STUDY ON THE PRECISION OF THE OCCLUSAL CONTACTS IN WORKING MODELS MOUNTED ON A NEW ANALOG DENTAL ARTICULATOR PROTOTYPE

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Abstract: The manufacture of dentures, restoring the function of the masticatory apparatus, is carried out with the help of prosthetic field analogs—conventional or digital working models. Imitating the movements of the mandible, the articulator allows the modelling of the occlusal surfaces of the restorations with maximum precision by excluding to a minimum their additional articulation. The aim of the current study is to establish the precision of the occlusal contacts in working models mounted on a prototype of a new analog dental articulator. Materials and Methods: The ResearchGate, Embase, Google Scholar, PubMed, and Scopus digital databases were used. The studied articles were published in the period from 2015 to 2024, with 80% of them—in the last 5 years. Four experimental specimens were cast (standard models from hard plaster—class IV, 2 maxillae and 2 mandibles, using an impression of the prosthetic field of a patient with intact permanent dentition, without dental prosthetic constructions). They were subsequently scanned using a laboratory scanner. The created STL files were used for the 3D printing of the models. The scans of the printed maxillary and mandibular models were imported via the Exocad dental software into the Virtual Articulator module. Results: The prototype of the new analog dental articulator was an arcon type, class III, with median parameters (angle of condylar guidance—33º, Bennett angle—17º, intercondylar distance—100 mm). There was the option of transferring information from the facial arch. Dental plaster and magnets were not used to mount the models. From the measurements taken and the comparison of the results, high precision was established in the work of the new device. The correspondence of the occlusal contacts, registered with the help of bicolored articulating paper with 40-micron thickness, and their digital images in the Virtual Articulator module confirmed the precision of the device. Conclusion: The utility model of the new dental articulator reproduced with high precision the registered occlusal contacts in the main positions—central occlusion, laterotrusion to the left and to the right, and protrusion. The advantage of the new dental articulator is that dental plaster is not used to mount the models, which saves: technological time and material costs; there are no volume deviations as a result of the expansion and the subsequent shrinkage of the plaster; it is more convenient to use (we can work on the models outside the articulator and then return them, if needed, in the same correct position). In fixed dental prostheses, there is no danger of filling the slots, where locking pins are secured, with plaster.
Keywords: prototype, dental articulator, 3D scanning, CBCT

1. INTRODUCTION

The precise registering and reproduction of each patient's occlusion is an important condition, even in the times of CAD/CAM systems. Imitating the movements of the mandible, the articulator allows the modelling of the occlusal surfaces of the restorations with maximum precision by excluding to a minimum their additional articulation (4;5;6;7). The authors of the article are participants in Project No. 23005: ***A Study on the Accuracy of the TMJ Movements Replicated by a New Dental Articulator Prototype, Including Central Occlusion Models, via 3D Scanning with a Laboratory Scanner, CBCT, and Conventional Methods***, from the 2023 competition session of the Science Fund of the Medical University of Varna, Bulgaria. The research aim of the project is: testing a new analog articulator with the help of digital and conventional methods, which would prove its efficiency and help its introduction and promotion in the fields of dental technology and dentistry. The methods used to establish the level of precision are divided into 2 groups:

- Digital: 3D scanning with a laboratory scanner; cone-beam computed tomography (CBCT); comparison between the 3D scans and the CBCT ones; registering the dynamic occlusion with the help of the Exocad dental software using the Virtual Articulator, Dental Cad, and DICOM Viewer modules.
- Conventional: visual assessment (cephalometric analysis of the distances between reference points with the help of a ruler, protractor, and establishing the deviations).

It is expected for the study, which has scientific and practical aspects, to lead to the introduction and promotion of the Dental Articulator utility model, registered by the Patent Office of the Republic of Bulgaria in 2024, in the fields of dental technology and dentistry practice, as well as in the training of students in these disciplines.

The manufacturing of dental prostheses, restoring the function of the masticatory apparatus, is done with the help of analogs of the prosthetic field—conventional or digital working models. Despite the increasing speed of digitalization, most of the technologies applied in creating dental prosthetic constructions and the still present inaccuracies during intraoral scanning require real models, mounted on an analog device reproducing the mandibular movements and these of the temporomandibular joint. These devices are based on the different mandibular movement theories and are called articulators. The most frequently encountered errors when working with them are premature contacts, which may lead to traumatic occlusion (8;9;10;11;12). The articulators with median parameters are the most widely used ones in clinical and laboratory practice. The median levels (angle of condylar guidance, Bennett angle) are preset in the framework of the device. Depending on the position of the condylar analogs, there are two types of devices:

- **arcon articulator**—built on an anatomical principle, where the condylar analogs are located on the mandibular arm, and the joint sockets—on the maxillary arm.
- **non-arcon articulator**—not built anatomically; the condylar analogs are located on the maxillary arm, and the joint sockets—on the mandibular arm (1;2;3).

2. AIM

The aim of the current study is to establish the precision of the occlusal contacts of the working models mounted on a prototype of the new analog dental articulator.

3. MATERIALS AND METHODS

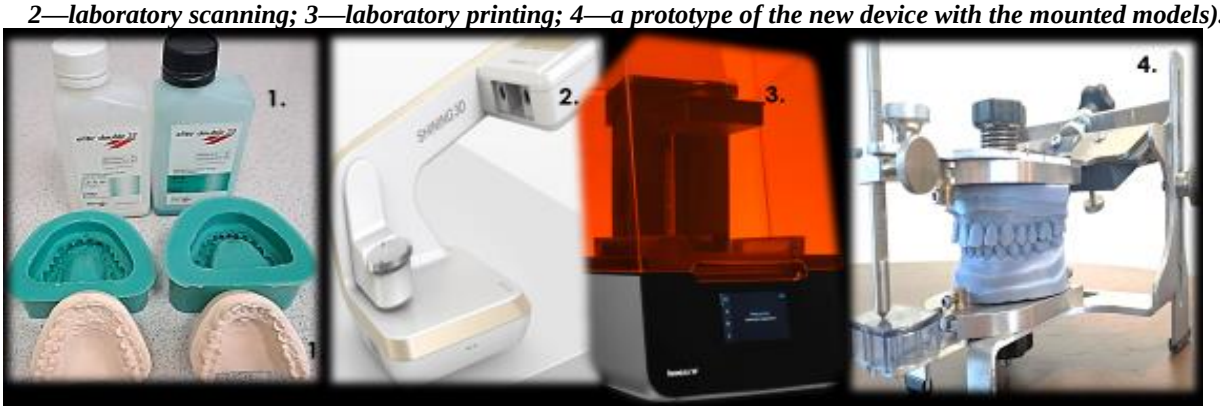
The digital databases ResearchGate, Embase, Google Scholar, PubMed, and Scopus were used. The search was limited to full-text articles in English from peer-reviewed scientific journals. The studied articles were published in the period from 2015 to 2024, with over 80% of them—in the last 5 years. Four experimental specimens were cast (standard models from hard plaster—class IV, 2 maxillae and 2 mandibles, using an impression of the prosthetic field of a patient with intact permanent dentition, without dental prosthetic constructions). They were subsequently scanned using a laboratory scanner (Fig. 1). The created STL files were used for the 3D printing of the models. The scans of the printed maxillary and mandibular models were imported via the Exocad dental software into the Virtual Articulator module (Fig. 2).

4. RESULTS

The prototype of the new analog dental articulator was an arcon type, class III, with median parameters (angle of condylar guidance—33º, Bennett angle—17º, intercondylar distance—100 mm). There was the option of transferring information from the facial arch. Dental plaster and magnets were not used to mount the models. The distribution, number, and size of the marked contact points on the masticatory surfaces of the teeth from the printed models were photographed. The number of the registered contacts on the masticatory tooth surfaces was examined by dividing the dentition into 4 quadrants, which were as follows: **upper right** (11, 12, 13, 14, 15, 16, 17), **upper left** (21, 22, 23, 24, 25, 26, 27), **lower left** (31, 32, 33, 34, 35, 36, 37), and **lower right** (41, 42, 43, 44, 45, 46, 47). The impressions of the patient's maxillary and mandibular prosthetic fields were missing the following teeth: 18, 28, 38, and 48, with the person's dental status mentioning the lack of germs of these teeth.

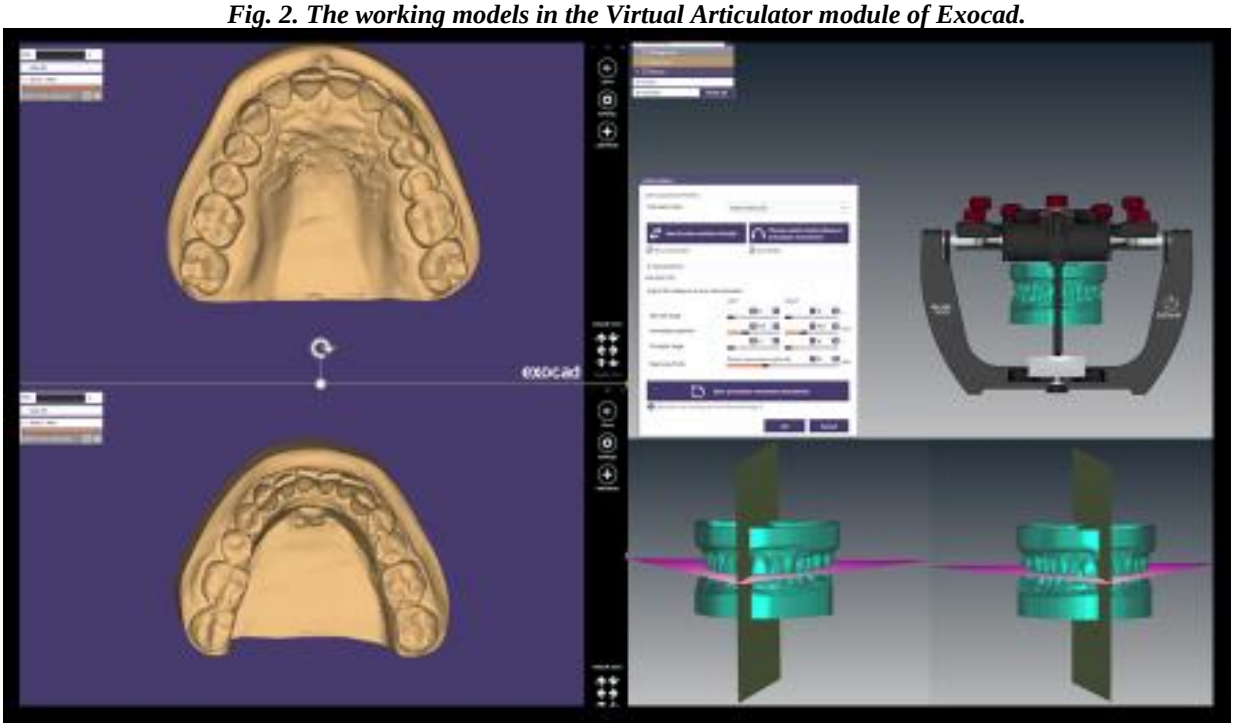
From the conventional and digital measurements taken and the comparison of the results, high precision was established in the work of the new device. The correspondence of the registered occlusal contacts, determined with the help of bicolored articulating paper with 40-micron thickness, and their digital images in the Virtual Articulator module confirmed the precision of the device.

Fig. 1. The stages of manufacturing and mounting of the working models (1—duplicating the plaster models; 2—laboratory scanning; 3—laboratory printing; 4—a prototype of the new device with the mounted models).



Source: Authors research

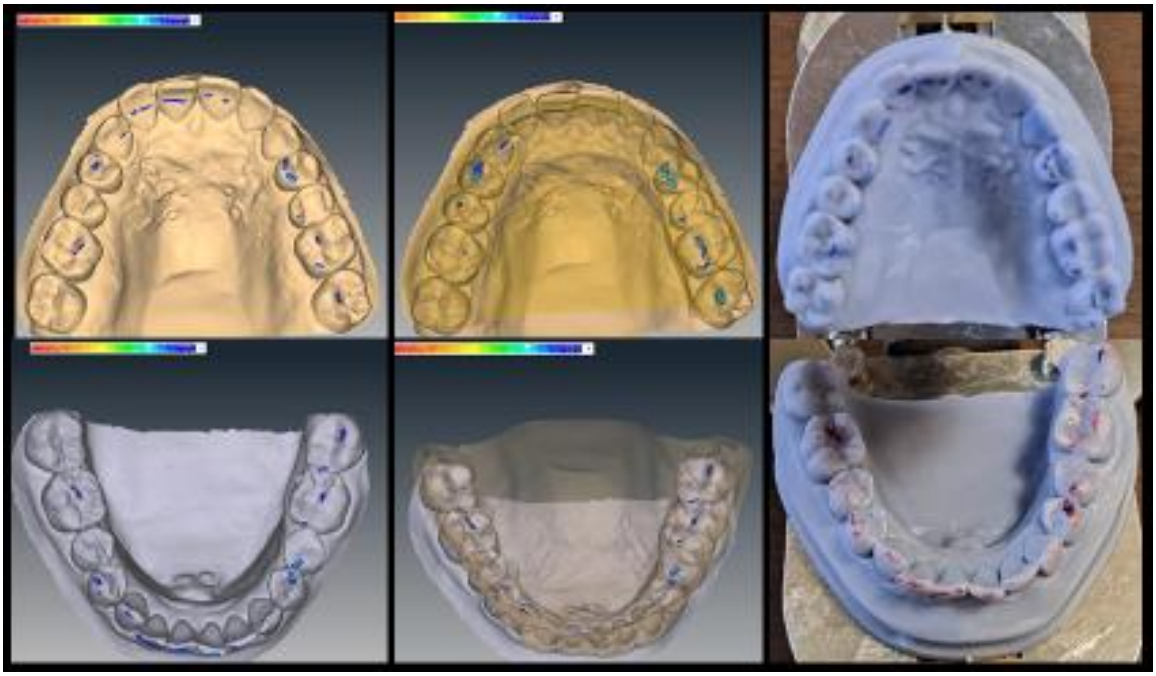
Fig. 2. The working models in the Virtual Articulator module of Exocad.



Source: Authors research

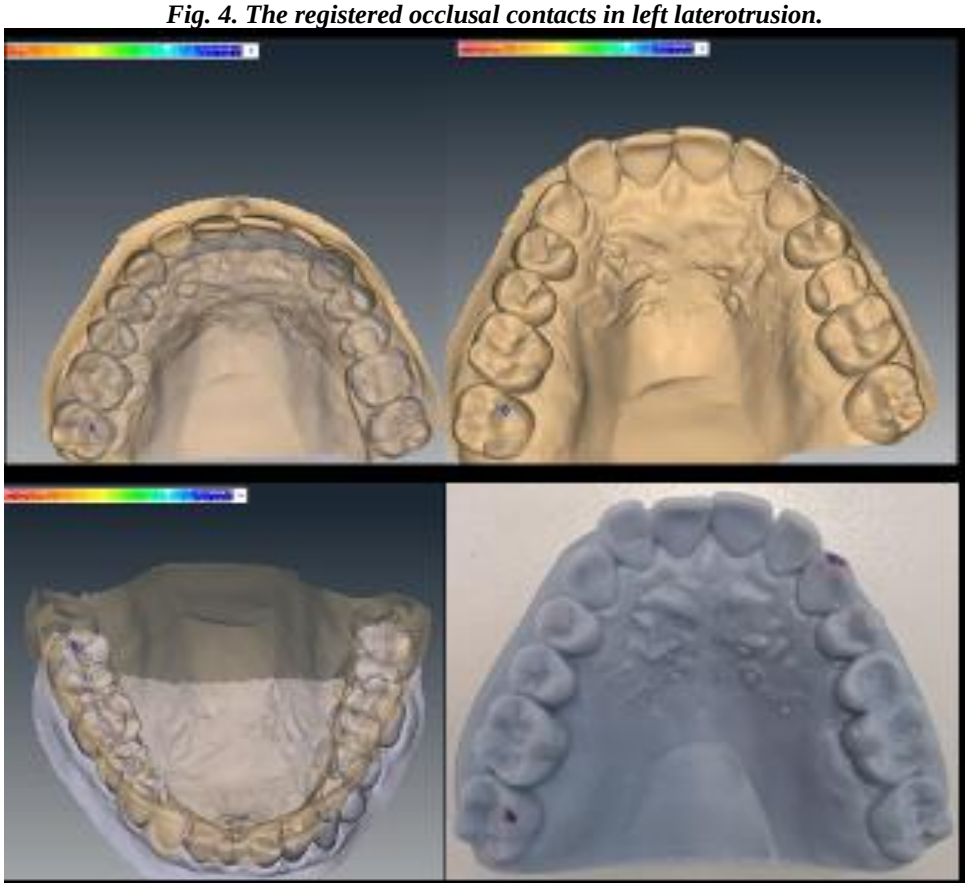
The main spatial relationships between the upper and the lower working model, which were studied, were: central occlusion, laterotrusion to the left and to the right, and protrusion. The results showed a predominant number of tooth contacts between the maxillary and the mandibular models in central occlusion, established with the help of articulating paper (I quadrant—7; II quadrant—9; III quadrant—7; IV quadrant—8). Their digital reading via the Virtual Articulator module of Exocad was as follows: I quadrant—6; II quadrant—8; III quadrant—7; IV quadrant—6 (Fig. 3). In left and right laterotrusion, as well as in protrusion, the occlusal contacts registered digitally and analogously were of the same number and type (Fig. 4, Fig. 5, and Fig. 6).

Fig. 3. The registered occlusal contacts in central occlusion.



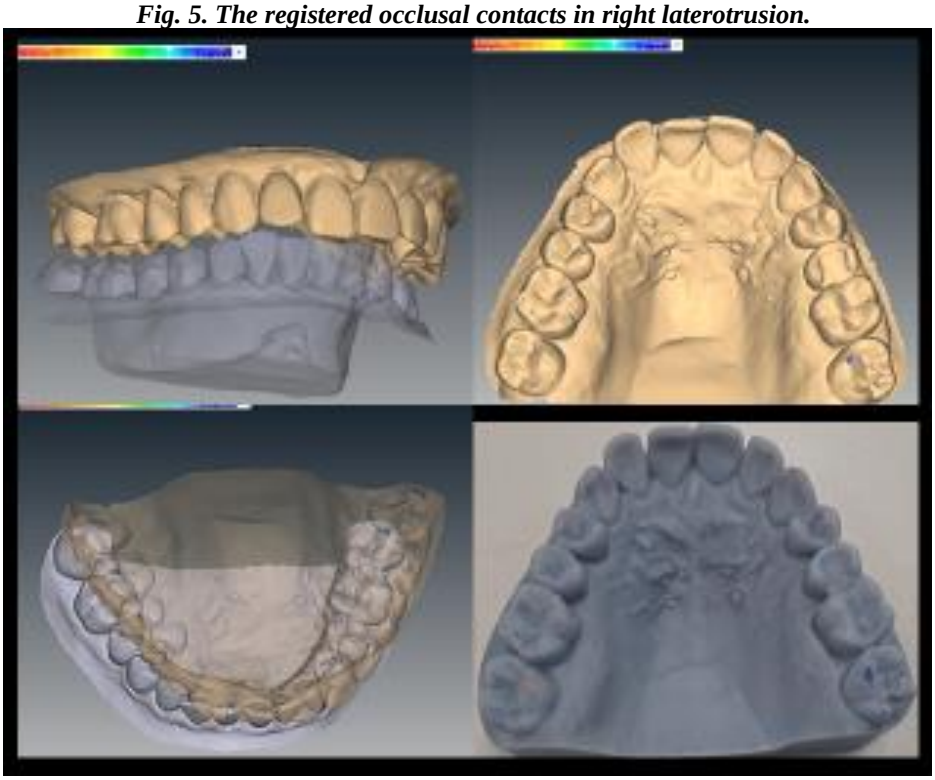
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Fig. 4. The registered occlusal contacts in left laterotrusion.



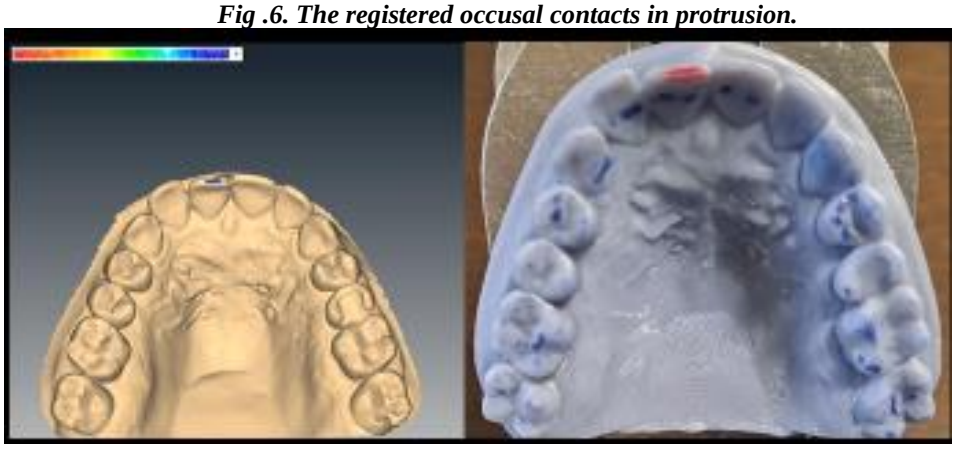
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Fig. 5. The registered occlusal contacts in right laterotrusion.



Source: Authors research

Fig .6. The registered occusal contacts in protrusion.



Source: Authors research

5. CONCLUSIONS

- The utility model of the new dental articulator reproduces with high precision the registered occlusal contacts in the main positions—central occlusion, laterotrusion to the left and to the right, and protrusion.
- Its precision is yet to be established by CBCT and subsequent comparison of the 3D scans with those from CBCT.
- The advantage of the new dental articulator is that dental plaster is not needed to mount the models, which saves: technological time and material costs; there are no volume deviations as a result of the expansion and the subsequent shrinkage of the plaster; it is more convenient to use (we can work on the models outside the articulator and then return them, if needed, in the same correct position).
- In fixed dental prostheses, there is no risk of filling the slots, where locking pins are secured, with plaster.

Conventional or virtual, the articulator is a mandatory device in the manufacturing of a dental prosthetic construction. The strive for its rationalization still continues.

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