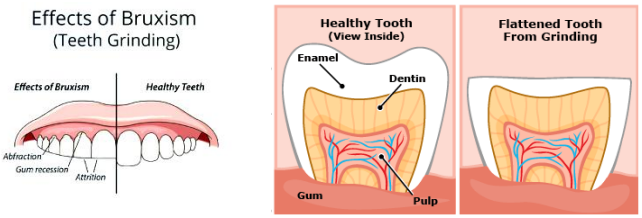
CREATING A 3D MODEL OF DENTAL SPLINT FOR BRUXISM

Tihomir Dovramadjiev[1,*], Diana Pavlova[2] and Alexandrina Bankova[1]
[1]Technical University of Varna, Department of Industrial Design, 9010 str. „Studentska" N1, Varna, Bulgaria
[2]Medical University of Varna, Department o Dental Material Science and Propaedeutics of Prosthetic Dental Medicine, 9002 „Tsar Osvoboditel Blvd" 150, Varna, Bulgaria

Abstract. *The present study examines the possibilities of applying modern technologies in the field of dental science and specifically in the treatment of bruxism. Based on an optimized methodology, a prototype, and digital and real dental splint models have been developed using biocompatible material and specialized equipment including a 3D scanner and a 3D printer. The details of the production of the models are precisely designed, taking into consideration the medical and technical requirements.*

1 Introduction

Bruxism is a specific condition, which is characterized with excessive teeth grinding or jaw clenching. When a person is affected, he or she unconsciously grinds the teeth during the day or in their sleep. These unconscious jaw movements may lead to enamel scraching and painful teeth sensitivity, jaw pain, headaches, etc. Bruxism causes teeth crackings, developes deep dental caries, and damages teeth bridges, fillings and crowns.[1 - 6]. Fig. 1 shows effects of Bruxism against Healthy Teeth respectively in Visible View[7] and Section View[8].



(a) (b)

Fig. 1. *Effects of Bruxism and Healthy Teeth: (a) Visible View [7], (b) Section View [8].*

The actual destructive process caused by Bruxism is shown in Fig. 2, where the serious problem that this condition represents can be seen.

Fig. 2. *Effects of Bruxism – real pictures [8].*

Regarding the musculoskeletal movements caused by bruxism, treatment may be applied by splinters or by other similar mouthguards. they are designed to keep the teeth separated in order to prevent them from destruction. The application of different technological methods and techniques has been presented in the works of various scientific teams and specialists working in the field of dentistry specifically regarding Bruxism [9 - 18].

2 Materials and methods

The construction of the specific splinter (for Bruxism) involves the conventional development of a three-dimensional real jaw pattern (by model) and a technological pathway constructing a 3D print model. The method sequence is shown in Fig.3.

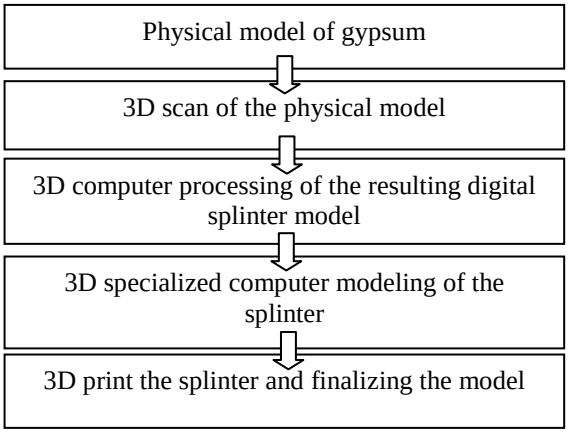
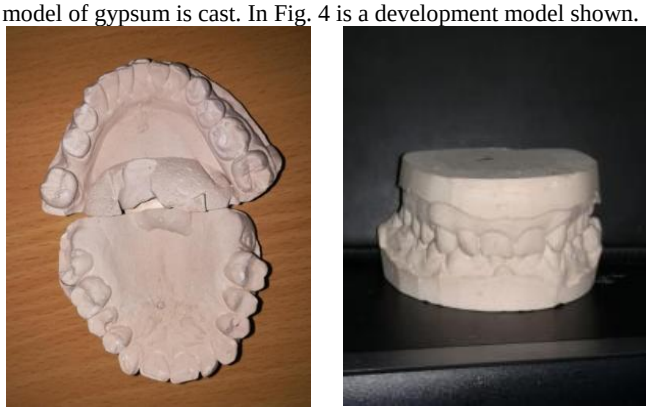


Fig. 3. *Method for making a bruxism splinter.*

2.1 Physical model of gypsum

A silicone imprint is taken from the patient's mouth and a physical model of gypsum is cast. In Fig. 4 is a development model shown.



(a) (b)

Fig. 4. *Physical model of gypsum: (a) Top view of upper and lower jaw, (b) Front view.*

2.2 3D scan of the physical model

The physical model is scanned with a 3Shape D750 Series Laboratory Scanner (Fig. 5). Technically the scanner provides scanning of a gypsum model. Operates with 2 x 1.3Mp cameras, blue LED lighting.The scanning time of a single structure is 25 seconds, and a 3-membered tooth bridge - 55 seconds.Accuracy for crown and bridge scanning is 10 µmand formplant Bars - 12 µm.The scanner is equipped with computer control and Dental SystemTM Premium dental software, which allows drawing and links to .stl files. The software can generate single caps, anatomic crowns, dental bridge constructions, gingival mask, inlays, onlays, veneers, temporary dental structures, virtual diagnostic models, telescopic crowns, individual spoon prints, mouthprotectors [19].

Fig. 5. *Positioning the gypsum scan model.*

2.3 3D computer processing of the resulting digital splinter model

The creation of the 3D model is accomplished by the presence of data obtained by scanning the imprint of the upper and lower jaw. A STL file from the Applianse Designer 3Shape program is received (Fig. 6).

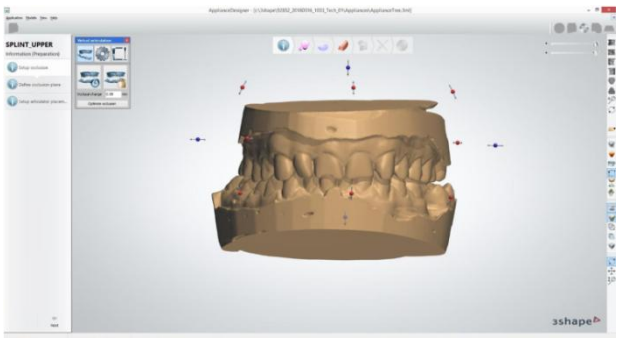


Fig. 6. Scanned imprints of upper and lower jaw.

The scanned pattern is processed with Applicanse Designer 3Shape. A virtual articulator is used to fix the jaw while maintaining the trajectory of movement of the lower jaw part relative to the upper jaw part [20]. The STL file format is saved (Fig. 7).

Fig. 7. Articulator (virtual).

Unblocking of the retention areas for normal splinter mounting is shown in Fig.8.

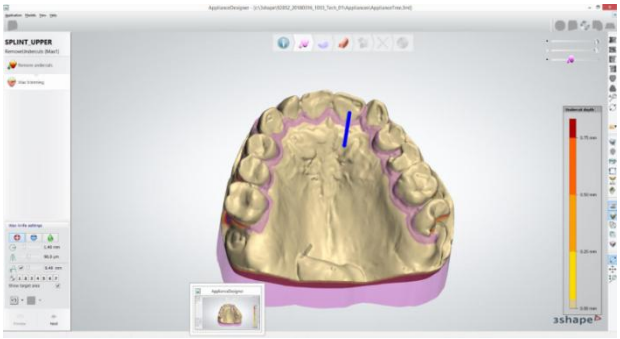


Fig. 8. Unblocking of the retention areas for normal splinter mounting.

Defining the boundary of the bruxism splinter vestibularly and lingually is shown in Fig. 9.

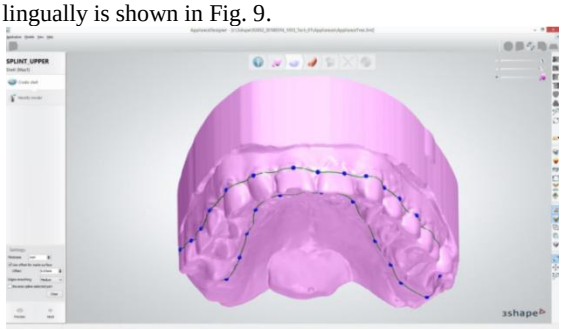


Fig. 9. Defining the boundary of the bruxism splinter vestibularly and lingually.

Three-dimensional software has good interactivity and the ability to visualize the work pattern from different views. An example is given in Fig.10.

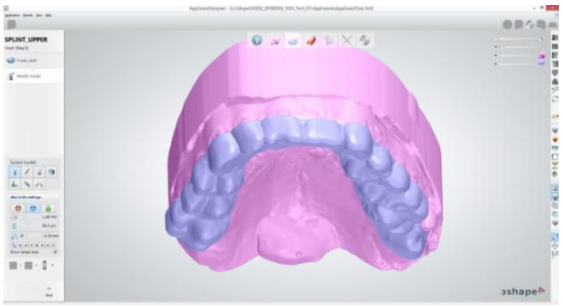


Fig. 10. Splinter view.

The virtual conclusion of upper and lower jaw and the attached bruxism splinter are shown in Fig. 11.

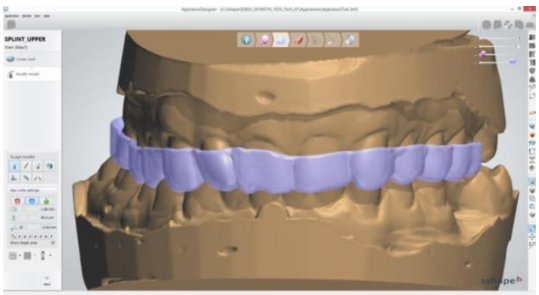


Fig. 11. Conclusion(virtual) of upper and lower jawwith attached bruxism splinter.

Specific geometric elements on the splinter are bent to prevent its fast abrasion. The thickness can be 1-2 or 3 mm. It is predetermined by the dentist according to the physiological characteristics of the patient (Fig. 12).

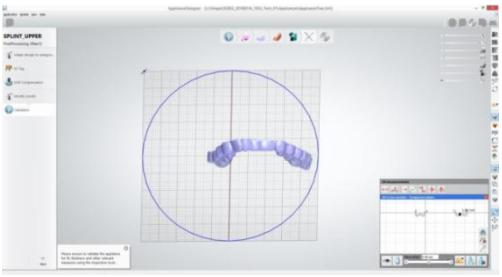


Fig. 12. Checking the thickness of the splinter for critical locations.

2.4 3D specialized computer modelling of the splinter

The netfabb Professional for RapidShape program [21] activates the received model (from the STL file). A platform is placed, the model is positioned and the retaining pins are added to help the construction stability during printing. An optimal position and direction is selected. The final design of the model is forwarded to the 3D printer for printing (Fig. 13).

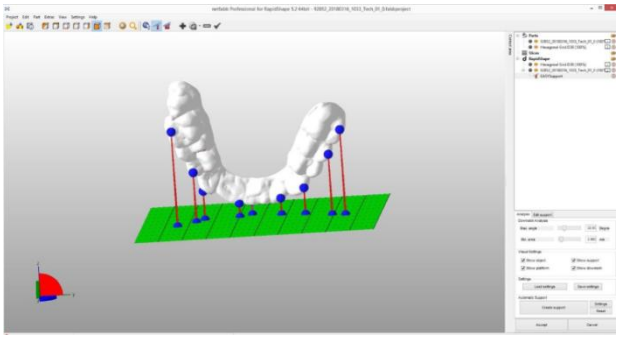


Fig. 13. *3D Printing Support Structures.*

Digital Prview of the layout construction of the three-dimensional model (Fig. 14).

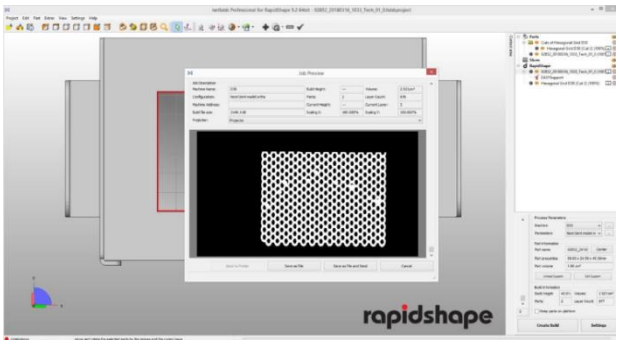


Fig. 14. *A work view showing each layer of construction.*

Fig. 15 shows the digital model of the bruxism splinter with added support columns needed to finalize the ready printed model.

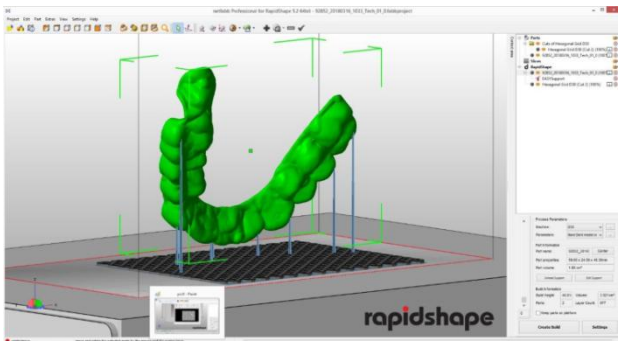


Fig. 15. *Model view when using the printer.*

Once the digital model has been finalized, it is moved to 3D printing.

2.5 3D printing of the splinterand finalizing the model

3D prototyping has a number of benefits, the capabilities of which are enhanced by technological advances regarding the geometry accuracy [22]. 3D printer (Rapid Shape Series D30, [23]) is an open-ended system and is often used in conjunction with the 3Shape lab 3D scanner as well as in this specific case. Besides the current development of a bruxism splinter this type of 3D printer can print models, individual dental spoons, surgical guides, temporary dental bridges and crowns, casting models, gingival masks, dentures, mouthprotectors. The kit also includes an additional polymerization device after printing. The principle of the 3D printer is a layer construction of the model through photopolymerization of photopolymers [19]. Professional RapidShape 3D printers (Fig.16) work with various types of liquid resin specializing in industrial and other applications;for example for Orthodontic material, NextDent Ortho is used [24].

Fig. 16. *3D printer Rapid Shape Series D30.*

The final 3D print model of the bruxism splinter is shown in Fig. 17.

Fig. 17. *The final 3D print model of the bruxism splinter.*

The following students worked too on creating the bruxism splinter: Pavlina Andonova, Momchil Minchev, Alexandra Boeva and Velizara Maneva from the Technical University - Varna specialty "Industrial Design", practising their technical skills at the Medical University - Varna, based on the project "Student Practices" - Phase 1, BG05M20P001-2.002-0001 of the Ministry of Education and funded by Operational Program "Science and Education for Smart Growth 2014-2020", European Social Fund of the European Union. [25].

3 Conclusion

Using the modern technological means and the correct methodology of work, a model of the bruxism splinter is created. The process of designing has been optimized by applying the right approach to both the model itself and the stages of gathering information on the subject and systematizing the parameters, the geometric features and other data typical for the physiological condition of bruxism.With advanced technology, modern 3D scanners and 3D printers have greatly improved their technical features, making it easy to develop the tested models. They are distinguished by the correct geometric shape and accuracy.It also saves time, resulting in optimization of the workflow and cost reduction.

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