the measured indicators according to VITA 3D Master with veneer 0.5 mm and Try-in paste transparent.*

For all colors, the color deviation when using a 0.5 mm veneer and Try-in transparent paste is above the permissible norm of 5.0.

Regarding the color deviation when using 0.5 mm veneer and Try-in paste transparent, despite the difference from the base color, the closest values are observed in -M1 colors, and the largest deviation is in -M3 colors ($p < 0.01$).

Value, using a 0.5 mm veneer and Try-in transparent paste, showed the closest values in the 5M- group ($p < 0.05$).

The change in chroma is a mirror image of the color deviation, as the closest values are observed in -M1 colors, and the largest deviations are at -M3 ($p < 0.01$).

The hue when using 0.5 mm veneer and Try-in transparent paste is close to the base color at 1M1, 1M2, 3M3, 2L1.5 and 2L2.5. For the other colors there is a significant variation in the values ($p < 0.01$).

Fig. 46 shows the color change according to the measured indicators according to VITA 3D Master using 0.5 veneer and gel. There is a significant difference in terms of color deviation, value, chroma and hue compared to the main color according to VITA 3D Master ($p < 0.01$).

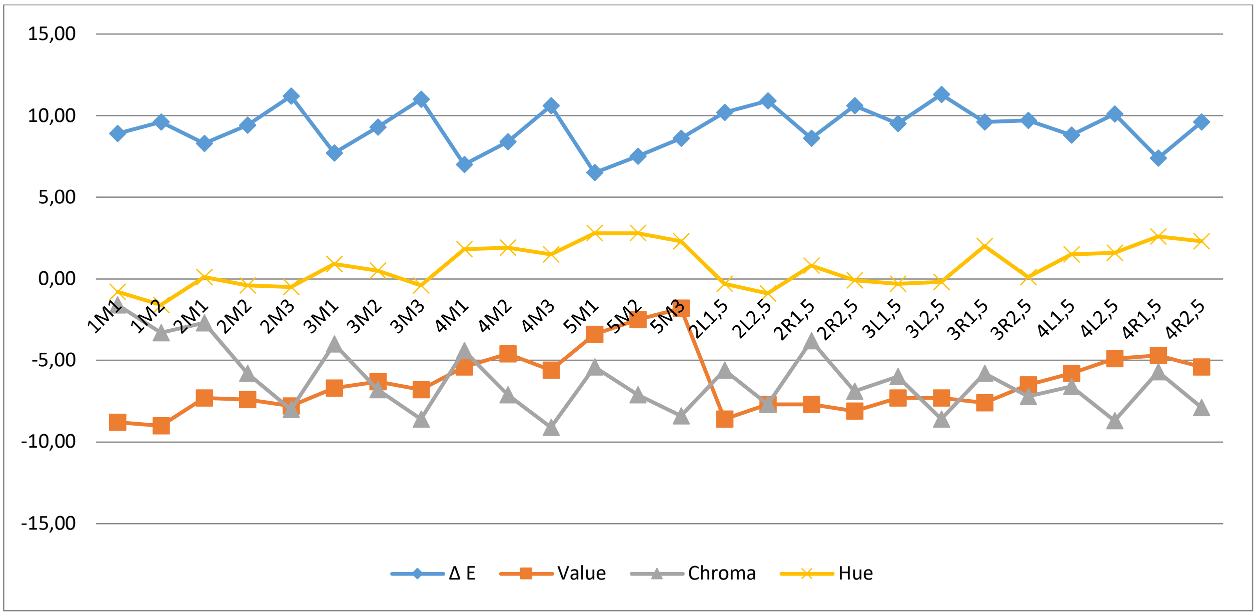


Fig. 46. *Color change according to the measured indicators according to VITA 3D Master with 0.5 mm veneer and gel.*

For all colors, the color deviation when using a 0.5 mm veneer and gel is above the permissible norm of 5.0.

Regarding the color deviation when using a veneer of 0.5 mm and gel, despite the difference from the main color, the closest values are observed in -M1 colors, and the largest deviation is in -M3 colors ($p < 0.01$).

Value, using a 0.5 mm veneer and gel, shows the closest values in the 5M3 and 5M2 groups ($p < 0.05$).

The change in chroma is a mirror image of the color deviation, as the closest values are observed in -M1 colors, and the largest deviations are at -M3 ($p < 0.01$).

The hue when using a 0.5 mm veneer and ultrasound gel is close to the base color at 1M1, 2M1, 2M2, 3M3, 2L1.5, 2L2.5, 2R2.5, 3L1.5, 3L2.5 and 3R2.5. For the other colors there is a significant variation in the values ($p < 0.01$).

Fig. 47 shows the color change according to the measured indicators according to VITA 3D Master when using a facet 0.8 and Try-in paste transparent. There was a significant difference in terms of color deviation, value, chroma and hue compared to the main color according to VITA 3D Master ($p < 0.001$).

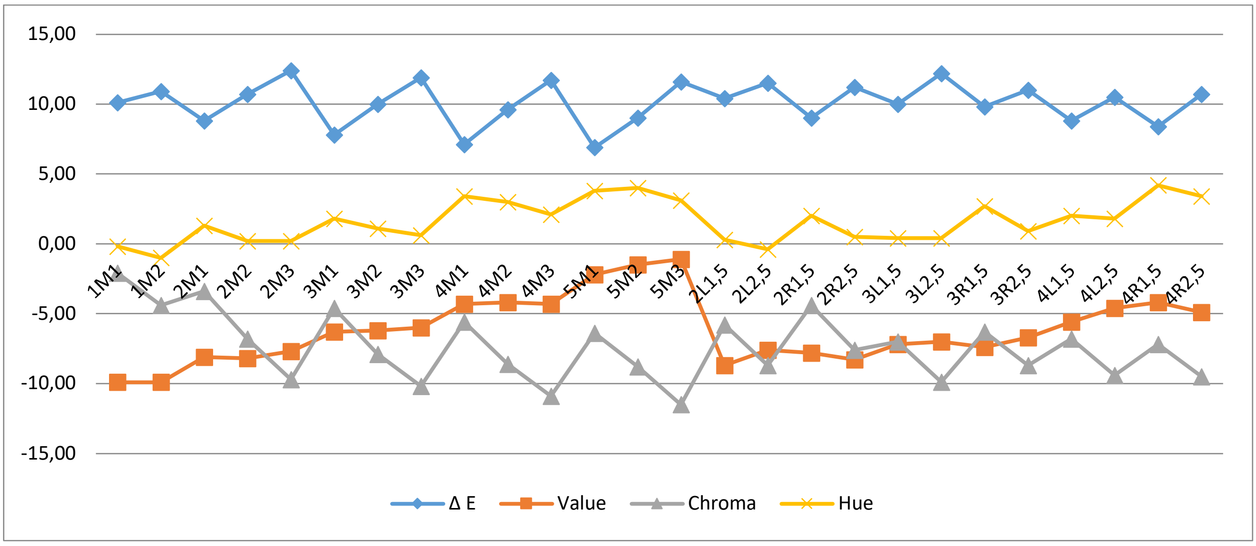


Fig. 47. *Color change according to the measured indicators according to VITA 3D Master with 0.8 mm veneer and Try-in transparent paste.*

For all colors, the color deviation when using a 0.8 mm veneer and Try-in transparent paste is above the permissible norm of 5.0.

Regarding the color deviation when using a 0.8 mm veneer and Try-in paste transparent, despite the difference from the base color, the closest values are observed in -M1 colors, and the largest deviation is in -M3 colors (p <0.01).

Value, using 0.8 mm veneer and Try-in transparent paste, shows the closest values in the group 5M3 and 5M2 (p <0.05).

The change in chroma is a mirror image of the color deviation, as the closest values are observed in -M1 colors, and the largest deviations are at -M3 (p <0.01).

The hue when using a 0.8 mm veneer and Try-in paste transparent is close to the base color at 1M1, 1M2, 2M2, 2M3, 3M3, 2L1.5, 2L2.5, 2R2.5, 3L1.5 and 3L2.5. For the other colors there is a significant variation in the values (p <0.01).

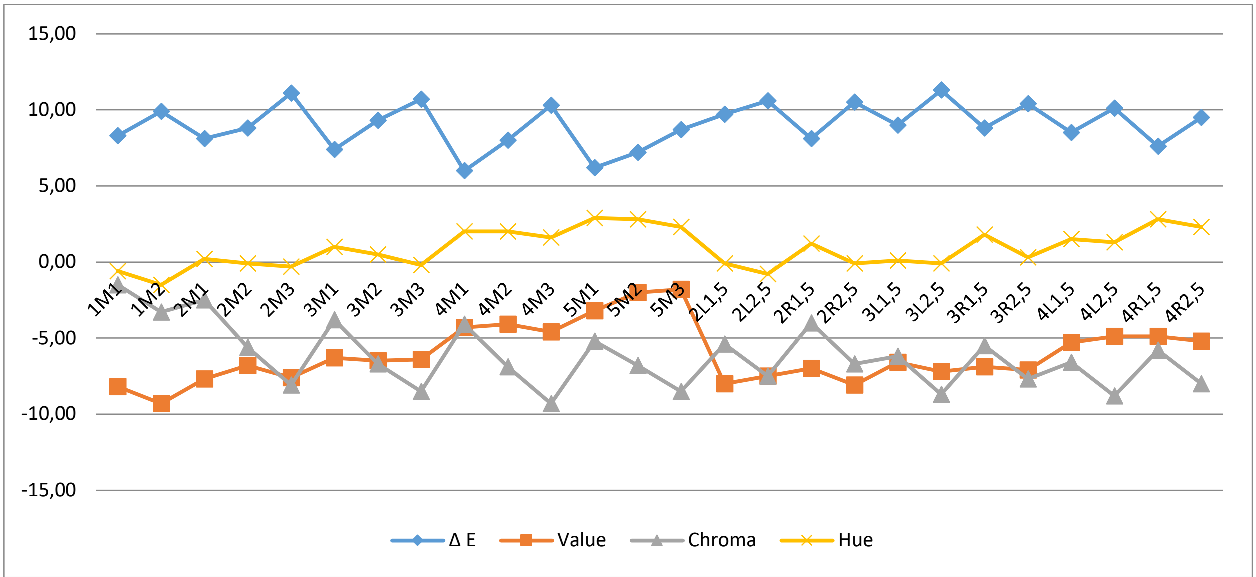


Fig. 48. *Color change according to the measured indicators according to VITA 3D Master with 0.8 mm veneer and gel.*

Fig. 48 shows the change in color according to the measured indicators according to VITA 3D Master when using veneer 0.5 and gel. There is a significant difference in terms of color deviation, value, chroma and hue compared to the main color according to VITA 3D Master (p <0.01).

For all colors, the color deviation when using a 0.8 mm veneer and gel is above the permissible norm of 5.0.

Regarding the color deviation when using a veneer of 0.8 mm and gel, despite the difference from the main color, the closest values are observed in -M1 colors, and the largest deviation is in -M3 colors (p <0.01).

Value, when using a 0.8 mm veneer and gel, shows the closest values in the group 5M3 and 5M2 (p <0.05).

The change in chroma is a mirror image of the color deviation, as the closest values are observed in -M1 colors, and the largest deviations are at -M3 (p <0.01).

The hue when using a 0.8 mm veneer and gel is close to the base color at 1M1, 2M1, 2M2, 2M3, 3M3, 2L1.5, 2R2.5, 3L1.5, 3L2.5 and 3R2.5. For the other colors there is a significant variation in the values (p <0.01).

Fig. 49 presents a comparative analysis of the studied groups according to the color deviation according to VITA 3D Master is presented.

There was a significant difference in the color deviation in terms of the thickness of the veneer used and the air-eliminating material (p <0.01) compared to the initial results. Despite the differences in the values of the indicator, the best results are obtained when using gel in almost all colors except 1M2, 2M1 and 2L1.5 where 0.5 mm veneers and Try-in paste transparent are used.

In 5M3, 3R2.5 and 4R1.5 the best results in terms of color deviation from the initial values are achieved when using a 0.5 mm veneer and gel, in other colors the best results are achieved when using 0.8 mm veneer and gel.

For 3M2 and 4 L2.5, the use of gel was more influential than the thickness of the veneers, as both 0.5 mm and 0.8 mm veneers used had the same effect.

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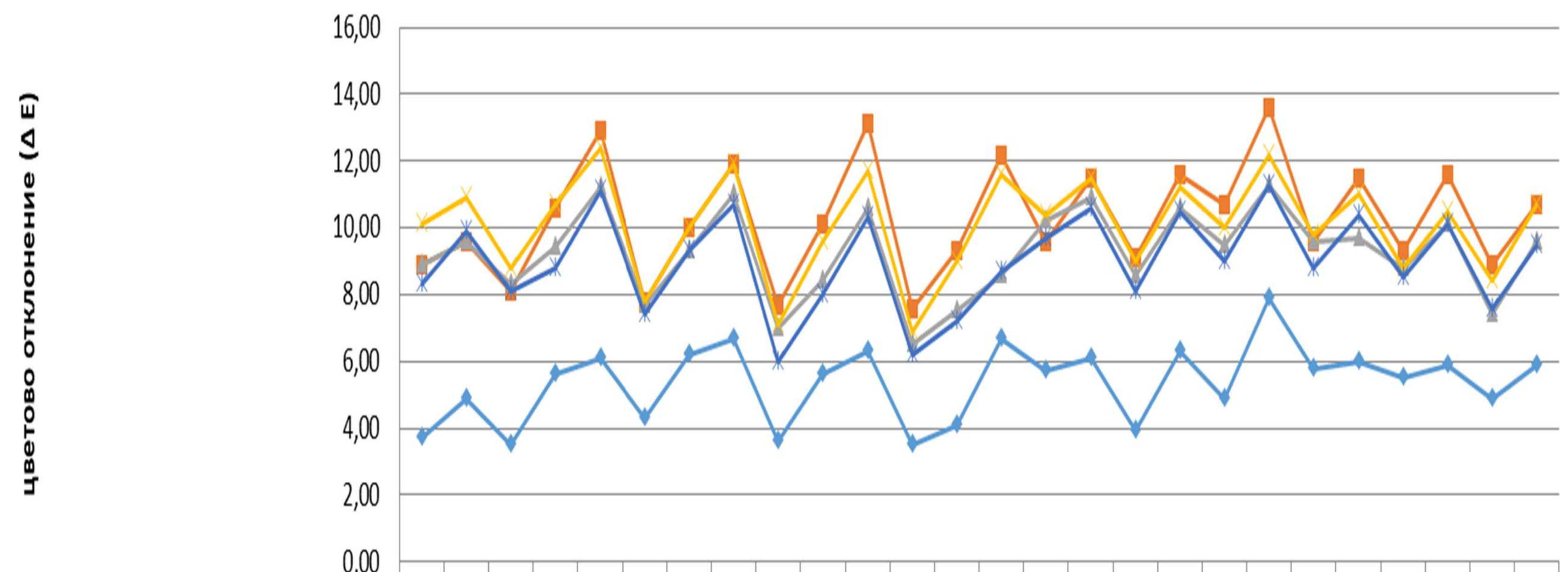


	1M1	1M2	2M1	2M2	2M3	3M1	3M2	3M3	4M1	4M2	4M3	5M1	5M2	5M3	2L1, 5	2L2, 5	2R1, 5	2R2, 5	3L1, 5	3L2, 5	3R1, 5	3R2, 5	4L1, 5	4L2, 5	4R1, 5	4R2, 5
изходно цветово отклонение (Δ E)	3,70	4,90	3,50	5,60	6,10	4,30	6,20	6,70	3,60	5,60	6,30	3,50	4,10	6,70	5,70	6,10	3,90	6,30	4,90	7,90	5,80	6,00	5,50	5,90	4,90	5,90
фасета 0.5 мм и Try-in паста transparent	8,90	9,60	8,10	10,60	12,90	7,80	10,00	11,90	7,70	10,10	13,10	7,60	9,30	12,20	9,60	11,50	9,10	11,60	10,70	13,60	9,60	11,50	9,30	11,60	8,90	10,70
фасета 0.5 мм и гел	8,90	9,60	8,30	9,40	11,20	7,70	9,30	11,00	7,00	8,40	10,60	6,50	7,50	8,60	10,20	10,90	8,60	10,60	9,50	11,30	9,60	9,70	8,80	10,10	7,40	9,60
фасета 0.8 мм и Try-in паста transparent	10,10	10,90	8,80	10,70	12,40	7,80	10,00	11,90	7,10	9,60	11,70	6,90	9,00	11,60	10,40	11,50	9,00	11,20	10,00	12,20	9,80	11,00	8,80	10,50	8,40	10,70
фасета 0.8 мм и гел	8,30	9,90	8,10	8,80	11,10	7,40	9,30	10,70	6,00	8,00	10,30	6,20	7,20	8,70	9,70	10,60	8,10	10,50	9,00	11,30	8,80	10,40	8,50	10,10	7,60	9,50

Fig. 49. *Comparative analysis of the color deviation according to VITA 3D Master.*

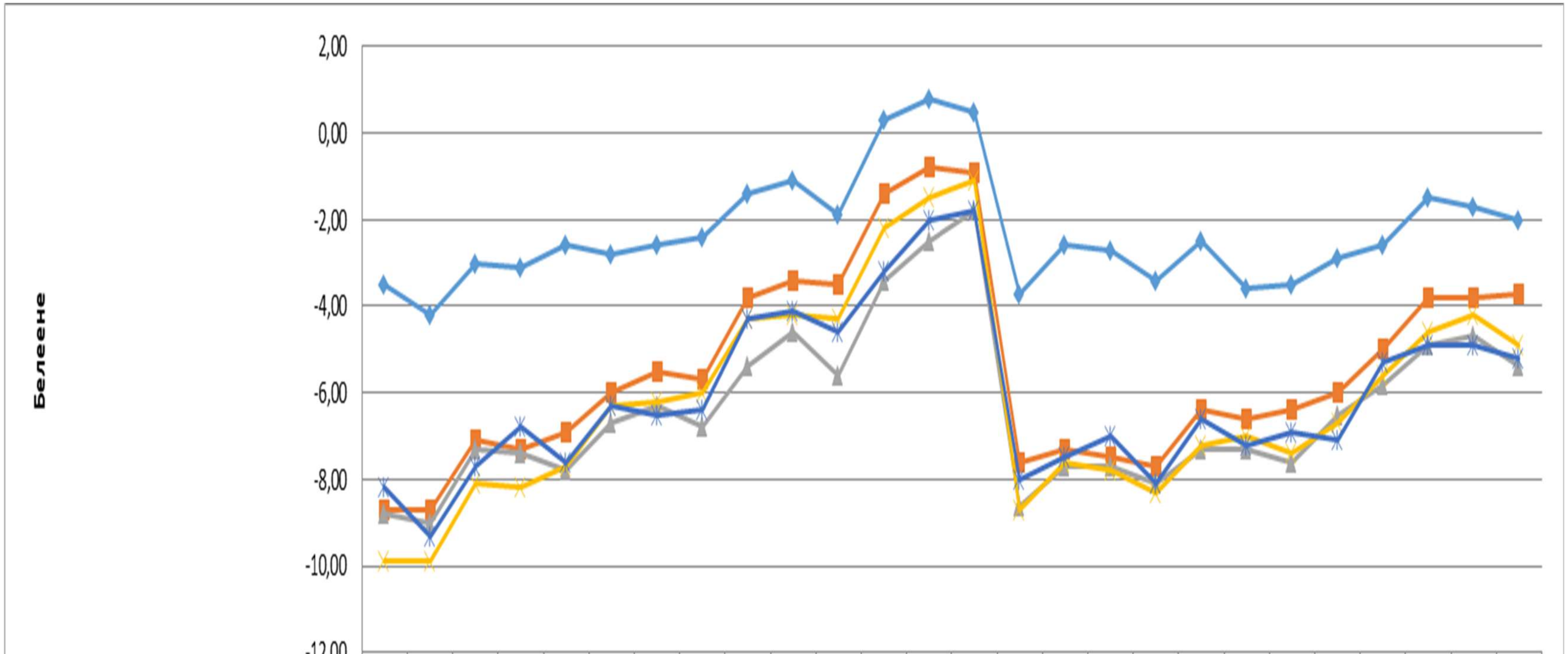
Fig. 50 presents a comparative analysis of the studied groups according to value with VITA 3D Master. There was a significant difference in value in terms of the thickness of the veneer used and the air-eliminating material ($p < 0.01$) compared to the initial results.

In contrast to the color deviation in the study of value, it turned out that in most colors the thickness of the veneer has a significant impact, and in these colors the use of veneers 0.5 mm and Try-in paste transparent shows the best results compared to baseline. For 5M2, the values obtained using a 0.5 mm veneer and Try-in transparent paste are the same as the baseline in terms of value.

For three colors (1M1, 2M2 and 2R1.5) the best results compared to the initial values are achieved when using a 0.8 mm veneer and gel.

Fig. 51 presents a comparative analysis of the studied groups according to value withVITA 3D Master. There was a significant difference in chroma with respect to the thickness of the veneer used and the air-eliminating material ($p < 0.01$) compared to the initial results. However, all results show the best values when using gel.

With 7 colors the best results are achieved compared to the initial values when using a veneer with a thickness of 0.5 mm - 4M2, 5M3, 2R1.5, 3R2.5, 4L2.5, 4R1.5 and 4R2.5. In the two colors - 1M2 and 4L1.5 - the same results are achieved in terms of the initial value when using veneers with a thickness of 0.5 mm and 0.8 mm. For other colors, the thickness of the veneer used is 0.8 mm.



	1M1	1M2	2M1	2M2	2M3	3M1	3M2	3M3	4M1	4M2	4M3	5M1	5M2	5M3	2L1,5	2L2,5	2R1,5	2R2,5	3L1,5	3L2,5	3R1,5	3R2,5	4L1,5	4L2,5	4R1,5	4R2,5
изходно белеене	-3,50	-4,20	-3,00	-3,10	-2,60	-2,80	-2,60	-2,40	-1,40	-1,10	-1,90	0,30	0,80	0,50	-3,70	-2,60	-2,70	-3,40	-2,50	-3,60	-3,50	-2,90	-2,60	-1,50	-1,70	-2,00
фасета 0.5 мм и Try-in паста transparent	-8,70	-8,70	-7,10	-7,30	-6,90	-6,00	-5,50	-5,70	-3,80	-3,40	-3,50	-1,40	-0,80	-0,90	-7,60	-7,30	-7,50	-7,70	-6,40	-6,60	-6,40	-6,00	-5,00	-3,80	-3,80	-3,70
фасета 0.5 мм и гел	-8,80	-9,00	-7,30	-7,40	-7,80	-6,70	-6,30	-6,80	-5,40	-4,60	-5,60	-3,40	-2,50	-1,80	-8,60	-7,70	-7,70	-8,10	-7,30	-7,30	-7,60	-6,50	-5,80	-4,90	-4,70	-5,40
фасета 0.8 мм и Try-in паста transparent	-9,90	-9,90	-8,10	-8,20	-7,70	-6,30	-6,20	-6,00	-4,30	-4,20	-4,30	-2,20	-1,50	-1,10	-8,70	-7,60	-7,80	-8,30	-7,20	-7,00	-7,40	-6,70	-5,60	-4,60	-4,20	-4,90
фасета 0.8 мм и гел	-8,20	-9,30	-7,70	-6,80	-7,60	-6,30	-6,50	-6,40	-4,30	-4,10	-4,60	-3,20	-2,00	-1,80	-8,00	-7,50	-7,00	-8,10	-6,60	-7,20	-6,90	-7,10	-5,30	-4,90	-4,90	-5,20

Fig. 50. *Comparative analysis of Value on vita 3D master.*

	1M1	1M2	2M1	2M2	2M3	3M1	3M2	3M3	4M1	4M2	4M3	5M1	5M2	5M3	2L1,5	2L2,5	2R1,5	2R2,5	3L1,5	3L2,5	3R1,5	3R2,5	4L1,5	4L2,5	4R1,5	4R2,5
изходна наситеност на цвета	-1,30	-2,40	-1,80	-4,60	-5,40	-3,30	-5,60	-6,20	-3,30	-5,50	-6,10	-3,40	-4,00	-6,60	-4,30	-5,50	-2,70	-5,20	-4,20	-7,00	-4,70	-5,20	-4,90	-5,70	-4,60	-5,50
фасета 0.5 мм и Try-in паста transparent	-2,00	-4,10	-3,80	-7,70	-10,90	-5,00	-8,40	-10,40	-6,60	-9,50	-12,60	-7,30	-9,20	-12,10	-5,80	-8,80	-5,10	-8,60	-8,50	-11,80	-7,10	-9,80	-7,80	-10,80	-7,90	-10,00
фасета 0.5 мм и гел	-1,60	-3,30	-2,70	-5,80	-8,00	-4,00	-6,80	-8,60	-4,40	-7,10	-9,10	-5,40	-7,10	-8,40	-5,60	-7,70	-3,80	-6,90	-6,00	-8,60	-5,80	-7,20	-6,60	-8,70	-5,70	-7,90
фасета 0.8 мм и Try-in паста transparent	-2,10	-4,40	-3,40	-6,80	-9,70	-4,60	-7,90	-10,20	-5,60	-8,60	-10,90	-6,40	-8,80	-11,50	-5,80	-8,70	-4,40	-7,60	-7,00	-9,90	-6,30	-8,70	-6,80	-9,40	-7,20	-9,50
фасета 0.8 мм и гел	-1,50	-3,30	-2,50	-5,60	-8,10	-3,80	-6,70	-8,50	-4,10	-6,90	-9,30	-5,20	-6,80	-8,50	-5,40	-7,50	-4,00	-6,70	-6,20	-8,70	-5,50	-7,70	-6,60	-8,80	-5,80	-8,00

Fig. 51. *Comparative analysis of chroma according to VITA 3D Master.*

Fig. 52 presents a comparative analysis of the studied groups according to the hue as per VITA 3D Master. There was a significant difference in chroma with respect to the thickness of the veneer used and the air-eliminating material ($p < 0.01$) compared to the initial results.

Three colors gave the same values as the original when using gel, with 2M1 using a 0.5 mm thick veneer, 2L2.5 using a 0.8 mm thick veneer, and 2R2.5 using 0.5 and 0mm thick veneers 0.8.

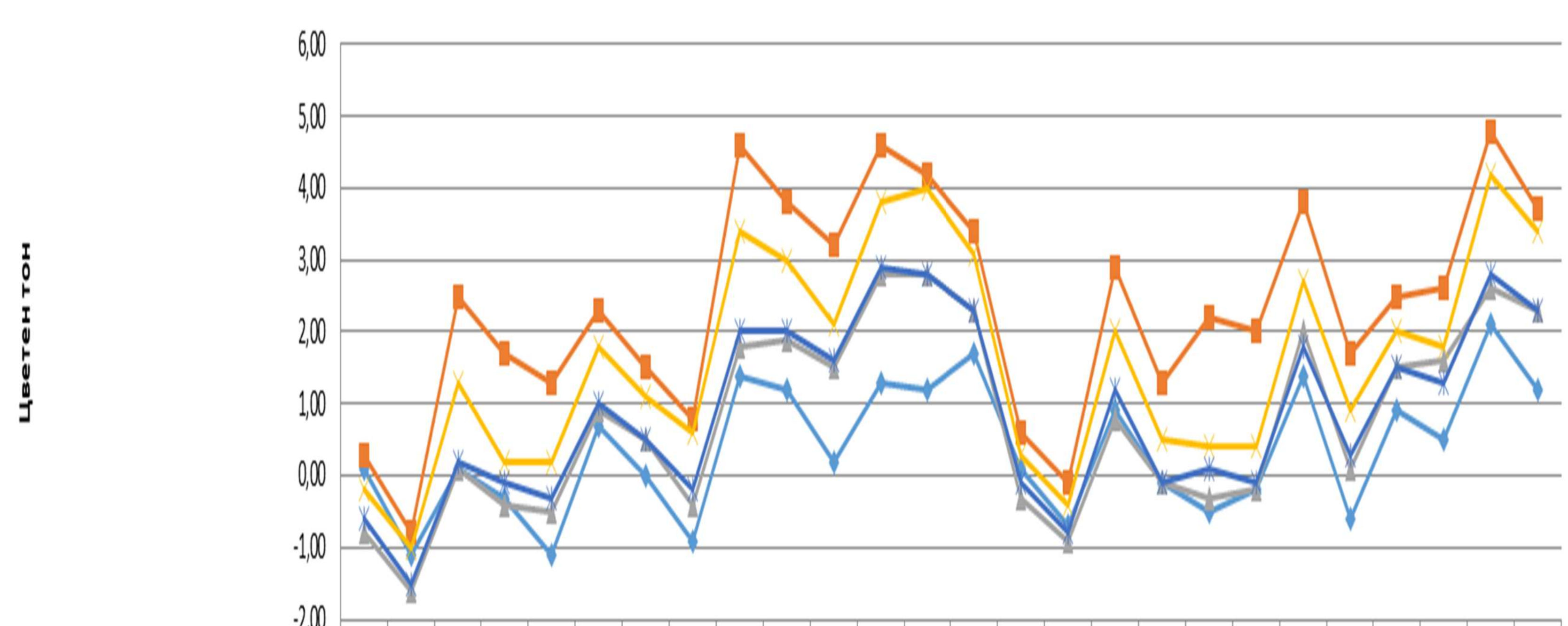
Four colors achieved the best results compared to the initial values when using veneers with thicknesses of 0.5 mm and 0.8 mm and gel - 3M2, 5M2, 5M3 and 4R2.5.

Four colors achieved the best results compared to the initial values when using veneers with a thickness of 0.8 mm and gel - 2M2, 3M2, 3R1.5 and 4L2.5.

At 1M1 and 2M3 the best results compared to the initial values were achieved with the use of 0.8 mm veneers and Try-in transparent paste.

At 1M2 and 2L2.5 the best results compared to the initial values were achieved with the use of 0.5 mm veneers and Try-in transparent paste.

In all other colors, the best results compared to the initial values were achieved with the use of 0.5 mm veneers and gel.



	1M1	1M2	2M1	2M2	2M3	3M1	3M2	3M3	4M1	4M2	4M3	5M1	5M2	5M3	2L1,5	2L2,5	2R1,5	2R2,5	3L1,5	3L2,5	3R1,5	3R2,5	4L1,5	4L2,5	4R1,5	4R2,5
изходен цветови тон	0,10	-1,10	0,10	-0,30	-1,10	0,70	0,00	-0,90	1,40	1,20	0,20	1,30	1,20	1,70	0,10	-0,70	0,90	-0,10	-0,50	-0,20	1,40	-0,60	0,90	0,50	2,10	1,20
фасета 0.5 мм и Try-in паста transparent	0,30	-0,80	2,50	1,70	1,30	2,30	1,50	0,80	4,60	3,80	3,20	4,60	4,20	3,40	0,60	-0,10	2,90	1,30	2,20	2,00	3,80	1,70	2,50	2,60	4,80	3,70
фасета 0.5 мм и гел	-0,80	-1,60	0,10	-0,40	-0,50	0,90	0,50	-0,40	1,80	1,90	1,50	2,80	2,80	2,30	-0,30	-0,90	0,80	-0,10	-0,30	-0,20	2,00	0,10	1,50	1,60	2,60	2,30
фасета 0.8 мм и Try-in паста transparent	-0,20	-1,00	1,30	0,20	0,20	1,80	1,10	0,60	3,40	3,00	2,10	3,80	4,00	3,10	0,30	-0,40	2,00	0,50	0,40	0,40	2,70	0,90	2,00	1,80	4,20	3,40
фасета 0.8 мм и гел	-0,60	-1,50	0,20	-0,10	-0,30	1,00	0,50	-0,20	2,00	2,00	1,60	2,90	2,80	2,30	-0,10	-0,80	1,20	-0,10	0,10	-0,10	1,80	0,30	1,50	1,30	2,80	2,30

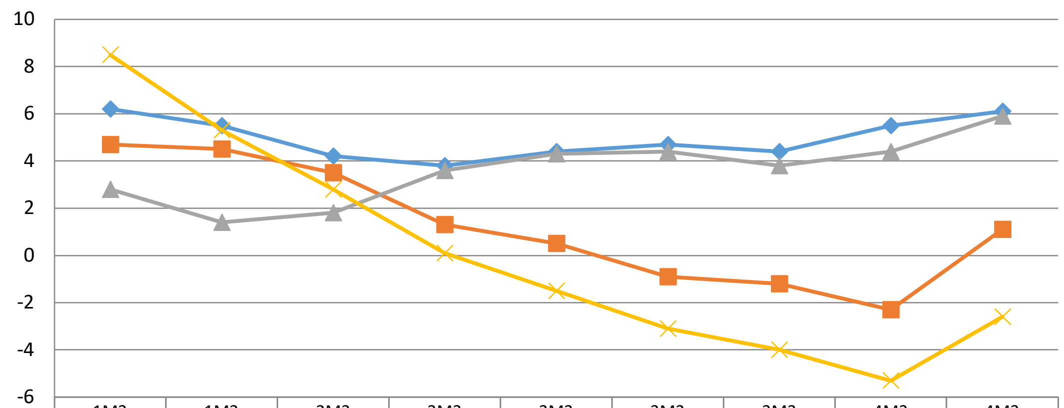
Fig. 52. *Comparative analysis of the colour tone according to VITA 3D Master*

Conclusions from task 1:

From the results obtained, it should be concluded that the use of *egg-shell* printed crowns from Dental LT Clear Resin® (Formlabs ™) will have a significant impact on most of the colors used. The method described above for fast and digital planning and easy materialization of prototypes is not recommended when working in the aesthetic area. It could be used only in the distal areas. For this reason, we believe that its application should be greatly reduced in strict monitoring of situations where the impact on certain color combinations would not be significant. This, in general, limits its mass application and for more accurate reproduction of the desired colors, alternative approaches should be sought so that the resulting colors are as close as possible to the color standards.

IV.2. Results and discussion on task 2

In the first group the results of mixing White Resin® with Model Resin®, are examined presented in **Fig. 53**.



	1M3 B2 0,9ml/0,1ml	1M2 B3 0,8ml/0,2ml	2M3 B4 0,7ml/0,3ml	3M3 B4 0,6ml/0,4ml	3M3 B4 0,5ml/0,5ml	3M3 B4 0,4ml/0,6ml	3M3 B4 0,3ml/0,7ml	4M3 B4 0,2ml/0,8ml	4M3 A4 0,1ml/0,9ml
Delta E	6,2	5,5	4,2	3,8	4,4	4,7	4,4	5,5	6,1
Value	4,7	4,5	3,5	1,3	0,5	-0,9	-1,2	-2,3	1,1
Chroma	2,8	1,4	1,8	3,6	4,3	4,4	3,8	4,4	5,9
Hue	8,5	5,3	2,8	0,1	-1,5	-3,1	-4	-5,3	-2,6

Fig. 53. *Change in color characteristics in the White Resin® / Model Resin® group.*

According to the obtained results, the combination White Resin® / Model Resin® in the ratio 0.6 ml / 0.4 ml (ΔE = 3.8) ($p < 0.001$) is closest to the main color of the color standards of VITA Classic and VITA 3D Master.

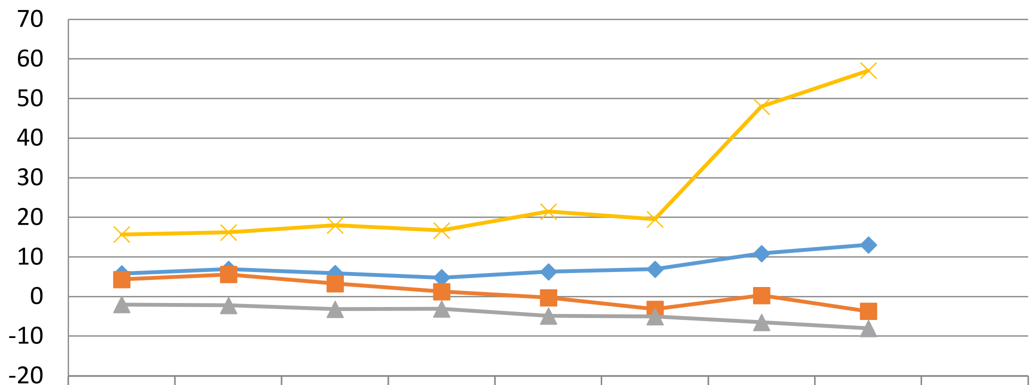
When evaluating ΔE according to the deviation norm (5.0) set by us in the device used (VITA Easyshade® V) for color evaluation, 55.5% of the combinations are within the norm. The largest deviation was observed at the ratios 0.9 ml / 0.1 ml and 0.1 ml / 0.9 ml (6.2 and 6.1, respectively) ($p < 0.01$).

Value is most close to the base color at a ratio of 0.5 ml / 0.5 ml (0.5) and away at a ratio of 0.9 ml / 0.1 ml (4.7) ($p < 0.01$).

Chroma is closest to the base color in ratio 0.8 ml / 0.2 ml (1.4) followed by 0.7 ml / 0.3 ml (1.8), with a maximum distance of 0.1 ml / 0.9 ml (5.9) ($p < 0.01$).

Hue is closest to the main color of the considered colors at a ratio of 0.6 ml / 0.4 ml (0.1), and differs mostly at a ratio of 0.9 ml / 0.1 ml (8.5) ($p < 0.01$).

In the second group, the results of mixing White Resin® with Dental LT Clear Resin® were studied, and the results are presented in **Fig. 54.**



	0M3 B1 0,9ml/0,1 ml	0M3 B1 0,8ml/0,2 ml	0M2 B1 0,7ml/0,3 ml	0M1 B1 0,6ml/0,4 ml	1M1 B1 0,5ml/0,5 ml	2M1 B1 0,4ml/0,6 ml	3M1 0,3ml/0,7 ml	4M1 0,2ml/0,8 ml	5M1 0,1ml/0,9 ml
Delta E	5,8	6,9	5,9	4,8	6,3	6,9	10,9	13,1	
Белеене	4,3	5,6	3,3	1,3	-0,3	-3,2	0,3	-3,7	
Наситеност	-2	-2,2	-3,2	-3,1	-4,9	-5	-6,5	-8	
Цветен тон	15,7	16,2	18	16,7	21,5	19,5	48	57,1	

Fig. 54. *Change in color characteristics in a group White Resin® / Dental LT Clear Resin®.*

According to the obtained results, the combination White Resin® / Dental LT Clear Resin® in the ratio 0.6 ml / 0.4 ml (Delta E-4.8) (p <0.001) is the closest to the main color of the color standards of VITA Classic and VITA 3D Master.

When evaluating ΔE according to the deviation norm (5.0) set by us of the used color evaluation device (VITA Easyshade® V), 12.5% of the combinations or only one combination (0.6 ml / 0.4 ml) falls within the norm. The largest deviation was observed at the ratios 0.3 ml / 0.7 ml and 0.2 ml / 0.8 ml (10.9 and 13.1, respectively) (p <0.01).

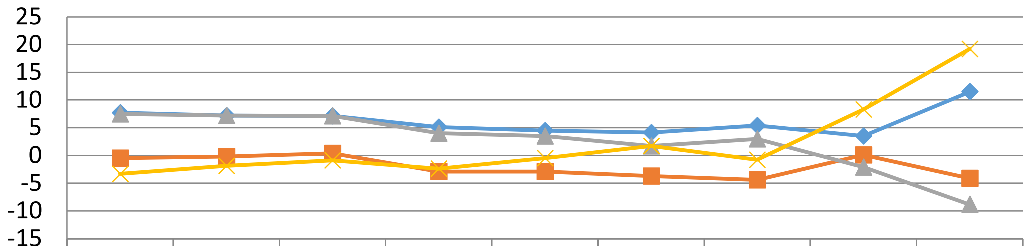
Value is closest to the base color at a ratio of 0.5ml / 0.5ml and 0.3 ml / 0.7 ml (-0.3 and 0.3, respectively), and most distant at a ratio of 0.8 ml / 0.2 ml (5.6) (p <0.01).

Chroma is closest to the base color at a ratio of 0.9ml / 0.1 ml (-2) followed by that at a ratio of 0.8 ml / 0.2 ml (-2.2), the most distant at a ratio of 0.2 ml / 0.8 ml (- 8) (p <0.01).

Regarding the hue, there is a significant deviation from the main color of the considered colors, as it is most significant in the ratios 0.3 ml / 0.7ml (48.0) and 0.2 ml / 0.8 ml (57.1) (p <0.05).

When evaluating the White Resin® / Dental LT Clear Resin® ratio of 0.1 ml / 0.9 ml, the results were not reported as a color by the meter.

The third group examined the results of mixing Model Resin® with Dental LT Clear Resin®, and the results are presented in **Fig. 55.**



	4M3 A4 0,9ml/0,1 ml	4M3 A4 0,8ml/0,2 ml	4M3 A4 0,7ml/0,3 ml	4M3 B4 0,6ml/0,4 ml	4M3 B4 0,5ml/0,5 ml	4L2,5 B4 0,4ml/0,6 ml	4L2,5 D4 0,3ml/0,7 ml	4M1 C4 0,2ml/0,8 ml	5M1 0,1ml/0,9 ml
Delta E	7,7	7,2	7,1	5,1	4,5	4,1	5,4	3,5	11,5
Value	-0,5	-0,2	0,4	-2,9	-2,9	-3,7	-4,4	0,1	-4,1
Chroma	7,5	7,2	7,1	4	3,5	1,7	3	-2,1	-8,8
Hue	-3,3	-1,9	-0,9	-2,4	-0,5	1,7	-0,8	8,3	19,2

Fig. 55. *Change in color characteristics in the Model Resin® / Dental LT Clear Resin® group.*

Според получените резултати най-много до основния цвят на цветовите стандарти на VITA Classic и VITA 3D Master се доближава комбинацията Model Resin® /Dental LT Clear Resin® в съотношение 0.2 ml/0.8 ml (*ΔE* =3.5) ($p<0.001$).

При оценка на Delta E според приетата норма за отклонение (5.0) на използвания уред за оценка на цвета *(VITA Easyshade® V)* в границите на нормата влизат 33.3 % от комбинациите. Най-голямо отклонение се наблюдава при съотношенията 0.1 ml/0.9 ml (11.5) ($p<0.01$).

Белеенето най-много се доближава до основния цвят при съотношение 0.2 ml/0.8 ml (0.1), следвано от съотношението 0.8 ml/0.2 ml (-0.2), 0.7 ml/0.3 ml (0.4) и 0.9 ml/0.1ml (-0.5), а най-много се отдалечава при съотношение 0.3 ml/0.7 ml и 0.1 ml/0.9 ml (съответно -4.4 и -4.1) ($p<0.01$).

Наситеността най-много се доближава до основния цвят при съотношение 0.4 ml/0.6 ml 1.7) следвана от тази при съотношение 0.2 ml/0.8 ml (-2.1), като най-много се отдалечава при съотношение 0.1 ml/0.9 ml (-8.8) ($p<0.01$).

Цветния тон най-много се доближава до основния цвят на разглежданите разцветки при съотношение 0.5 ml/0.5 ml (-0.5), а най-много се отдалечава при съотношение 0.1 ml/0.9 ml (19.2) ($p<0.01$).

According to the obtained results, the combination Model Resin® / Dental LT Clear Resin® in the ratio 0.2 ml / 0.8 ml (ΔE = 3.5) ($p <0.001$) is the closest to the basic color of the color standards of VITA Classic and VITA 3D Master.

When evaluating Delta E according to the accepted deviation standard (5.0) of the color assessment device used (VITA Easyshade® V), 33.3% of the combinations fall within the norm. The largest deviation was observed in the ratios 0.1 ml / 0.9 ml (11.5) ($p <0.01$).

Value is closest to the base color at a ratio of 0.2 ml / 0.8 ml (0.1), followed by a ratio of 0.8 ml / 0.2 ml (-0.2), 0.7 ml / 0.3 ml (0.4) and 0.9 ml / 0.1ml (-0.5).), and is furthest at a ratio of 0.3 ml / 0.7 ml and 0.1 ml / 0.9 ml (-4.4 and -4.1, respectively) ($p <0.01$).

Chroma is closest to the base color at a ratio of 0.4 ml / 0.6 ml 1.7) followed by that at a ratio of 0.2 ml / 0.8 ml (-2.1), furthest at a ratio of 0.1 ml / 0.9 ml (-8.8) ($p <0.01$).

Hue is closest to the main color of the considered colors at a ratio of 0.5 ml / 0.5 ml (-0.5), furthest at a ratio of 0.1 ml / 0.9 ml (19.2) ($p <0.01$).

Fig. 56 presents a comparative analysis of the change in the color characteristics of the studied groups and ratios. The results show a significant difference in color characteristics according to the VITA Classic and VITA 3D Master color standards (p <0.001).

A4 according to VITA Classic and 4M3 according to VITA 3D Master was achieved in two combinations and four ratios - Model Resin® / Dental LT Clear Resin® - 0.9ml / 0.1ml; Model Resin® / Dental LT Clear Resin® - 0.8ml / 0.2ml; Model Resin® / Dental LT Clear Resin® - 0.7ml / 0.3ml and White Resin® / Model Resin® - 0.1ml / 0.9ml. The closest color to A4 is White Resin® / Model Resin® in the ratio 0.1ml / 0.9ml, where ΔE is 6.1, and in the other three combinations the difference is minimal. However, all combinations and ratios used have values above the accepted deviation rate (5.0). Value and hue are closest to the base color in the Model Resin® / Dental LT Clear Resin® combination and a ratio of 0.7ml / 0.3ml (0.4 and -0.9, respectively). The chroma is closest to the base color in the combination White Resin® / Model Resin® in the ratio 0.1ml / 0.9ml (5.9).

B1 according to VITA Classic and 0M3, 0M2, 0M1, 1M1, 2M1 according to VITA 3D Master was achieved with one combination White Resin® / Dental LT Clear Resin® in six different ratios - 0.9ml / 0.1ml; 0.8ml / 0.2ml; 0.7ml / 0.3ml; 0.6ml / 0.4ml; 0.5ml / 0.5ml; 0.4ml / 0.6ml. The combination White Resin® / Dental LT Clear Resin® in the ratio 0.6ml / 0.4ml is the closest to color B1, where ΔE is 4.8, with the other combinations the values vary from 5.8 to 6.9. Value is closest to the base color in the combination White Resin® / Dental LT Clear Resin® and a ratio of 0.5ml / 0.5ml (-0.3). The hue has the largest deviation from the base color. The chroma is closest to the base color in the combination White Resin® / Dental LT Clear Resin® in the ratio 0.9ml / 0.1ml (-2.0).

B2 according to VITA Classic and 1M3 according to VITA 3D Master was achieved only with one combination White Resin® / Model Resin® in the ratio 0.9ml / 0.1ml, where ΔE is 6.2.

B3 according to VITA Classic and 1M2 according to VITA 3D Master was also achieved with one combination White Resin® / Model Resin® in the ratio 0.8ml / 0.2ml, where ΔE is 5.5.

B4 according to VITA Classic and 2M3, 3M3, 4M3, 4L2.5 according to VITA 3D Master was achieved in two combinations in nine different ratios - White Resin / Model Resin - 0.7ml / 0.3ml, White Resin / Model Resin - 0, 6ml / 0.4ml, White Resin / Model Resin - 0.5ml / 0.5ml, White Resin / Model Resin - 0.4ml / 0.6ml, White Resin / Model Resin - 0.3ml / 0.7ml, White Resin / Model Resin - 0.2ml / 0.8ml, Model Resin / Dental LT Clear Resin - 0.6ml / 0.4ml, Model Resin / Dental LT Clear Resin - 0.5ml / 0.5ml and Model Resin / Dental LT Clear

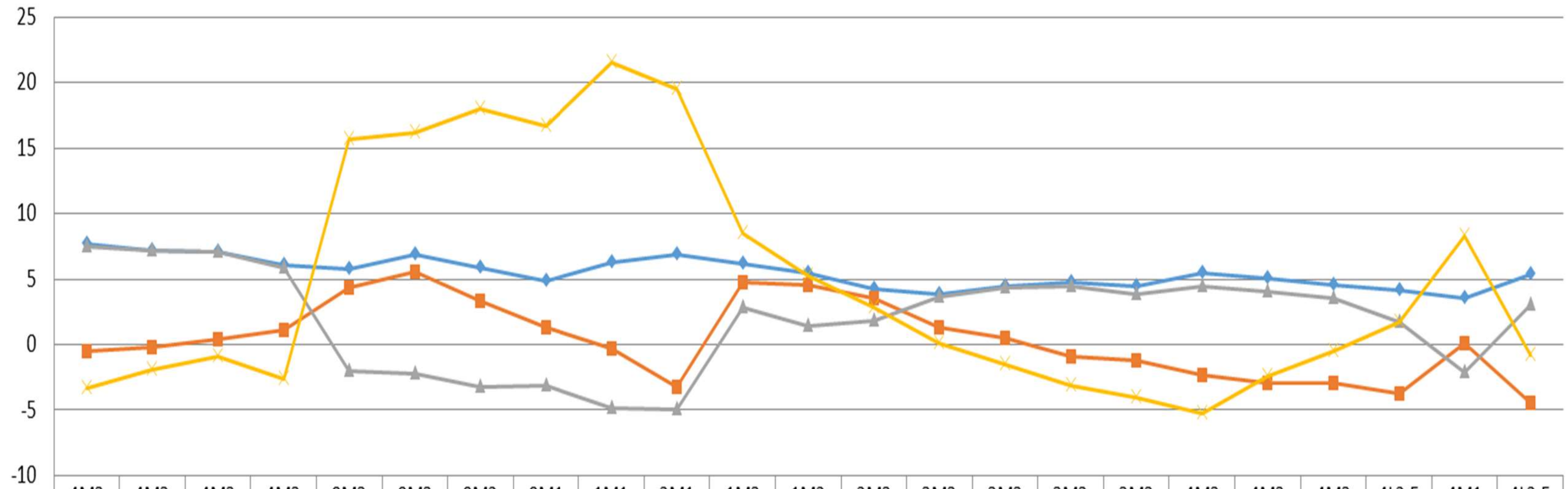
Resin - 0.4ml / 0.6ml. The combination White Resin / Model Resin in the ratio 0.6ml / 0.4ml is the closest to color B4, where ΔE is 3.8, with the other combinations the values vary from 4.1 to 5.5. According to the accepted deviation norm (5.0), 77.7% of the combinations are in the norm for this color. Value is closest to the base color in the combination White Resin® / Model Resin® and a ratio of 0.5ml / 0.5ml (0.5). In terms of hue, the combination White Resin® / Model Resin® in the ratio 0.6ml / 0.4ml (0.1) is closest to the main color. Chroma is closest to the base color in the combination White Resin® / Dental LT Clear Resin® in the ratio 0.4ml / 0.6ml (1.7).

C4 according to VITA Classic and 4M1 according to VITA 3D Master was achieved only with one combination White Resin® / Model Resin® in the ratio 0.9ml / 0.1ml, where ΔE is 3.5.

D4 according to VITA Classic and 4L2.5 according to VITA 3D Master was achieved only with one combination White Resin® / Model Resin® in the ratio 0.9ml / 0.1ml, where ΔE is 5.4.

Based on these results, the color combinations are optimal:

1. White Resin / Model Resin - in a ratio of 9/1, corresponding to color B2;
2. White Resin / Model Resin - in a ratio of 8/2, corresponding to color B3;
3. White Resin / Model Resin - in a ratio of 7/3, corresponding to color B4;
4. White Resin / Model Resin - in a ratio of 6/4, corresponding to color B4;
5. White Resin / Model Resin - in a ratio of 1/9, corresponding to color A4;
6. White Resin / Dental LT Clear Resin - in a ratio of 9/1, corresponding to color B1;
7. White Resin / Dental LT Clear Resin - in a ratio of 4/6, r corresponding to color B1;
8. White Resin / Dental LT Clear Resin - in a ratio of 3/7, corresponding to color 3M1 (according to VITA 3D Master);
9. White Resin / Dental LT Clear Resin - in a ratio of 2/8, corresponding to color 4M1 (according to VITA 3D Master);
10. Model Resin / Dental LT Clear Resin - in a ratio of 5/5, corresponding to color B4.



	4M3 A4 Model/ Dental LT - 0,9ml/0,1ml	4M3 A4 Model/ Dental LT - 0,8ml/0,2ml	4M3 A4 Model/ Dental LT - 0,7ml/0,3ml	4M3 A4 White/ Model - 0,1ml/0,9ml	0M3 B1 White/ Dental LT - 0,9ml/0,1ml	0M3 B1 White/ Dental LT - 0,8ml/0,2ml	0M2 B1 White/ Dental LT - 0,7ml/0,3ml	0M1 B1 White/ Dental LT - 0,6ml/0,4ml	1M1 B1 White/ Dental LT - 0,5ml/0,5ml	2M1 B1 White/ Dental LT - 0,4ml/0,6ml	1M3 B2 White/ Model - 0,9ml/0,1ml	1M2 B3 White/ Model - 0,8ml/0,2ml	2M3 B4 White/ Model - 0,7ml/0,3ml	3M3 B4 White/ Model - 0,6ml/0,4ml	3M3 B4 White/ Model - 0,5ml/0,5ml	3M3 B4 White/ Model - 0,4ml/0,6ml	3M3 B4 White/ Model - 0,3ml/0,7ml	4M3 B4 White/ Model - 0,2ml/0,8ml	4M3 B4 Model/ Dental LT - 0,6ml/0,4ml	4M3 B4 Model/ Dental LT - 0,5ml/0,5ml	4L2,5 B4 Model/ Dental LT - 0,4ml/0,6ml	4M1 C4 Model/ Dental LT - 0,2ml/0,8ml	4L2,5 D4 Model/ Dental LT - 0,3ml/0,7ml
Delta E	7,7	7,2	7,1	6,1	5,8	6,9	5,9	4,8	6,3	6,9	6,2	5,5	4,2	3,8	4,4	4,7	4,4	5,5	5,1	4,5	4,1	3,5	5,4
Белеене	-0,5	-0,2	0,4	1,1	4,3	5,6	3,3	1,3	-0,3	-3,2	4,7	4,5	3,5	1,3	0,5	-0,9	-1,2	-2,3	-2,9	-2,9	-3,7	0,1	-4,4
Наситеност	7,5	7,2	7,1	5,9	-2	-2,2	-3,2	-3,1	-4,9	-5	2,8	1,4	1,8	3,6	4,3	4,4	3,8	4,4	4	3,5	1,7	-2,1	3
Цветен тон	-3,3	-1,9	-0,9	-2,6	15,7	16,2	18	16,7	21,5	19,5	8,5	5,3	2,8	0,1	-1,5	-3,1	-4	-5,3	-2,4	-0,5	1,7	8,3	-0,8

Fig. 56. *Change in color characteristics in the three groups according to color standards (VITA Classic and VITA 3DMaster).*

Discussion on task 2

White Resin / Model Resin in the ratio 0.1ml / 0.9ml, where ΔE is 6.1, is the closest to color A4 according to VITA Classic and 4M3 according to VITA 3D Master, although it is above the accepted deviation norm and the color difference between the extension structure and the natural teeth can be perceived by the untrained eye. Value and hue are closest to the base color in the combination Model Resin / Dental LT Clear Resin and a ratio of 0.7ml / 0.3ml (0.4 and -0.9, respectively). Chroma is closest to the base color in the combination White Resin / Model Resin in the ratio 0.1ml / 0.9ml (5.9).

The combination White Resin / Dental LT Clear Resin in the ratio 0.6ml / 0.4ml, where ΔE is 4.8, which enters within the permissible margin for the achieved clinical result, while the difference in color remains perceptible only to the eye of a trained dental specialist. Value is closest to the base color in the combination White Resin / Dental LT Clear Resin and a ratio of 0.5ml / 0.5ml (-0.3). With regards to the hue, in this group there are significant deviations and it is not possible to determine a combination and ratio that are close to the main color. Chroma is closest to the base color in the combination White Resin / Dental LT Clear Resin in the ratio 0.9ml / 0.1ml (-2.0).

Although there is a significant difference in the color deviation, color B2, according to VITA Classic and 1M3 according to VITA 3D Master, was achieved only with one combination White Resin / Model Resin in the ratio 0.9ml / 0.1ml, where ΔE is 6.2.

Color B3 according to VITA Classic and 1M2 according to VITA 3D Master was also achieved with one combination White Resin / Model Resin in the ratio 0.8ml / 0.2ml, where ΔE is 5.5, slightly above the accepted deviation limit.

The B4 color, according to VITA Classic, and 2M3, 3M3, 4M3, 4L2,5, according to VITA 3D Master is closest to the combination White Resin / Model Resin in the ratio 0.6ml / 0.4ml, where ΔE is 3.8, as the difference in color falls within the tolerance and remains elusive to the untrained eye of the patient. Value is closest to the base color in the combination White Resin / Model Resin and a ratio of 0.5ml / 0.5ml (0.5). In terms of hue, the combination White Resin / Model Resin in the ratio 0.6ml / 0.4ml (0.1) is closest to the main color. Chroma is closest to the base color in the combination White Resin / Dental LT Clear Resin in the ratio 0.4ml / 0.6ml (1.7).

C4 according to VITA Classic and 4M1 according to VITA 3D Master was achieved only with one combination White Resin / Model Resin in the ratio 0.9ml / 0.1ml, where ΔE is 3.5.

D4 according to VITA Classic and 4L2.5 according to VITA 3D Master was achieved only with one combination White Resin / Model Resin in the ratio 0.9ml / 0.1ml, where ΔE is 5.4.

1. 1 Regarding the combination White Resin / Model Resin, the best results in terms of ΔE are achieved at a ratio of 0.6ml to 0.4ml, where the color is optically close to B4 by VITA Classic and 3M3 by VITA 3D Master.
2. The results of the study show that the combination of these two resins (White Resin and Model Resin) achieves the best performance in terms of ΔE (below the accepted norm of 5.0), value, chroma and hue in color B4.
3. The combination White Resin / Dental LT Clear Resin gives the best result in terms of ΔE when achieving color B1 according to VITA Classic and 0M1 according to VITA 3D Master in a ratio of 0.6ml to 0.4ml, and this combination can be used in the manufacture of temporary structures mainly with color B1.
4. The combination Model Resin / Dental LT Clear Resin shows the best results in relation to Delta E in the ratio of 0.2ml to 0.8ml and the achievement of color C4 according to VITA Classic and 4M1 according to VITA 3D Master.
5. The combination Model Resin / Dental LT Clear Resin shows good results in terms of Delta E and color B4.
6. None of the combinations of resins used achieved color A4, B1, B2, B3 and D4 at ΔE below the established norm.

Conclusions on task 2:

The results of the study to determine the color of the test specimens confirm the initially formulated hypothesis that different combinations of the three starting resins affect the final color and cover a wide range of possible colors when choosing treatment, and coming as close as possible to the natural shade of the patient's teeth, as a result of which the high aesthetic qualities of the restoration are guaranteed. From the conducted tests and analyzes it can be said that the colors B1, B4 and C4 can be reproduced without problems by the newly obtained resins for temporary constructions, while in colors A4, B2, B3 and D4 the results deviate significantly from the allowable norm for color difference, which is visible to the patient and is associated with a possible unsatisfactory clinical outcome in terms of aesthetics. The limitations of the newly created resins are that they can not reproduce a greater variety of colors, and the choice is limited to 7 primary colors, of which only 3 falls within the tolerance of color deviation and are unnoticable by the untrained eye of the patient.

The question whether the results achieved in this way of the designed color recipes would meet the requirements for mechanical strength indicators in accordance with ISO standards remains unclear.

IV.3. Results and discussion on task 3

A comparative analysis of the determined newly obtained resins was performed by a three-point bending strength test.

In the White Resin® / Model Resin® group, five combinations were selected, two of which fall within the set tolerance of 5.0 ΔE. The 0.6ml / 0.4ml ratio is closest to the 3M3 / B4 base color (ΔE = 3.8) followed by the 0.7ml / 0.3ml ratio, which is close to the 2M3 / B4 base color (ΔE = 4.2). The other three ratios are above the tolerance - 0.9ml / 0.1ml (ΔE = 6.2 for 1M3 / B2), 0.8 ml / 0.2 ml (ΔE = 5.5 for 1M2 / B3) and 0.1 ml / 0.9 ml (ΔE = 6.1 for 4M3 / A4).

In the White Resin® / Dental LT Clear Resin® group, four combinations were selected, none of which fell within the tolerance of 5.0: 0.9ml / 0.1ml (ΔE = 5.8 for 0M3 / B1), 0.4ml / 0.6ml (ΔE) = 6.9 for 2M1 / B1), 0.3ml / 0.7ml (ΔE = 10.9 for 3M1) and 0.2ml / 0.8ml (ΔE = 13.1 for 4M1).

In the Model Resin® / Dental LT Clear Resin® group, only one 0.5ml / 0.5ml combination was chosen in which the deviation falls within the domestic standard for the base color 4M3 / B4 (ΔE = 4.5).

A comparative analysis of the change in flexural strength at different concentrations of White Resin® was performed. The results showed a significant difference in the bending strength at individual concentrations with a tendency to decrease with increasing White Resin® concentration (F = 112.87; p <0.001) (**Table 1**).

Table 1. *Comparative analysis of bending strength according to different concentrations of White Resin®.*

Concentration of White (ml)	Number of specimens	Mean (N)	Standart deviation (SD)	Standart error mean (SEM)	95% Confidence interval of the difference		Minimum	Maximum
					Lower	Upper		
0.1	30	497,5333	48,67821	8,88738	479,3566	515,7101	422,00	581,00
0.2	30	432,3000	32,62340	5,95619	420,1182	444,4818	396,00	493,00
0.3	30	408,8333	59,91435	10,93881	386,4609	431,2057	302,00	478,00
0.4	30	371,6000	27,75086	5,06659	361,2377	381,9623	325,00	412,00
0.6	30	354,4000	24,74783	4,51832	345,1590	363,6410	311,00	407,00
0.7	30	337,8000	30,80237	5,62372	326,2982	349,3018	270,00	392,00
0.8	30	317,3000	14,47030	2,64190	311,8967	322,7033	290,00	339,00
0.9	60	299,1500	36,39372	4,69841	289,7485	308,5515	205,00	379,00
Total	270	368,6741	72,85070	4,43355	359,9452	377,4029	205,00	581,00

The difference between the bending force at a concentration of White Resin 0.1 ml and 0.9 ml is 198.38 N in favor of the lower concentration. The values obtained from the Newtonian (N) apparatus were converted to Megapascals (MPa) using the flexural strength formula given in the task methodology. The average values at the different concentrations of this group are presented in **Fig.57.**

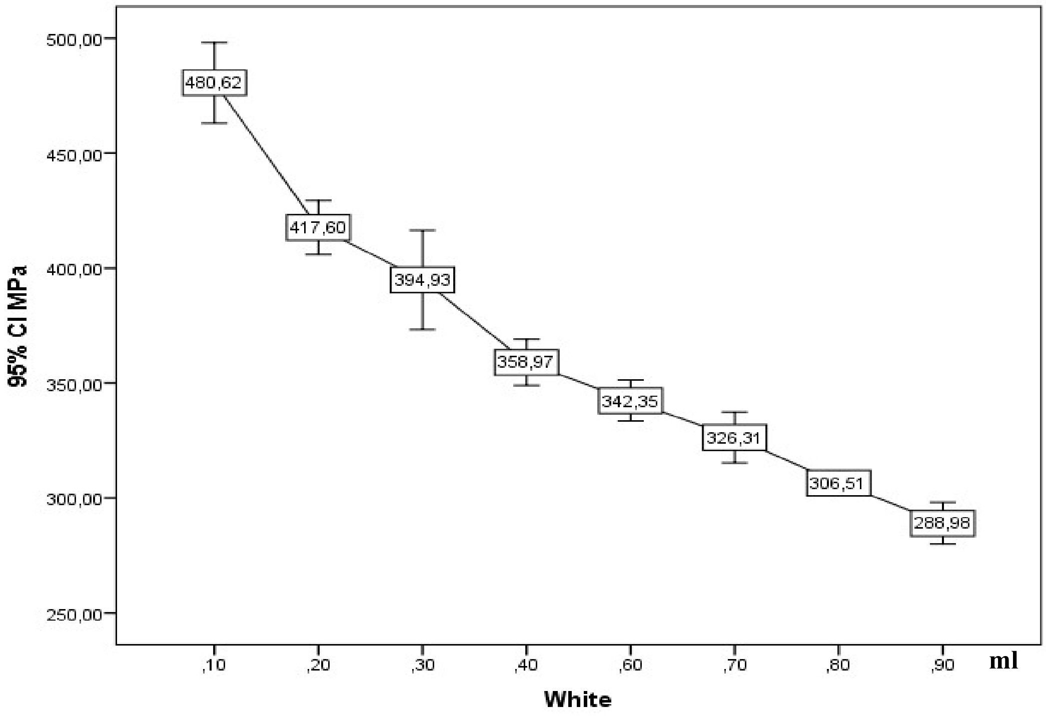


Fig. 57. Average value of bending strength according to the different concentrations of White Resin® in MPa.

On the other hand, a strong inverse relationship between the bending strength at different concentrations of White Resin® (r = -0.839; p <0.001) was found, which shows that the concentration of White Resin® has a 70.3% influence on the bending strength of the test specimens. (**Fig. 58**).

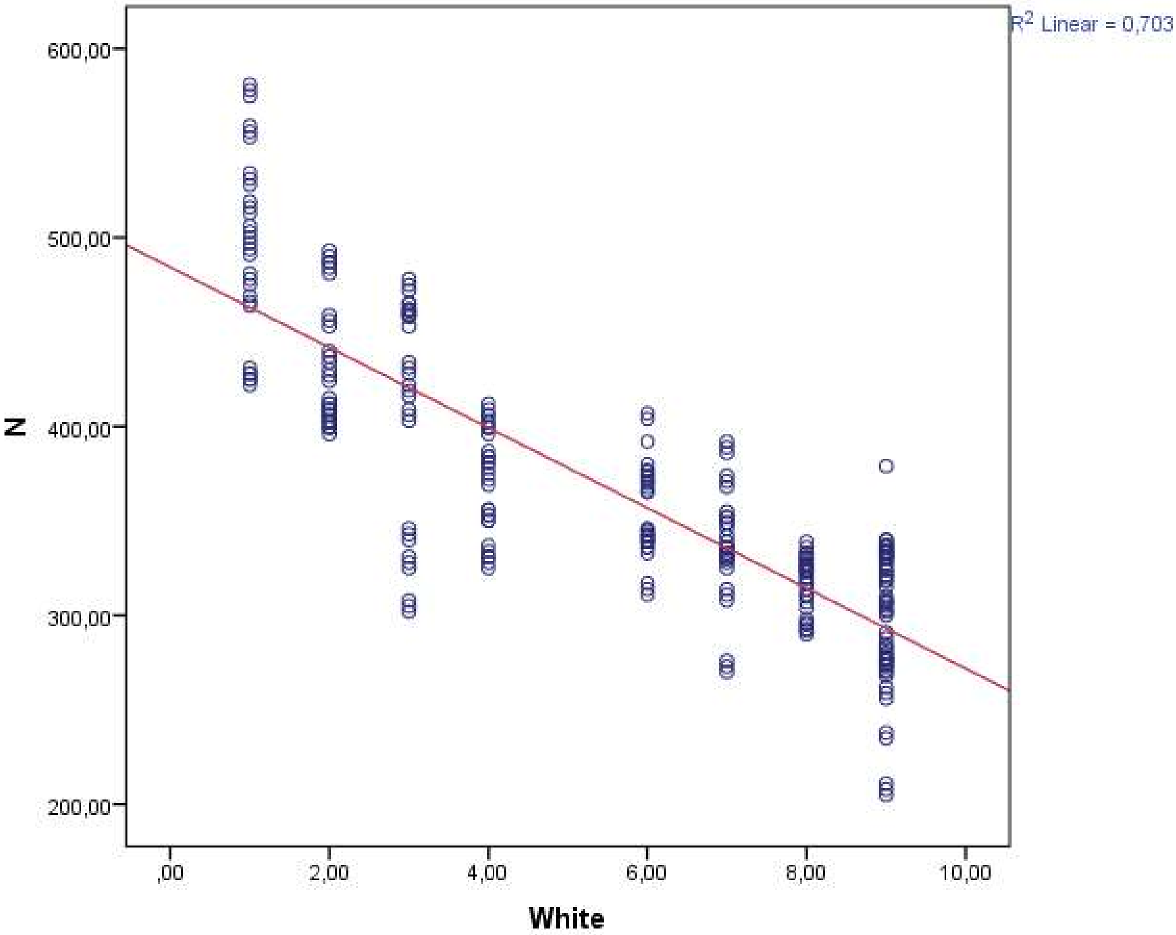


***Fig. 58.** Correlation analysis between White Resin and flexural strength.*

A comparative analysis of the bending strength at different concentrations of Dental LT Clear Resin revealed a significant difference and a tendency to increase the strength at higher concentrations of this resin (F = 55.81; p <0.001) **(Table 2).** Lower concentrations of Dental LT Clear Resin are associated with lower flexural strength values.

Table 2. *Comparative analysis of bending strength according to different concentrations of Dental LT Clear Resin.*

Concentration of	Number of specimens	Mean (N)	Standart deviation (SD)	Standart error mean (SEM)	95%Cofidence interval of the difference		Minimum	Maximum
					Lower	Upper		
0.1	30	297,9333	39,43212	7,19929	283,2091	312,6575	205,00	340,00
0.5	30	461,6667	61,39096	11,20841	438,7429	484,5904	353,00	562,00
0.6	30	371,6000	27,75086	5,06659	361,2377	381,9623	325,00	412,00
0.7	30	408,8333	59,91435	10,93881	386,4609	431,2057	302,00	478,00
0.8	30	432,3000	32,62340	5,95619	420,1182	444,4818	396,00	493,00
Total	150	394,4667	72,88602	5,95112	382,7072	406,2262	205,00	562,00

The values obtained from the Newtonian (N) apparatus were converted to Megapascals (MPa) using the flexural strength formula given in the task methodology. The average values at the different concentrations of this group are presented in **Fig. 59**.

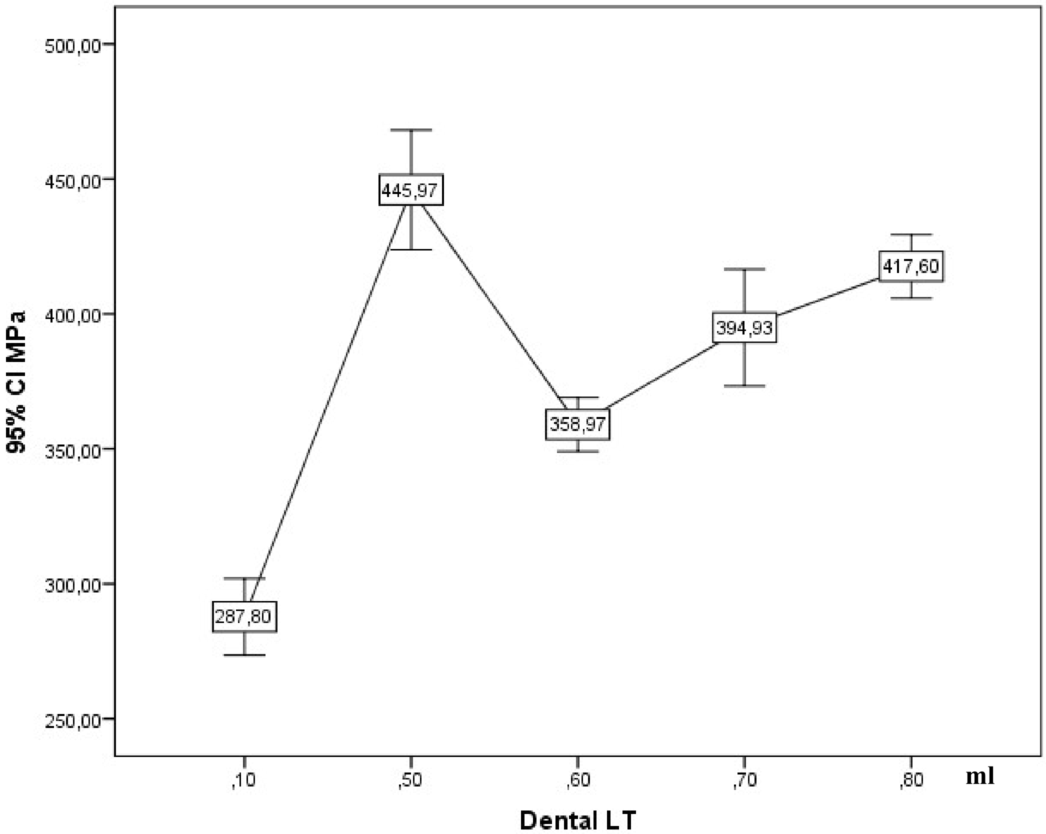


Fig. 59. *Average value of bending strength according to the different concentrations of Dental LT in MPa.*

There was also a significant proportional relationship between the bending force at different concentrations of Dental LT Clear Resin (r = 0.576; p <0.001), which shows that the concentration of this resin has an effect of 33.2% on the bending force of the test bodies (**Fig. 60**).

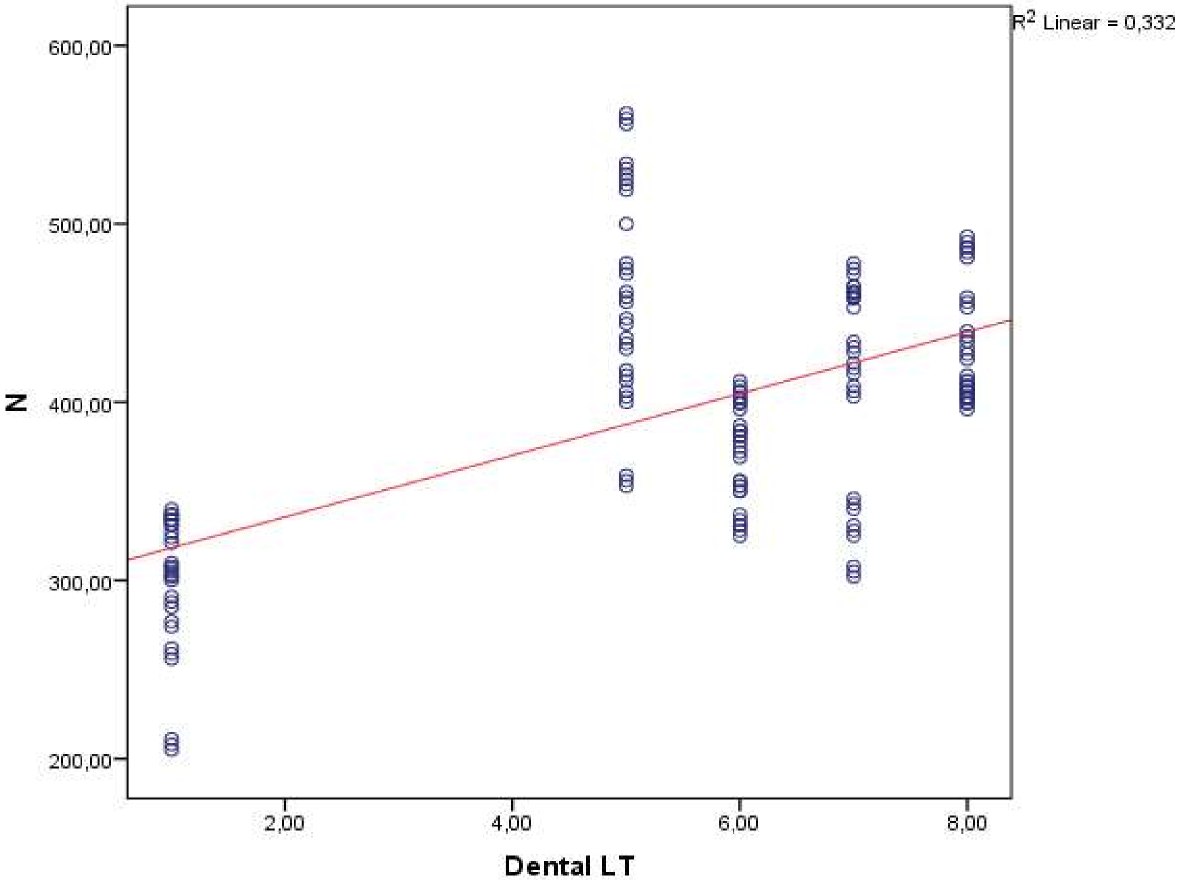


Fig. 60. *Correlation analysis between Dental LT Clear Resin and flexural strength.*

A similar trend is observed at the Model Resin concentration. The comparative analysis of the bending strength at different concentrations of this resin showed the presence of a significant difference and a tendency to increase the strength at its higher concentrations F = 132.02; p <0.001) **(Table 3).** Lower Model Resin concentrations are associated with lower flexural strength values.

Table 3. Comparative analysis of bending strength according to different concentrations of Model Resin.

Concentration of Model	Number of samples	Mean (N)	Standart deviation (SD)	Standaert error mean (SEM)	95%Cofidence interval of the difference		Minimum	Maximum
					Lower	Upper		
0.1	30	300,3667	33,71532	6,15555	287,7772	312,9562	235,00	379,00
0.2	30	317,3000	14,47030	2,64190	311,8967	322,7033	290,00	339,00
0.3	30	337,8000	30,80237	5,62372	326,2982	349,3018	270,00	392,00
0.4	30	354,4000	24,74783	4,51832	345,1590	363,6410	311,00	407,00
0.5	30	461,6667	61,39096	11,20841	438,7429	484,5904	353,00	562,00
0.9	30	497,5333	48,67821	8,88738	479,3566	515,7101	422,00	581,00
Total	180	378,1778	83,81625	6,24729	365,8500	390,5056	235,00	581,00

The values obtained from the Newtonian (N) apparatus were converted to Megapascals (MPa) using the flexural strength formula given in the task methodology. The average values at the different concentrations of this group are presented in **Fig. 61.**

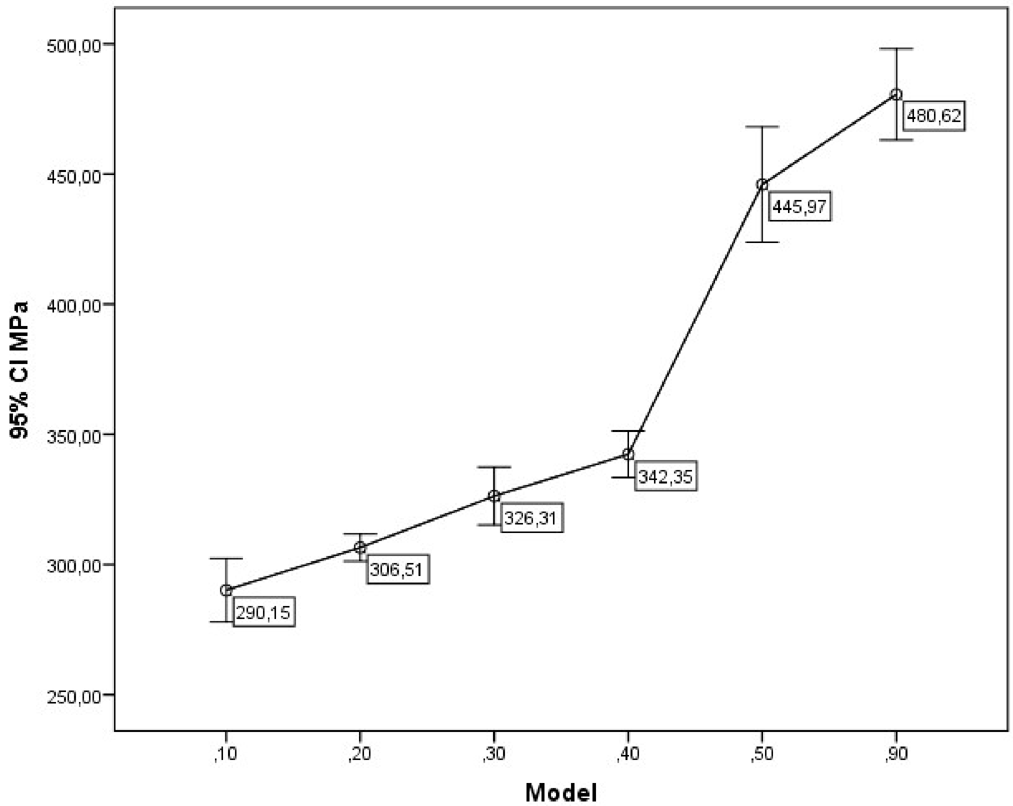


***Fig. 61**. Average value of bending strength according to the different concentrations of Model Resin in MPa.*

There was also a strong proportional relationship between the bending force at different concentrations of Model Resin ($r = 0.831$; $p < 0.001$), which shows that the concentration of this resin has an effect of 69.0% on the bending force of the test specimens (**Fig. 62**).

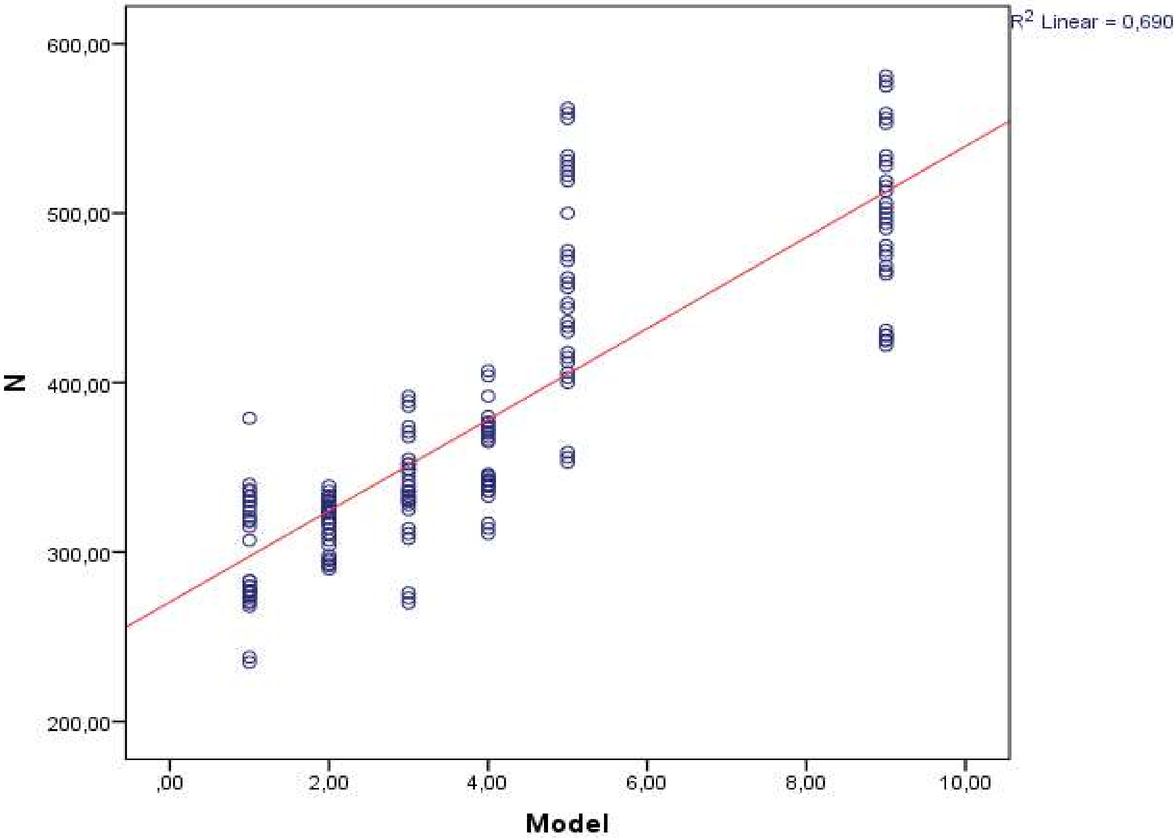


Fig. 62. *Correlation analysis between Model Resin and flexural strength.*

A significant difference in bending strength was found according to the color of the test specimens ($F = 90.53$; $p < 0.001$) (**Fig. 63**). The highest values of bending strength were achieved in color 4M3 / A4, and the lowest in color 0M3 / B1 (**Fig. 64**).

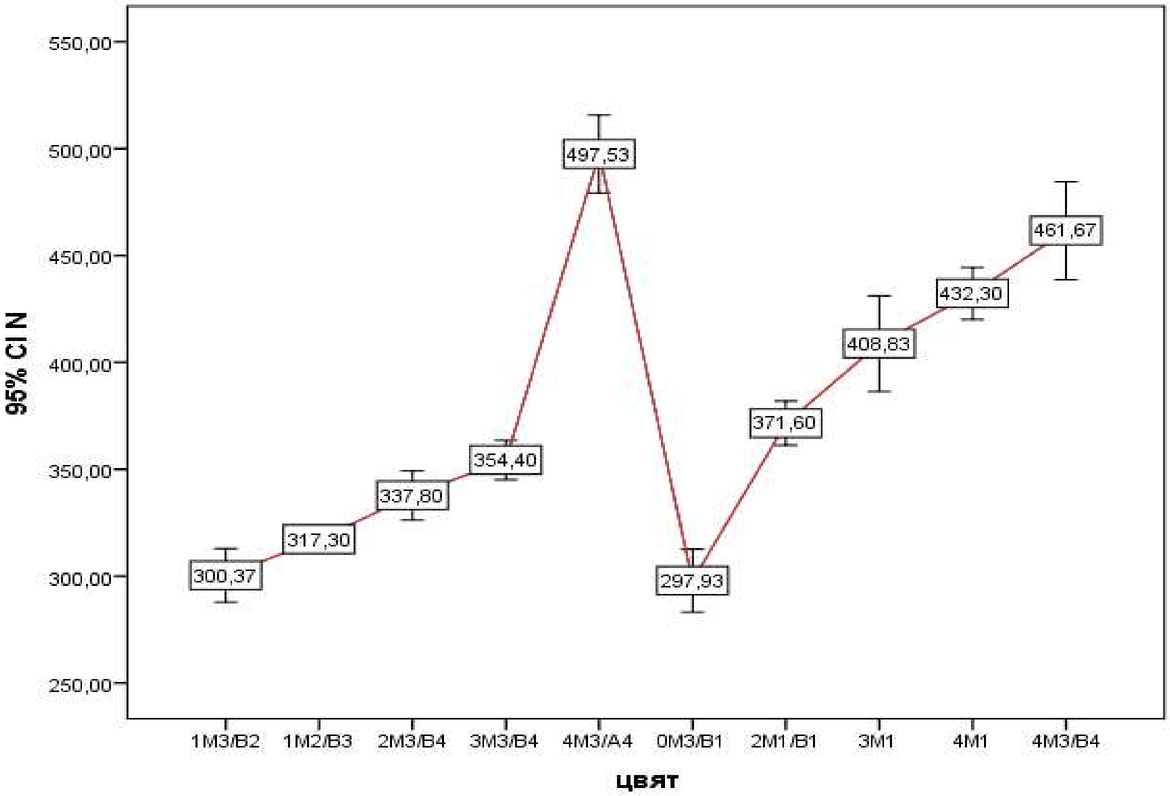


Fig. 63. *Average values of bending strength according to color.*

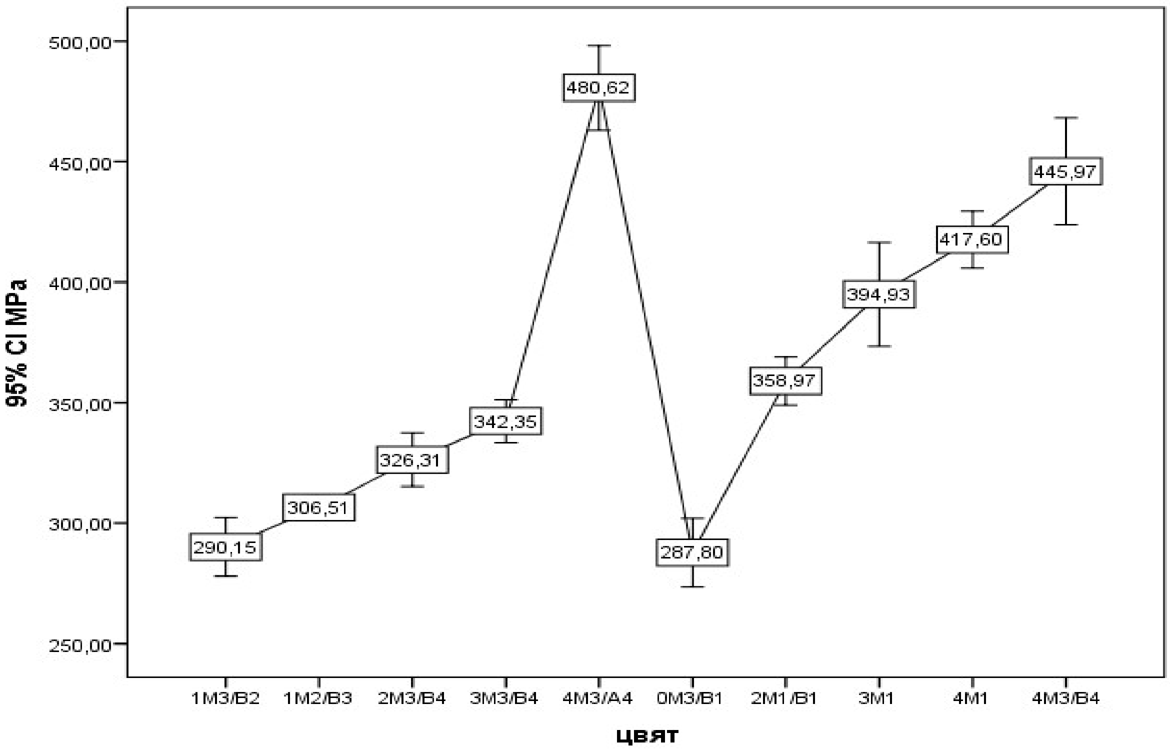


Fig. 64. *Average values of flexural strength according to color in MPa.*

Discussion on task 3

The mechanical and strength properties of the newly obtained resins depend on the ratios of the used starting resins, and the concentration of Dental LT Clear® and Model Resin® resins is essential for their increase.

The tests were selected on the basis of international standards: ISO 10477 "Dentistry - Polymer-based crown and bridge materials" and ISO 4049 "Dentistry - Polymer-based restorative materials". In the standard ISO 10477 the specified minimum allowable bending strength is greater than or equal to 50 MPa, and in the standard ISO 4049 it is a minimum of 100 MPa. Although there is a significant difference in the bending strength of the three starting resins used, it can be said that all of them are above the permissible minimum limit of 50 MPa and 100 MPa.

The results of the study show that in combinations with White Resin there is a decrease in flexural strength with increasing concentration and this resin is more relevant to the value of the prosthetic structure than to its flexural strength.

The use of Dental LT Clear Resin in different concentrations also showed a significant difference in flexural strength, but a positive relationship was found between the increased resin concentration and the flexural strength.

The third resin used in the Model Resin study showed the strongest positive relationship between concentration and flexural strength, and it can be said that combinations with high concentration of Model Resin are characterized by high values of flexural strength and are the most resistant to mechanical fractures.

The combination of White Resin / Model Resin in the ratio 1/9, corresponding to color A4 / 4M3 - 480.62 MPa, stood out with the highest bending strength, but according to the color characteristics there is a significant deviation, which is visible to the patient. Structures made of this resin are characterized by high mechanical strength properties, but low aesthetic performance, which makes them suitable for restorations in the distal areas of the dentition where the masticatory force is higher. The high bending strength makes this newly created resin suitable for bridge restorations.

In restorations where there is a high concentration of White Resin, logically lower values of flexural strength are observed, but they have high aesthetic characteristics, which makes them preferred by patients, especially in the frontal area of the dentition (White Resin / Model Resin - in ratio 9/1, corresponding to color B2 / 1M3 and White Resin / Dental LT Clear Resin

- in ratio 9/1, corresponding to color B1 / 0M3). In this regard, it is desirable to use these resins for single restorations with temporary crowns.

An inverse relationship was found between the bending strength and the concentration of White Resin, which shows that increasing the concentration of the resin reduces its mechanical strength.

The concentration of Dental LT Clear Resin and Model Resin resins correlates positively with the bending strength and shows that increasing the concentration leads to an improvement in the mechanical strength properties of the resins.

The combination between White Resin and Dental LT Clear Resin or Model Resin is associated with better aesthetic properties, but with lower mechanical-strength qualities, while the combination between Dental LT Clear Resin and Model Resin is associated with better mechanical-strength qualities, but also with lower aesthetics.

The difference in mechanical strength and aesthetic qualities makes the resins preferred for certain areas of the dentition, combinations with high concentrations of White Resin can be used to make temporary non-removable structures in the frontal area, while combinations with high concentrations of Dental LT Clear Resin and Model Resin are suitable for restorations in the distal area.

The combination of the two resins with a positive relationship between resin concentration and bending strength also shows high mechanical strength properties (Model Resin / Dental LT Clear Resin - in a ratio of 5/5, corresponding to color B4 / 4M3), but the difference in color is above the permissible deviation, which makes the structures made of this resin suitable for the distal area of the dentition.

Conclusions on task 3:

The optimal option for temporary constructions, which achieve both high aesthetic and mechanical characteristics, is the combination White Resin / Dental LT Clear Resin in a ratio of 4/6, corresponding to color B1 / 2M1. In these constructions, the concentration of White Resin is responsible for achieving one of the most preferred by patients color (B1), corresponding to the color of bleached teeth, while the concentration of Dental LT Clear Resin is associated with good mechanical properties. Under these conditions, the combination of White Resin / Dental LT Clear Resin in a ratio of 4/6 makes the resin suitable for use in both the frontal and distal areas of the dentition. The concentration of Dental LT Clear Resin up to

60% is associated with the transparency of natural dentition, contributing to the imitation of tooth enamel and achieving a closer to the natural color of hard dental tissues.

The question of whether it is possible to modify resins with lower tensile strength so as to achieve optimal or even higher strength than specified in the standards in cases where it is necessary to apply resins with lower strength in areas under heavy load for the needs of long-term prosthetics remains uncertain.

IV.4. Results and discussion on task 4

The measurement results for the bridge restoration 44-47, through the modification made, allow volume replacement with heterogeneous material in the field of connections in percentages as follows:

- between the fourth and fifth tooth - 27.37% (**Fig. 65**);
- between the fifth and sixth tooth 22.58% (**Fig. 66**);
- between the sixth and seventh tooth 18.84% (**Fig. 67**);
- in the area of the largest section reaches 9.53% (**Fig. 68**).

Respectively in linear relation to the length of the smallest section in the same places the possibilities for substitution are:

- between the fourth and fifth tooth -88.23% (**Fig. 69**);
- between the fifth and sixth tooth -75.9% (**Fig. 70**);
- between the sixth and seventh tooth-74.85% (**Fig. 71**);
- in the area of the largest section up to 64.29% (**Fig. 72**).

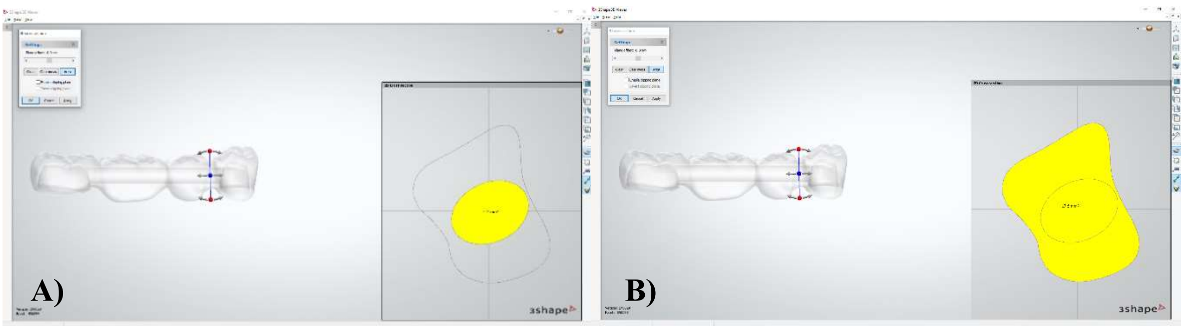


Fig. 65. *Cross section in the area of the connectors between tooth 44 and 45 and percentage distribution of the occupied area.* ***A)*** *Cross section of the channel;* ***B)*** *Area of the connector.*

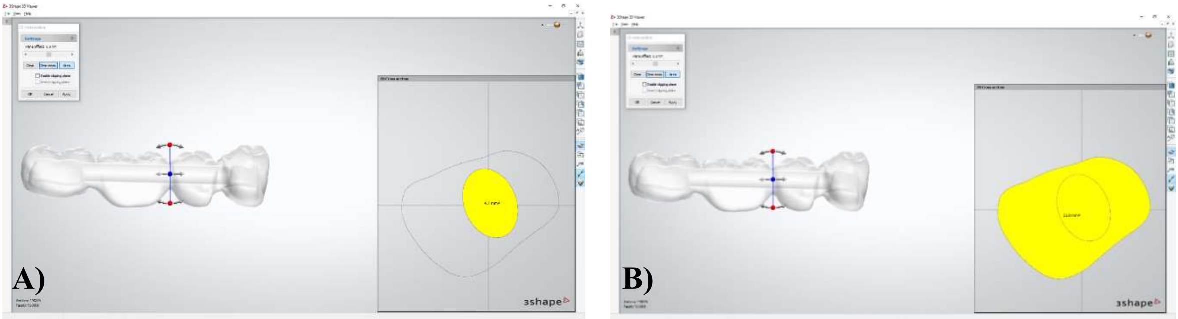


Fig. 66. *Cross-section in the area of the connectors between tooth 45 and 46 and percentage distribution of the occupied area.* ***A)*** *Cross section of the channel;* ***B)*** *Area of the connectors.*

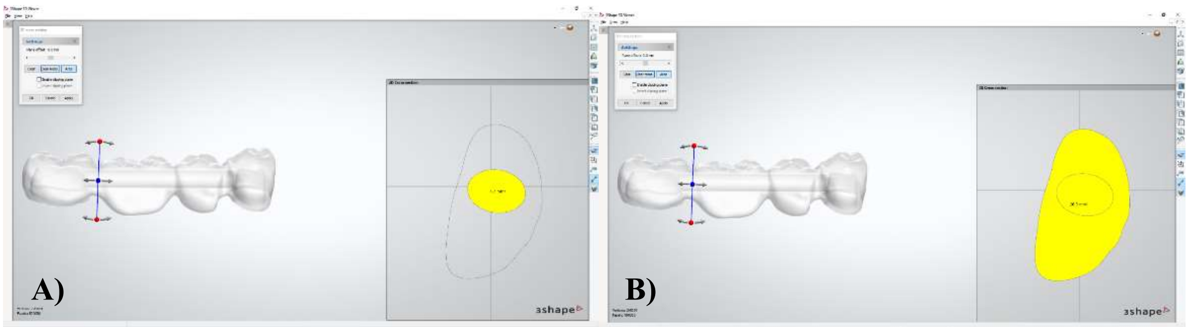


Fig. 67. *Cross-section in the area of the connectors between tooth 46 and 47 and percentage distribution of the occupied area.* ***A)*** *Cross section of the channel;* ***B)*** *Area of the connectors.*

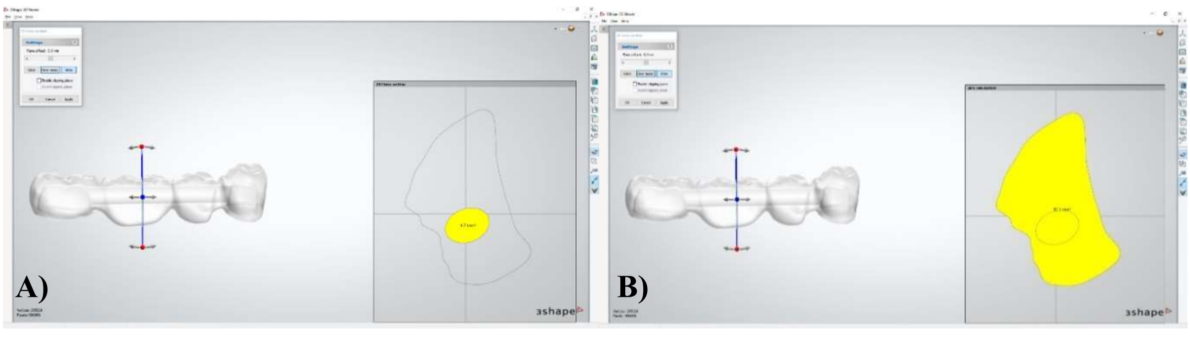


Fig. 68. *The largest section in the area of the pontic 46 and percentage distribution of the occupied area.* ***A)*** *Cross section of the channel;* ***B)*** *Section area.*

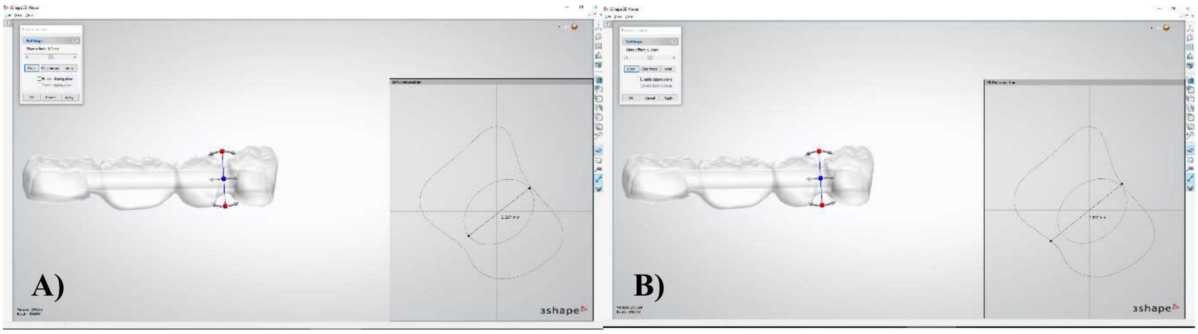


Fig. 69. A) *Width of the section in millimeters between tooth 44 and 45, and percentage to its entire width;* ***B)*** *Width of the section.*

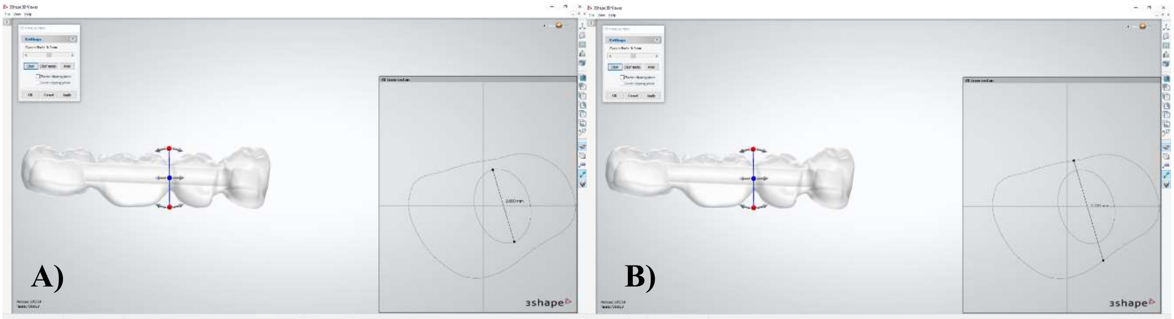


Fig. 70. A) *Width of the section in millimeters between tooth 45 and 46, and percentage to its entire width;* ***B)*** *Width of the section.*

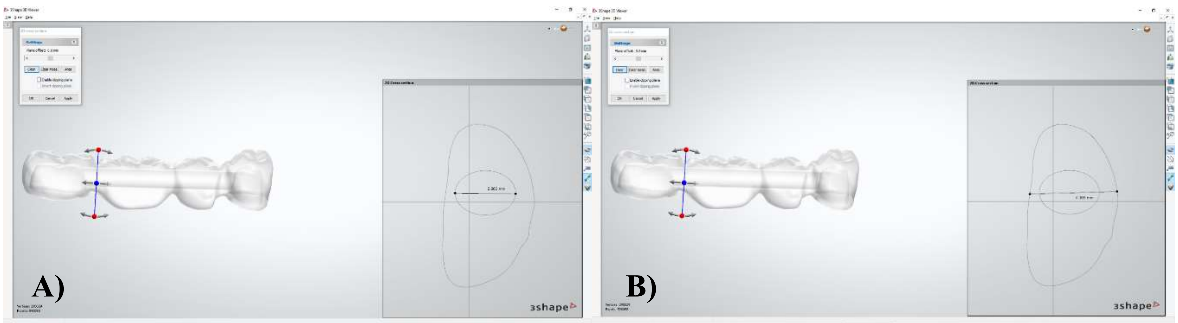


Fig. 71. A) *Width of the section in millimeters between tooth 46 and 47, and percentage to its entire width;* ***B)*** *Width of the section.*

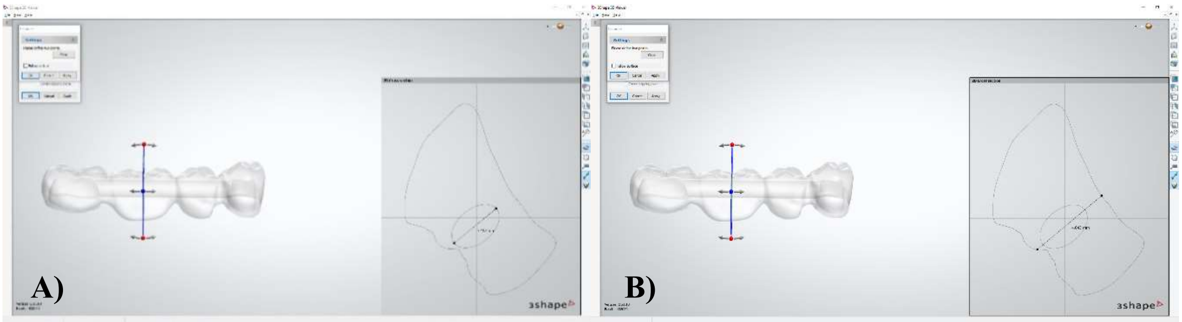


Fig. 72. ***A)*** *Width of the section in the area of the bridge body of tooth 46 and percentage ratio to its entire width;* ***B)*** *Width of the section.*

The measurement results for the bridge restoration 13-23, through the modification made, allow volume replacement with heterogeneous material in the field of joints in percentages as follows:

- between the second and third tooth-25.39% **(Fig. 73);**
- between the first and second tooth - 22.06% **(Fig. 74);**
- between the two central incisors - 19.2% **(Fig. 75);**
- in the area of the largest section up to 7.9% **(Fig. 76).**

Respectively in linear relation to the length of the smallest section in the same places the possibilities for substitution are:

- between the second and third tooth-38.29% **(Fig. 77);**
- between the first and second tooth-41.92% **(Fig. 78);**
- between the two central incisors - 40.32% **(Fig. 79);**
- in the area of the largest section up to 37.7% **(Fig. 80).**

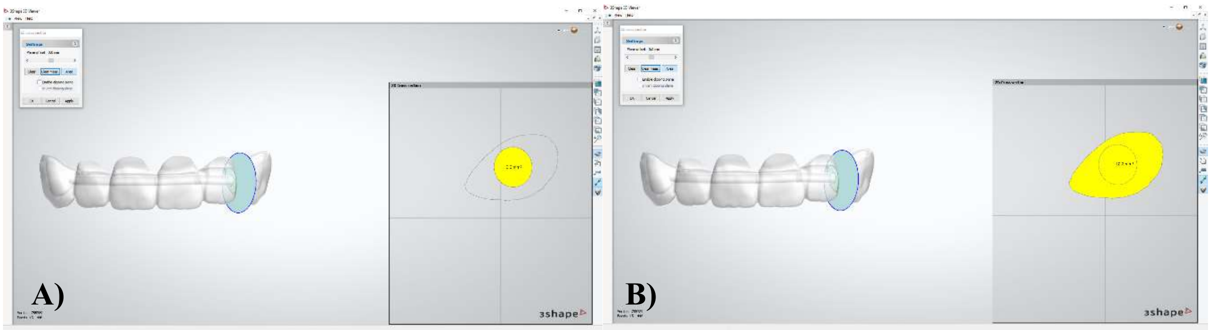


Fig.** 73.* *Cross-section in the area of the connectors between tooth 22 and 23 and percentage distribution of the occupied area.* ***A) *Cross section of the channel**;** **B)*** *Area of the connectors.*

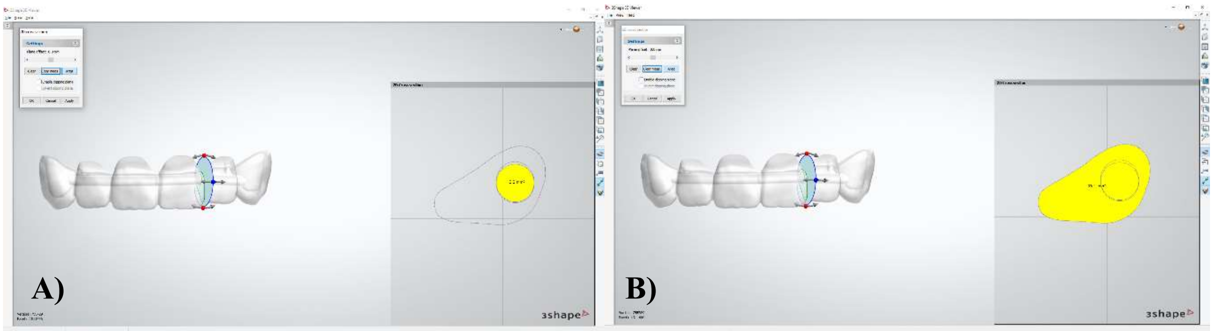


Fig.** 74.* *Cross-section in the area of the connectors between tooth 21 and 22 and percentage distribution of the occupied area.* ***A) *Cross section of the channel;* ***B)*** *Area of the connectors.*

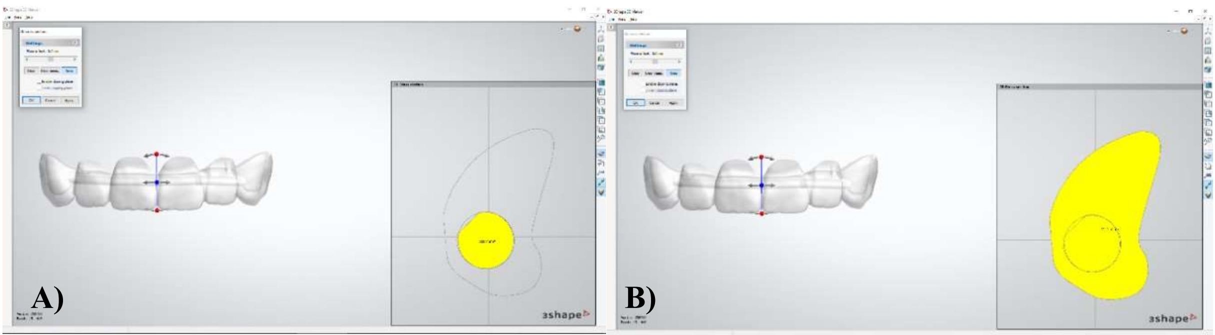


Fig.** 75.* *Cross-section in the area of the connectors between the two central cutters and percentage distribution of the occupied area**.** **A) *Cross section of the channel;* ***B)*** *Area of the connectors.*

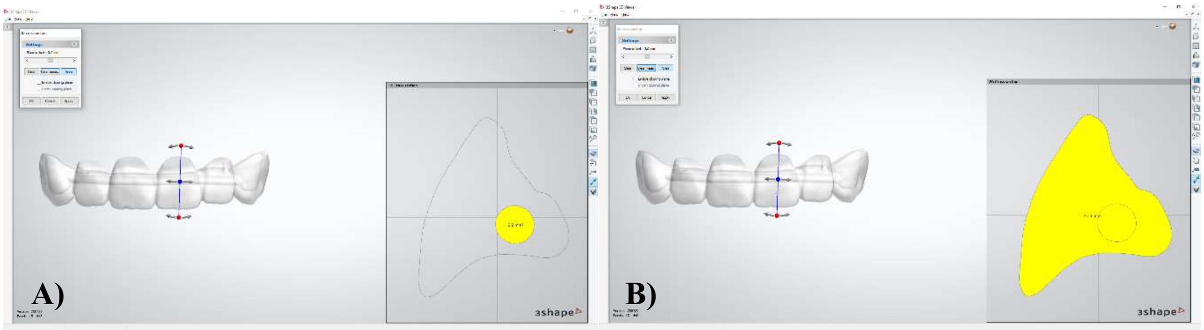


***Fig.** 76. Cross-section in the area of the largest section of the pontic 21 and percentage distribution of the occupied area. **A)** Cross section of the channel; **B)** Area of the connectors.*

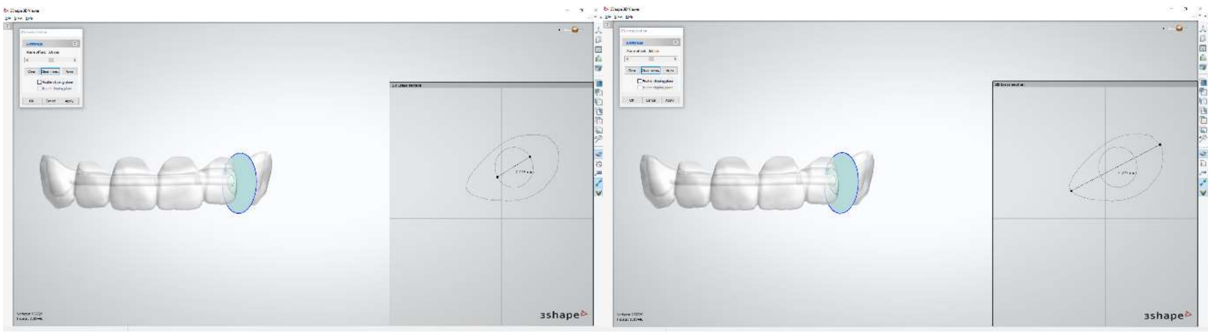


***Fig.** 77. **A)** Width of the section in millimeters between tooth 22 and 23, and percentage to its entire width; **B)** Width of the section.*

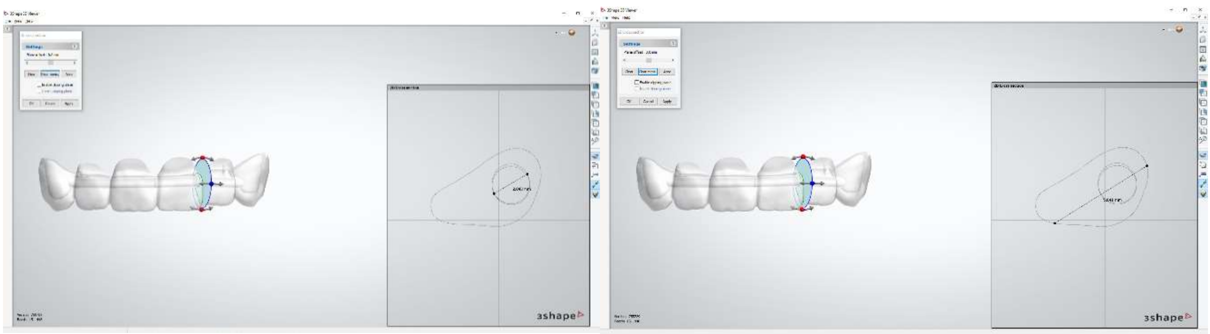


***Fig.** 78. **A**) Width of the section in millimeters between tooth 21 and 22, and percentage to its entire width; **B)** Width of the section.*

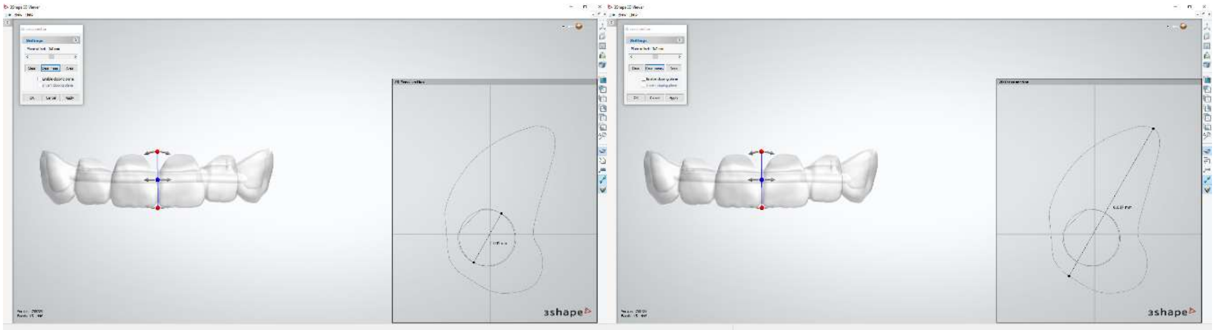


***Fig. 79. A)** Width of the section in millimeters of the two central incisors and percentage of its total width; **B)** Width of the section.*

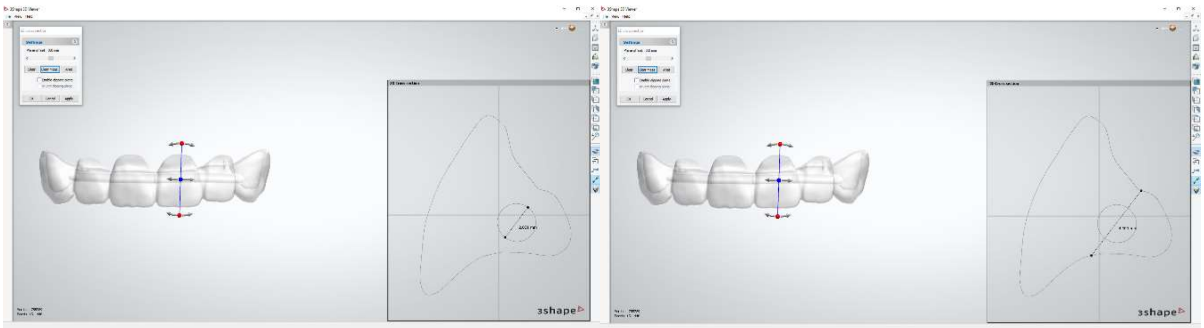


***Fig. 80. A)** Width of the section in the area of the bridge body of tooth 21 and percentage ratio to its entire width; **B)** Width of the section.*

Conclusions on task 4

The created modification allows the formation of a space that can be replaced if necessary. In the critical areas for the occurrence of fractures, in the area of the connectors of the pontics with the retainers, a significant space for replacement is presented. A significant benefit is the possibility of reinforcement in the linear direction, directed in the direction of action of the masticatory forces, which is evident from the high measured values of the substitution in the vertical direction in both designs.

The results obtained in both restorations clearly prove that the proposed modification creates a significant space that can be filled with material with different structure such as fiber, or a material which dominates with it mechanical strength qualities above others that appear as a limitation on the previous tasks of this study, to be injected in the newly formed cavity.

The question of how and what materials would contribute optimally to increase the strength in the joints remains unclear, however the proposed modification is a key factor for future research in this direction and diversity to study the impact of interactions with different materials.

V. CONCLUSIONS

1. The use of *egg-shell* printed temporary crowns by Dental LT Clear Resin® (Formlabs ™) affects the colors used, which limits their widespread use. Their use in the visible aesthetic area is not recommended and could be used only in the distal parts of the dentition.
2. The tests and analyzes performed 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. Colors B1, B4 and C4 can be reproduced with great accuracy at color deviation values ΔE below the set norm. The obtained colors A4, B2, B3 and D4 exceed the accepted permissible norm of ΔE and their deviation is visible to the patient.
3. Combinations with high concentrations of White Resin can be used to make temporary non-removable structures in the frontal area, while combinations with high concentrations of Dental LT Clear Resin or Model Resin are suitable for restorations in the distal area.
4. The optimal variant for temporary constructions, in which high aesthetic and mechanical characteristics are achieved at the same time, is in the combination White Resin / Dental LT Clear Resin in the ratio 4/6, corresponding to color B1 / 2M1.
5. The concentration of White Resin resin is responsible for achieving one of the most preferred by patients color corresponding to the color of bleached teeth -B1, and the increased concentration of Dental LT Clear Resin provides better mechanical properties of resins.
6. The concentration of Dental LT Clear Resin resin up to 60% is associated with the transparency of the natural dentition, contributing to the imitation of tooth enamel and achieving a color closer to the natural color of hard tooth tissues.
7. All combinations between the three starting resins: White Resin®, Model Resin® and Dental LT Clear Resin® show a bending strength above the minimum allowable limit specified in the international standards ISO 10477 and ISO 4049.
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 for a material with higher mechanical strength characteristics to be injected in the newly formed cavity.
9. In critical areas for fractures - in the area of the connectors of the pontics to the bridge retainers, replacement with a heterogeneous material with higher bending strength would increase the overall strength of structures and allow their use as a method for long-term prosthetics.

VI. IN CLOSING

This dissertation is dictated by the rapidly evolving additive technologies and their entry into dentistry. On the other hand, there are still uncertainties regarding their use in temporary prosthetics.

The results of our research confirm the possibilities for the application of temporary restorations printed with a stereolithographic printer. The color formation of the provisional restorations is a result of the action of a number of factors such as the physical properties of the original resins - their hue, density and value. For this purpose, **task 1** tested and demonstrated that the application of *egg-shell* printed temporary structures from Dental LT Clear Resin® (Formlabs ™) is only suitable for the distal areas of the dentition due to the deviation that this resin creates on the underlying color.

The limited choice of available colors for 3D-printing of temporary restorations determines our goal for the development of recipes for resins under **task 2**, which will cover a wider range of color standards. The possible colors created by us completely cover the B-range of Vita Classic® colors, as well as the darker tones from the other ranges - A4, C4 and D4. A logical and regular change in the color of the obtained resins was found when the ratio of the original White Resin®, Model Resin® and Dental LT Clear Resin® changed. An increase in value has been shown to increase the concentration of White Resin® in the resin, and it has also been shown that the amount of Model Resin® affects the hue. The effect of Dental LT Clear Resin® concentration on color density and translucency was reported.

Regarding the mechanical and strength properties of the newly obtained resins for 3D printing of temporary structures, it was established by performing a specially designed experimental setup on **task 3** that they fully meet the minimum requirements for bending strength set in international standards ISO 10477 and ISO 4049. The results of the mechanical and strength properties of the studied resins led to the conclusion that high concentrations of White Resin® lead to a decrease in bending strength, and respectively those of Model Resin® and Dental LT Clear Resin® increase their strength.

In view of the results obtained under the previous task and in order to create conditions for improving the mechanical strength of temporary structures of these resins for the needs of long-term prosthetics was created software modification of their digital files in **task 4**. Proved the formation of significant space in the volume of the structures, which allows it to be filled with heterogeneous material with higher values of compressive strength and tensile strength, which will increase the overall strength of the structures, especially when located in areas with increased chewing load and need a longer stay in the oral cavity.

VII. CONTRIBUTIONS

Contributions of scientific and applied nature:

• Contributions of original character for the country:

1. For the first time in our country the influence of *egg-shell* printed temporary constructions from Dental LT Clear Resin® (Formlabs) on the colors of the underlying structures has been registered and documented.
2. For the first time, White Resin®, Model Resin® and Dental LT Clear Resin® are combined in order to create recipes for resins that reproduce proportionally and lawfully the color standards logically related to Munsell's theory of three-dimensional color formation.
3. The bending strength of the newly obtained resins according to the international standards ISO 10477 and ISO 4049 has been proven.

Contributions of an attached nature:

- **Contributions with an original character for the country:**

1. 7 colors of resins suitable for 3D printing of temporary non-removable structures - B1, B2, B3, B4, A4, C4 and D4.
2. A method for modification of the digital files of the temporary structures has been created in order to increase their mechanical-strength qualities.

VIII. PUBLICATIONS RELATED TO THE DISSERTATION

1. Delyan Georgiev, Magdalena Gugleva, "Elaboration of Recipes for 3D - Printing Resins, Reproducing Proportionally and Properly the Color Standards", International Journal of Science and Research (IJSR), Volume 10 Issue 10, October 2021, 284 – 28

2. Delyan Georgiev, "In - vitro Flexural Strength Assessment of 3D Printed Custom Resins for Temporary Fixed Dental Restorations", International Journal of Science and Research (IJSR), Volume 10 Issue 10, October 2021, 274 – 278

3. Delyan Georgiev, Stoyan Katsarov "A Digital Modification of 3D Printed Temporary Restorations", International Journal of Science and Research (IJSR), Volume 10 Issue 11, November 2021, 1038-1041

4. Stoyan Katsarov, Delyan Georgiev, Clinical assessment of plaque accumulation capacity of 3D printed temporary screw retained crowns, compared to resin and composite based temporary screw retained crowns on single implants, Clinical Oral Implants Research, 2020/10, 219-219