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A Digital Modification of 3D Printed Temporary Restorations

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Abstract: ***Purpose**: The aim of the research was to create a methodology for increasing the flexural strength of a temporary restorations for3D printing, through software modification of the digital file. **Methods**: Two fixed partial dentures were designed using dental CAM software. The STL files were modified with non-medical software for 3D-editioning. **Results**: The results showed significant space that can be filled with heterogeneous material. **Conclusion**: Areas that are considered to be critical for fractures due to material fatigue could be augmented by replacement or insertion of heterogeneous materials that have greater flexural strength. That would increase the overall strength of the restorations and allows their use as a method of long-term temporary restorations.*

Keywords: prosthetic dental medicine, temporary restorations, fracture strength, additive manufacturing

1. Background

The CAD/CAM manufacturing allows digitalizing most of the steps of the fabrication of a provisional restoration. The milling machines in the subtractive manufacturing are unable to shape complex details such as undercuts and their using leads to loss of raw material, that can't be reused again. In opposite, the additive manufacturing gives the opportunity this material to be used again, so it is more cost effective and shortens the fabrication time [1].

The manufacturing method influences the mechanical properties of the temporary restorations. Those made by CAD/CAM technique, show higher mechanical strength in comparison with the directly fabricated ones from the same material [2, 3, 4]. Other method for increasing the fracture durability is to increase the connector area [5].

The provisional restorations for long-term use require improved physical properties. There are different methods for reinforcement of the provisional fixed partial dentures, including use of metal wire, lingual cast metal reinforcement, and different types of fibers such as carbon, polyethylene, and glass [6, 7, 8, 9]. The degree of reinforcement depends of the position, quantity, and direction of the fibers and the degree of adhesion between the fibers and the polymer [10, 11, 12, 13, 14].

2. Materials and Methods

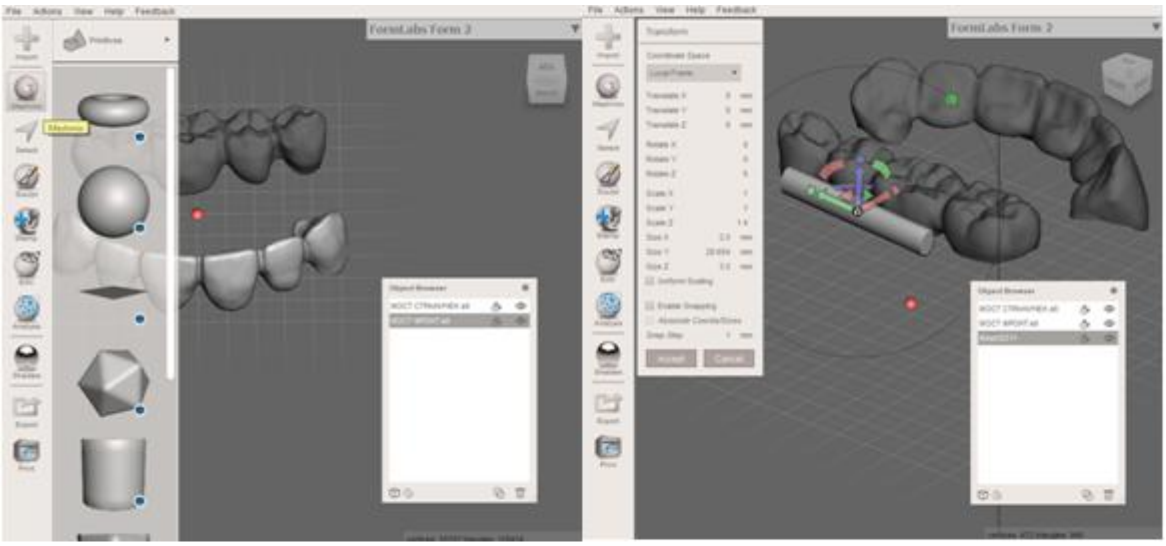
Astudy model of the upper jaw (Frasaco™) was used to create anedentulous space in the area of teeth: 12, 11, 21, 22 and on a lower jaw study model from the same type was created edentulous defect by removing teeth 45 and 46. The abutment teeth for the upper model-13 and 23, and respectively for the lower-44 and 47 were prepared with horizontal shoulder preparation line. The models were scanned using a dental laboratory scanner D850® (3Shape™). Two bridges were designed with specialized software 3Shape Dental System® (Fig.1 and Fig.2).

(A) (B) (C)

Figure 1. A) Occlusal view of the designed bridge 44-47; **B)** View from apical direction; **C)** Side view of the bridge showing the density of the pontics and the retainers.

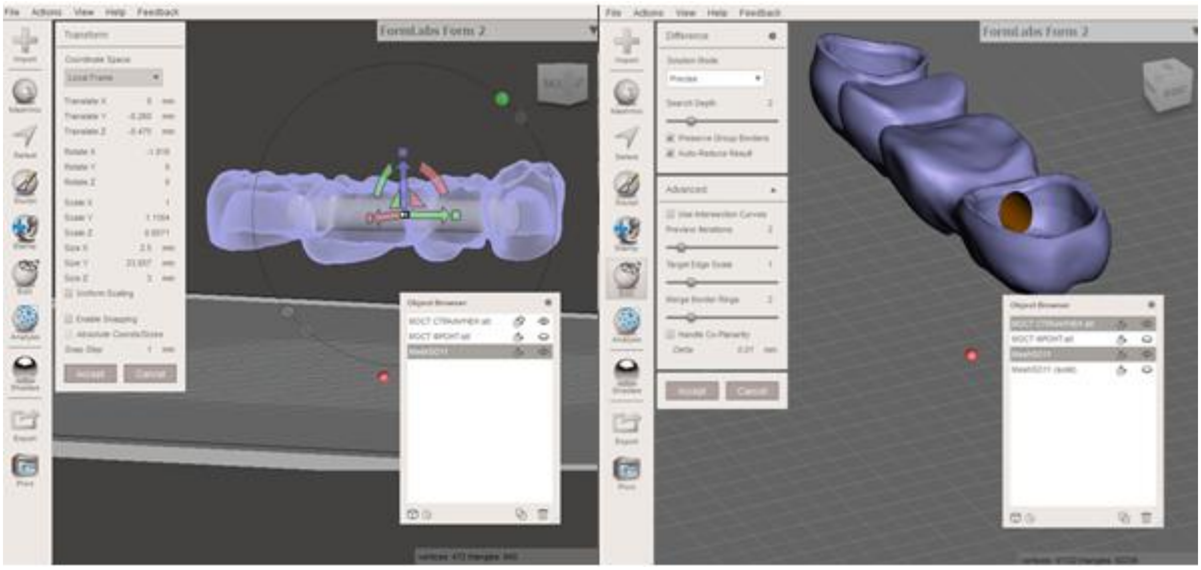
Figure 2: A) Frontal view of the designed bridge 13-23; **B)** View from apical direction; **C)** Frontal view of the bridge showing the density of the pontics and the retainers.

Because the standard STL files generated by the 3Shape Dental CAD system do not allow free access to alternative modeling tools, the finished files, the prototype bridges, were imported into specialized non-medical software for 3D-editioning-Autodesk Meshmixer® (Autodesk, Inc.). A cylindrical object was created from the program menu using the "meshmix" button (Fig.3. A). Using the "transform" function, the newly created cylindrical body was modified in shape and size so that it could fit into the volume of pontics without showing itself anywhere except in the area of the abutment crowns. (Fig.3. B) With the help of a "magnet tool", a precise control of the positioning of the cylindrical body was made. For the purpose of the assigned task was important to achieve optimal location. Using the "Boolean" function, the volume occupied, by elliptical body was removed from the total volume of the bridge restoration, leaving a cavity corresponding to the same size. (Fig.4). Similar to the already described methodology, several cylindrical bodies were created in the upper frontal bridge restoration 13-23 and were arranged independently along the length of the bridge pontics and joined into one object. The volume occupied by them was also extracted to form an internal channel along the bridge (Fig.5). Finally, the modified bridges were exported as a STL-file and analyzed using 3Shape 3D Viewer®.



(A) (B)

Figure 3: A) Creating the additional cylindrical body; **B)** Modifying the body in the desired shape.



(A) (B)

Figure 4: A) Removing the volume occupied by the created elliptical body; **B)** The created modified profile.

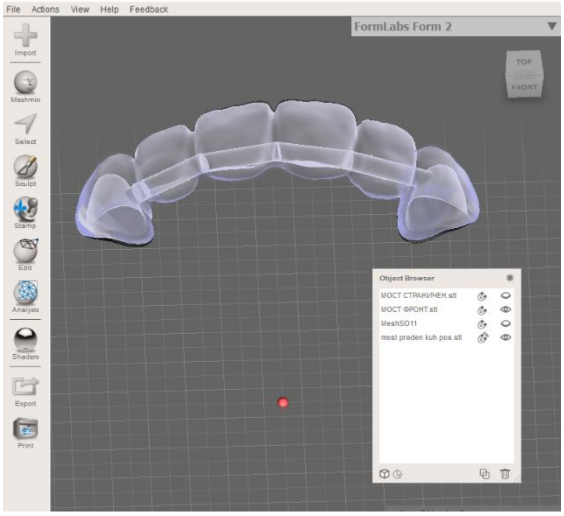


Figure 5: The modification made on the frontal bridge using the same functions

3. Results

The measurement results for the fixed partial denture44-47 on the mandible, by the modification made, allows volumetric replacement with heterogeneous material in the area of the connectors as a percentage as follows:

- between tooth 44 and 45-27, 37%;
- between 45 and 46-22, 58 %;
- between 46 and 47-18, 84 %;
- in the area of the largest cross-section-9.53%.

The area of the connectors of the FPD 13-23 on the maxilla shows the following percentage:

- between tooth 22 and 23-25.39%;
- between 21 and 22-22.06%;
- between the central incisors-19.2%;
- in the area of the largest cross-section up to 7.9%.

4. Discussion

The created modification allows the formation of space that can be replaced if necessary. The obtained results on the both FPD prove that the proposed modification can create a significant space that can be filled with heterogeneous materials such as fibers, fiber reinforced composite, or another material to dominate with its mechanical characteristics into the newly formed cavity. The question about how and what kind of materials would contribute optimally to increasing strength in connection zones still remains unclear, but the proposed modification is definitely a key factor for future research in this direction.

5. Conclusion

The criticalareas susceptible for fractures such as the connectors between pontics and retainers can be replacedwith anyheterogeneous material with greater flexural strength. That would increase the overall strength of the restorations and allows their use as a method of long-term temporary restorations.

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