Virtual Articulators in prosthodontics

Abstract

Virtual technologies in dentistry provide better education and training by simulating complex contexts and enhancing procedures that are traditionally limited, such as work with mechanical articulator. This paper review the need of virtual articulators, its advantages, disadvantages and different approaches.

Key Words: Virtual Articulators; CAD; CAM

Virtual technologies in dentistry will be used to provide better education and training by simulating complex contexts and enhancing procedures that are traditionally limited, such as work with mechanical articulator. The virtual articulator is intended to use as a tool for the analysis of the complex static and dynamic occlusal relations. Commonly used semi-adjustable articulators, however have major limitations, the movements of the mandible cannot be reproduced exactly, and also they do not provide time related information on jaw movement. Both problems can be solved by replacing the mechanical articulator by a digital simulation i.e., “Virtual Articulator.” This paper reviews the need of virtual articulator, its advantages in the field of Prosthodontics in particular.

Need of Virtual Articulator: The main goal of the virtual articulator is to improve the design of dental prosthesis, adding kinematic analysis to the design process. The mechanical articulator which is currently used in the fabrication of fixed dental prosthesis has numerous limitations. As the mechanical articulator 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 chewing, it cannot represent the real dynamic condition of the occlusion in mouth. Also many often problems regarding the technical procedures and dental materials decreases the accuracy of reproduction as a) the deformation of registering material (Eg. 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.

With the advent of the digital impression and dental CAM/CAM system, today’s dentistry has become dentistry of single visit. Patient can receive crown in single appointment. But even the latest CAD/CAM system has its own limitations. Main disadvantage of the system is limited accuracy of the occlusal surface. This is because it acts as simple mechanical occludators and cannot take into consideration the functional movements of the mandible. So the occlusal surface of new tooth has to be trimmed manually after in patient’s mouth, at the cost of valuable chair side time, and if we are not considering the mandibular movements and placing the restoration as it is, we are creating problems for the patient’s TMJ. So for accurate occlusal surface construction there is need to use kinematic method i.e. virtual articulator along with CAD/CAM system.

For accurate occlusal surface construction there were two ways. a) The use of fully adjustable articulator which simulates mandibular movements with high degree of precision and is time consuming and expensive. b) Use of virtual articulators with CAD/CAM system. The prostodontics applications of virtual articulators are to fabricate the best fitted occlusal restoration possible, to help students to understand the function of dental articulator, different excursive movement and their influence on the occlusal surface and to improve the quality of communication between the dentist and dental technician.

The advantages of the virtual articulators are dynamic visualization of the occlusal surface is possible with the virtual articulator, whereas mechanical articulator offers only static presentation, offers a detailed 3-D visualization of region of interest, possible to modify or introduce new setting according to the patient and helpful for patient’s education. Though the research is still going on in this field three different approaches have been made till now.

Szentpetery’s virtual articulator: It was introduced by Szentpetery in 1999. It is based on a mathematical simulation of the articulator movements. It is a fully adjustable 3D virtual dental articulator capable of reproducing the movement of an articulator. It offers possibilities that are not offered by some of the mechanical
articulators as curved Bennet angle movements which make it more versatile than mechanical articulator. But as it is a mathematical approach, if behaves as an average value articulator and so not possible to obtain easily the individualized movement paths of each patient.\(^{(2, 4)}\)

Virtual articulator of Kordass and Gartner: It was introduced by Kordass and Gartner in 2003, based on the exact registration of mandibular movement with the help of jaw movement analyzer. This virtual articulator system requires digital 3D 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 e.g. the Zebras jaw motion analyzer, the recorded jaw motion can be integrated in to animation. Jaw motion analyzer is a device used for the acquisition of Mandibular movements.\(^{(2, 5)}\)

Virtual articulator based on mechanical dental articulator: It was introduced by graphic design and engineering project developments, the University of the Basque Country in 2009. The project was focused on developing a different virtual articulator based on mechanical dental articulator, Knowing which setting parameters can be registered and transferred to the patient. Problems or the limitation of the previous approaches to develop virtual dental articulator were considered in this project. It is 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 to use in the simulation.\(^{(2)}\)

Design process: Virtual articulator in this approach involves reverse engineering tools for the acquisition of the patient’s occlusal morphology. Plaster models of upper and lower parts of the jaw are scanned to obtain and digitized set of data of the patient. In this phase, the real geometry of the mouth and its relation location are reconstructed in a CAD system using face bow. In the second phase, the type of articulator is selected depending on the required accuracy and/or on the patient setting data available in each case. Once the dental prosthesis is modeled, the function simulation is performed in order to obtain the interfering collision points which could produce a disease in the TMJ. Excursive movements, such as protrusion and latero-trusion, are simulated using a CAD system, analyzing possible occlusal collisions so that the design can be adequately modified. Finally, the dental prosthesis is milled and tested in patient’s mouth.\(^{(6)}\)

Selection of the articulator: If relationship of the antagonist teeth at the patient of maxillary intercuspation is the only concern of the dentist then selection of the 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 than this, it is capable of rotating around axes in 3 planes. The occlusal morphology of any restoration for the mouth must accommodate the free passage of the antagonist teeth without interfering with the movement of mandible. So, selection of the suitable articulator is important stage in the designing of virtual articulator by this approach.\(^{(2)}\)

Hanau H\(_2\): 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, the Rapid form XOR software has been 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 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.\(^{(2, 5)}\)

Stratus 200: The Ivoclar stratus 200 was modeled using a solid edge CAD system the handy scan 3D scanner was used to scan the articulator. Using Geomagic point cloud addition software the use full data taking from the millions of points that had been scanned. Finally as with the Hanau H\(_2\) the models were located in correct position, ready to apply kinematic analysis.

Simulating Kinematics: After the articulator was modeled, the simulation was run and any possible interference on the designed prosthesis were checked out and if they are present corrected accordingly.

Virtual reality enables new perspective in visualizing complex relationship in the diagnosis of the occlusion and function. 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 improve the functional occlusion, the occlusal profile of the teeth can be designed with increased or decreased cusps to eliminate occlusal interferences of the dynamic pattern. The data set of newly designed and improved occlusal surfaces can be transferred to a milling machine, producing
real crowns and fixed restoration with that particular, optimized functional occlusion.

The virtual articulator is a basic tool that deals primarily with the functional aspects of the occlusion; however, it also can be regarded as a core tool in many diagnostic and therapeutic procedures and in the CAD-CAM manufacture dental restoration. The concept of Virtual Articulator will change conventional ways of production and communication in dentistry and begin to replace the mechanical tools.

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