



REVIEW ARTICLE

VIRTUAL ARTICULATORS IN DENTISTRY-A REVIEW

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Abstract

The future of dentistry is linked strongly to the use of computer technology. Virtual reality technologies have a strong impact on research, development and industrial production. Virtual reality is the simulation of real and imagined environment that can be experienced visually in 3-dimension of width, height and depth. In addition it provides an interactive experience with sound, motion, tactile and other forms of feedback.¹ In dentistry, the use of computer aided design (CAD) systems and Reverse engineering tools permits the introduction of kinematic analysis in virtual design processes.² One such recent innovations in virtual field is related to the development of a stimulant to mechanical articulator called virtual articulator. With the advent of digitalization, dentistry has become easier, accurate and time saving. This article reviews few aspects of virtual articulators regarding their need, advantages, usage and limitations.

Key words: Virtual reality, dentistry, review

INTRODUCTION

In the last several years, many innovative and technological advancements have been made in the field of dentistry that are used to provide better education and training by simulating complex contexts and enhancing procedures that are traditionally limited.³ Innovative research has also invaded the field of prosthodontics with several articulator designs available in market which are used for fabrication of restorations compatible with stomatognathic system. The transition from numerous mechanical articulator designs to recently developed virtual articulators is a breakthrough in the development of the articulator design.

DISCUSSION:

According to GPT 8 , an articulator is defined as, “A mechanical instrument that represents the temporomandibular joints and jaws, to which maxillary and mandibular casts may be attached to simulate some or all mandibular movements”.

Several uses of articulators include , holding opposing casts in a predetermined fixed relationship; produce border and intraborder diagnostic sliding motions of the teeth similar to those in the mouth; to diagnose dental occlusal conditions in both natural and artificial dentitions; plan dental procedures that involve positions, contours, and relationship of both



natural and artificial tooth as they relate to each other; to aid in the fabrication of dental restoration and lost dental parts; correct and modify completed restorations, for viewing the lingual occlusion and articulators can be helpful in teaching and studying occlusion and mandibular movements.^{4,5}

Virtual Articulators:

Virtual articulators are also called as `Software Articulators`. They are not concrete but exist only as a computer program. They comprises of virtual condylar and incisal guide planes. Guide planes can be measured precisely using jaw motion analyzer or average values are set in the program like average value articulator. They are capable of simulating human mandibular movements, by moving digitalized occlusal surfaces against each other and enabling correction of digitalized occlusal surfaces to produce smooth and collision-free movements.⁶

Need for virtual articulator:

The main goal of virtual articulator is to improve the design of dental prosthesis, adding kinematic analysis to the design process.² 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.⁷

Because of those problems, the reproduction of dynamic, excessive contact seems to lower the reliability. Replacement of the mechanical articulator with the virtual articulator will solve this problems.³

Evolution of virtual articulators:

1. 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.³ (fig:1)

2. Virtual articulator of Kordass and Gartner:

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.⁹

Jaw Motion Analyser: This system is based on measuring the velocity of ultrasonic impulses emitted from three transmitters attached to the lower sensor bound to labial surface of mandible and four receivers attached to a face bow opposite to them for detecting all rotative and translative components in all degrees of freedom.

A special digitizing sensor is used to determine the reference plane, composed of the hinge axis-infra orbital plane and special points of interest (eg: on the occlusal surface)¹⁰ (Fig:2)



3.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. It is a more simple approach and the main advantage of this approach is that the user can choose the most suitable articulator for the simulation.¹¹

Selection of the Articulator

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 an important step in the designing of virtual articulator by this approach. Finally, the selected articulator should have a direct impact on the success of fixed and removable prosthetic restorations.¹²

Programming the Virtual Articulator

The programming and adjustment methods of virtual articulator were described by Kordass and Gartner in 1999. The input data entry is done as follows:

a) Scanning/digitising : of a tooth or tooth surface or restoration or complete denture models or centric relation can be scanned. The scanner projects a vertical laser beam onto the surface of the object and the digital camera equipped with a charge coupled device (CCD) registers the beam reflected from the object and transmits the digital signals to an electronic processing system. The processed image data are stored as digital matrix brightness values, ready for use by the scanner software and for on screen visualisation and computerised manipulation .

The scanning can be done in 2 ways:

Direct digitising – it is done directly from the patient's mouth using an intra oral scanner.

Indirect digitising – it is done outside on the patient's master cast, obtained after making final impression.

b) Patient Specific Motion Data of Temporo mandibular joint

i) Using Jaw motion analyser (JMA) tool (Comp Zebris, Isny, Germany):

It has reference points fixed on the patient mandible. An ultra sound is then used to measure the position of these points in space describing physiological masticatory motion of the patient.

thus simulating the patient specific movement patterns. The relative position of the upper or maxillary virtual model in reverse position is digitised using face bow and located directly in the virtual articulator. The lower or mandibular virtual model is then located in centric relation with the upper virtual model using an electronic bite.

Finally, visualise the occlusion 3D in all planes on the computer screen. The virtual articulator system is now ready to be applied for kinematic simulation analysis.

ii) If the jaw motion analyser tool is not available, different jaw motions can be defined via parameters as used with the mechanical articulators such as protrusion (radius of the condylar guide, maximum distance of condylar protrusion), retrusion (radius of the condylar guide, maximum distance of retrusion), laterotrusion (maximum protrusion, Bennett angle, radius of the



right and left condylar guide, right and left horizontal condylar slope, shift angle, immediate side shift), and opening/ closing movement (maximum opening angle).

After defining the motion parameters, collision detection is triggered to recognize the motion constraints, which results in the upper and lower jaws gliding on each other. For collision detection, a ray based algorithm is used that is executed in a preprocessing step. For occlusion detection, a distance corresponding to the thickness of the occlusion paper used in the mechanical articulator is chosen, for calculating the occlusion points according to this defined distance .

Other systems for the detection of mandibular movements available newly are based on other technologies such as optoelectronic devices that use CCD cameras to register the emissions of light emitting diodes (LED's) positioned over the head of the patient and generate an image from these signals.¹⁰

Advantages of Virtual Articulator:

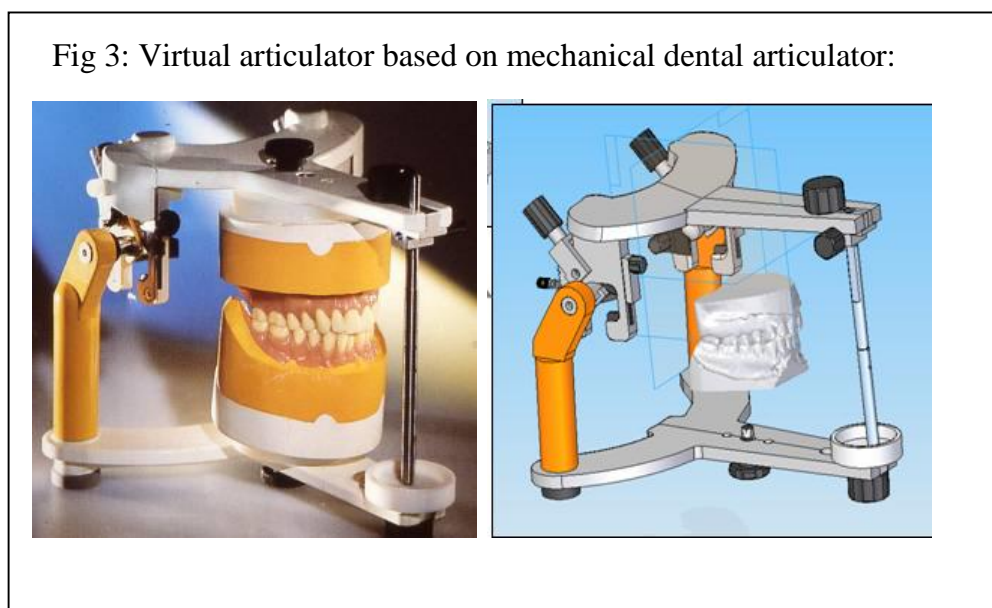
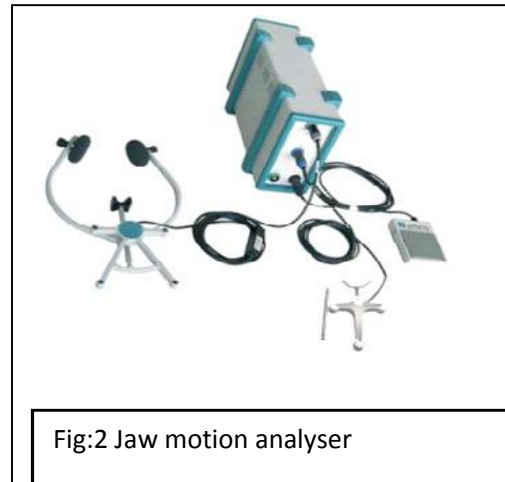
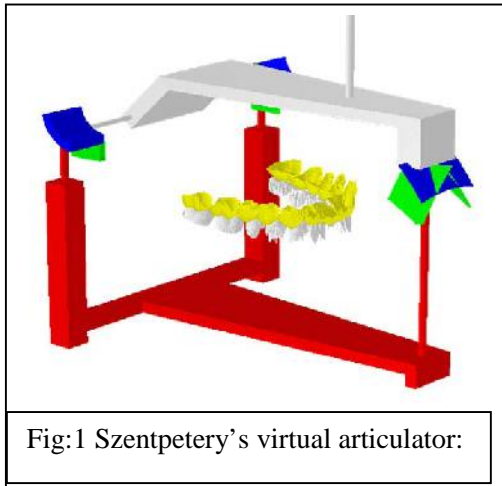
- Provides best quality of communication between the dentist and dental technician
- Analyses both static and dynamic occlusions.
- Designing of occlusal surface in CAD CAM system.
- Analyses gnathic and joint conditions.
- Offers a detailed 3-D visualization of region of interest.
- Possible to modify or introduce new setting according to the patient and helpful for patient's education.

Limitations of Virtual Articulator

- Cost effective as it requires the digital scanners, digital sensors, software's, and different types of virtual articulator models mimicking the mechanical ones according to the patient need.
- Knowledge about the CAD/CAM technology, mechanical articulators, designing and modeling of virtual articulators etc and technical skills regarding the interpretation of data recorded from scanners, sensors, minor adjustments, incorporating motion parameters etc.

CONCLUSION:

The virtual articulator is a precise tool for the full analysis of occlusion in a real patient.¹³ It 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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