REVIEW ARTICLE

# Digital Articulators : A Promising Technology of the Future

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## ABSTRACT

The Digital articulator is a basic tool that deals primarily with the functional aspects of the occlusion. It is regarded as the prime factor; not only in the diagnostic and therapeutic procedures but also in the CAD-CAM manufactured dental restorations. With the advent of digitalization, dentistry has become easier, accurate and time saving. This article reviews the need of Digital articulators, its advantages and its design parameterization.

**KEYWORD:** Collision Detection, Dental CAD/CAM, Dental Virtual Articulator, Occlusal contact

## EVOLUTION OF DIGITAL ARTICULATORS

### *Szentpetery's virtual articulator:*

It was introduced in 1999. It is a fully adjustable 3D virtual dental articulator. It can reproduce various movements of the mechanical articulator, including the curved Bennett angle movements, which makes it more versatile than mechanical articulator. But as it is a mathematical approach, it behaves as an average value articulator and it is not possible to easily obtain the individualized movement paths of each patient. [1,4]

### *Virtual articulator of Kordass and Gaertner*:

It was introduced in 2000. It aims at precise registration of mandibular movement with the help of jaw motion analyzer. This system requires digital representation of the jaws as input data generates an animation of the jaw movement and delivers a dynamic and tailored visualization of the collision points. If a device for the registering of the patient specific jaw movements is available as for e.g. the Zebras jaw motion analyzer, the recorded jaw motion

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can be integrated in to animation. Jaw motion analyzer is a device used for the acquisition of the Mandibular movements.[1,5]

### *Virtual articulator based on mechanical dental articulator:*

It was introduced by the University of the Basque Country in 2009. The project was focused on developing a different virtual articulator based on mechanical dental articulator. The implementation of this articulator enables the user to select which setting parameters are to be registered and transferred to the patient, and therefore compare the differences between the virtual articulator and the mechanical articulator for better simulation of the most adequate articulator. Problems or the limitation of the previous approaches to develop virtual dental articulator were considered in this project. It is a more simple approach than the virtual articulator developed by Kordass and Gaertner and at the same time more accurate result can be obtained than the Szentpetery's virtual articulator. The main advantage of this approach is that the user can choose the most suitable articulator for the simulation.[1]

## ADVANTAGES OF DIGITAL ARTICULATORS OVER MECHANICAL DENTAL ARTICULATOR

The main goal of the Digital articulator is to improve the design of dental prosthesis, adding kinematic analysis to the design process.[2] Commonly used semi adjustable articulators, however have major limitations.[1] The mechanical articulators follow border structure of mechanical joint and cannot represent the effects of resilience of the soft tissue or the time dependent muscle guided movement pattern of mastication. In addition to this, it cannot represent the real dynamic condition of the occlusion in mouth.[3] Often problems regarding the technical procedures and dental materials hamper the accuracy of reproduction as: a) the deformation of registration material (E.g. Wax, which is susceptible to heat), b) repositioning the cast into bite impression without leaving any space, c) the use of rigid and expanded plaster material and d) maintenance of the mechanical articulator. Because of these problems, the reproduction of dynamic, excessive contact seems to lower the reliability. Replacement of the mechanical articulator with the virtual articulator will solve these problems.

### *Advantages of Digital Articulators over Dental CAD/CAM systems:*

Dental CAD/CAM systems constitute a new way to produce dental prostheses. There is no doubt as to these high-tech instruments taking over dentistry in the future. However, considering the limited accuracy of the occlusal surface, this type of restoration can only match the possibilities offered by simple occludators (static design). The system cannot take into consideration functional movements, so the occlusal surface of the new tooth has to be manually trimmed to these movements in the mouth or in an articulator. Even an immaculately precise system such as the Cerec3, the latest CAD/CAM development, presents this severe handicap despite being able to make an occlusal surface fit the antagonists in intercuspal position.[6-8] This shortcoming is common to nearly all laboratory CAD/CAM systems. Unfortunately, in order to take these movements into account, it is not possible to integrate any mechanical dental articulator in such systems. These systems should use kinematic methods for occlusal surface construction or correction. Thus, this

shortcoming is overcome with the advent of the Digital Articulators.

## DIGITAL ARTICULATOR PARAMETERIZATION

The skill and care, with which the digital articulator is used, have a direct effect / impact on the success of fixed or removable restorations.

a. **Selection of the articulator:**
If the dentist's only concern is the relationship of the antagonist teeth at the point of maximum intercuspation, the design and the use of an articulator will be greatly simplified. In this scenario, the articulator capable of simple hinge movement will be sufficient for the designing of the prosthesis. But, the mandible does not act as a simple hinge; rather, it is capable of rotating around axes in three planes. The occlusal surface of any prosthesis for the mouth must accommodate the free passage of the antagonist teeth without any interference. Hence, selection of the suitable articulator plays a pivotal role in the designing of virtual articulator by this approach.[1]

b. **The design process:**
Once the articulators are selected, their structures and shapes are analyzed in order to clarify how to use the Reverse Engineering and measuring tools. This implies that, the upper and lower bodies, is similar in both articulators, but the condylar elements of the temporomandibular joints, which are the most important part of the articulators; present an enormous variety of configurations. The articulators that have been modelled are the Hanau H2 and the Ivoclar Stratos 200.

c. **Different approaches :-**

- **Hanau H2:**
The first articulator that has been modelled has simple geometrical bodies (cylinder, prismatic bodies and spheres). The ATOS I 3D scanner was used in order to have the drafts located on the corrected position in space. To get the section of the scanned point cloud, Rapid form XOR software was used. The whole articulator was constructed combining both measured and scanned parts. In the final step, the models were located on the articulator for this purpose and relative position of the upper model was scanned using the face bow. Then the location of the lower model was made using an electronic bite in centric relation and the virtual articulator was ready to apply the kinematic simulation using the CATIA CAD system.[1,5]
- **Ivoclar Stratus 200:**
The Ivoclar stratus 200 was modelled using a Solid Edge CAD system, the Handyscan 3D scanner was used to scan the articulator. Using Geomagic point cloud addition software they use full data- taking from the millions of points that had been scanned. Finally as with the Hanau H2 the models were located in correct position, ready to apply kinematic analysis.

d. **Impart flexibility and versatility:**
The advantage of this modelling and parameterization is that it makes it possible to introduce new settings which do not exist on the physical articulator. For instance, in the Hanau H2 articulator the inter-condylar distance can be introduced as a new setting parameter, making the simulation more accurate because the real radius is defined.

e. **Simulating Kinematics:**
The parts of the articulator are modelled in the CAD system and the scanned dentures are converted to solid by means of the Rapid-form software and then, they are assembled adding the necessary constraints. Then, the simulation is run and any possible interference on the designed prosthesis is checked out. If there is any collision, the interfering part is removed.[9]

f. **Removing interferences:**
The new virtual articulator provides interesting modules for presenting and analyzing the dynamic contact of the occlusal surface of the maxilla and mandible and the relation to the condylar movement. To improvise the functional occlusion, the occlusal morphology of the teeth can be designed with a better cuspal inclination and angulation that helps in eliminating the interferences during the excursive mandibular movements. These newly designed occlusal surfaces can be transferred to a milling machine to produce optimized functional occlusion.[9]

## CONCLUSION

The Digital Articulators are able to design prostheses kinematically.

They are capable of:

- Simulating human mandibular movements,
- Moving digitalized occlusal surfaces against each other according to these movements, and
- Eliminating the occlusal interferences to enable smooth and collision-free movements.

This design process of the Digital Articulators integrates all the necessary tools and performs a collaborative-based approach where each activity is directly supported by the acquired knowledge of the specific domain. Thus, the concept of Digital Articulator will revolutionise the conventional ways in dentistry and replace the mechanical tools.

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