VIRTUAL ARTICULATORS IN PROSTHODONTICS-A FUTURE ORIENTED TECHNOLOGY

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Article Info	ABSTRACT
	In the field of prosthetic and restorative dentistry, the virtual dental articulator incorporates virtual reality applications to the world of clinical dental practice for the analysis of complex static and dynamic occlusal relations. Its chief application is in the simulation of the mechanical articulator. The virtual articulator requires digital 3D representations of the jaws and patient specific data on jaw movements which then simulates jaw movements and provides a dynamic visualization of the occlusal contacts. This paper reviews the need of virtual articulators, programming of virtual articulators, their advantages, disadvantages and different approaches.

INTRODUCTION

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. The dentists who already offer the most advanced technologies at their dental laboratories are starting to call "dentistry of single visit". In a few minutes, the dentist is able to obtain the necessary electronic impression and then, the tooth is designed in a computer and afterwards it is milled from one ceramic block in less than an hour. However, considering the limited accuracy of the occlusal surface, this type of restoration can only provide 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 with the use of semi adjustable mechanical articulators, one cannot reproduce mandibular movements with associated time frames. These dilemmas can be resolved by replacing the mechanical articulator by its digital replication like virtual articulator [1].

Virtual articulator can signify and quantify the effects of resilience of the soft tissue on the time dependent basis during muscular movements of chewing or eating. That is why it can exemplify the real time dynamics of the occlusion [2]. Other significant advantages of using virtual articulators over mechanical ones are the reduction in inaccuracies while making interocclusal registration with materials prone to deformation (eg: Bite registration wax) and accurate repositioning of the master cast into bite impression without leaving any space. The most accurate occlusal surface reproduction can be achieved either by using fully adjustable articulator that simulates mandibular movements with high degree of precision or by using virtual articulators with CAD/CAM systems [5]. The Virtual articulator can be defined as a software tool for improved clinical outcome based on virtual reality technology [2-4].There are two types of virtual articulators namely -Completely adjustable and Mathematically simulated [1,6].

Completely Adjustable Virtual Articulator [1,6]: It records /reproduces exact movement paths of the mandible

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using an electronic jaw registration system called Jaw motion analyser (JMA).

The digitised dental arches then moves along these movement paths that can be viewed in the computer screen consisting of three main windows showing the same movement of the arches from different planes. The software calculates and visualises both static and kinematic occlusal collisions and is used in designing and correction of occlusal surfaces in computer aided designing (CAD) systems.

The software of the DentCAM virtual articulator developed at the University of Griefswald consists of three main windows and a slice window, which show the same movement of teeth from different aspects:

1)**Rendering window:** Shows both jaws during dynamic occlusion and can visualise unusual views throughout dynamic patterns of occlusion i.e.: the view from the occlusal cusps while watching the antagonistic teeth coming close to the intercuspidation position during chewing movements.

2)**Occlusion window:** Shows the static and dynamic occlusal contacts sliding over the surfaces of the upper and lower jaw as a function of time.

3)**Smaller window:** The movements of the temporomandibular joint are represented in a sagittal and transversal view which allows the analysis and diagnosis of interdependencies between tooth contacts and movements of the temporomandibular joint.

4)**Slice window:** Shows any frontal slice throughout the dental arch. This tool helps to analyse the degree of intercuspidation and the height and functional angles of the cusps. With this window, the analysis of guidance and balancing becomes easy [6].

Mathematically Simulated Virtual Articulator

It is based on a mathematical simulation of the articulator movements. It is a fully adjustable three dimensional virtual articulator capable of reproducing the movements of an mechanical articulator. In addition, mathematical simulation contributes to offering possibilities not offered by some mechanical dental articulators, such as curved Bennett movement or different movements in identical settings .This makes it more versatile than a mechanical dental articulator. On the other hand, since it is a mathematical approach, it behaves as an average value articulator, and therefore, is not possible to obtain easily the individualized movement paths of each patient [7].

Programming of Virtual Articulators(1)

Pre requisite for visualization on screen is 3D scanning/digitizing of tooth surface or restorations or denture models using 3D scanner. (Fig 1)
The scanning can be done in 2 ways:

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

Indirect digitising - done outside on the patient's master cast obtained after making final impression.

The scanned data helps to obtain the real geometry of the mouth and its relative location are reconstructed in a CAD system using the face bow. In the second phase, the type of articulator is selected depending on the required accuracy and/or on the patient's setting data available in each case.Once the dental prosthesis is modelled, the functional simulation is performed in order to obtain the interfering collision points which could produce a disease in the temporomandibular joints, which may end up producing a disease in the temporomadibular joints. Excursive movements, such as protrusion and laterotrusion, 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 on the
mouth of the patient.

Advantages of Virtual Articulator

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

The clinician can visualize the teeth surface occlusion for contact points and prematurities leading to proper information for the diagnosis [8,9]

Virtual articulators are also helpful in patient education and thereby improving the compliance for the treatment.

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.

Future Modules Of Virtual Articulator
1)**Fixed crown and bridge work with CAD/ CAM**

The virtual models of casts that are digitally mounted in virtual articulator are used for diagnosis and treatment planning of prosthetic restorations from single to multiple crowns to bridges including complex cases like full mouth rehabilitation achieved by CAD/CAM systems [5]. The virtual articulator combined with CAD/CAM technology offers great potential in treatment planning with dental implants since it affords greater precision and shorten the duration of implant treatment [2].

2) For the Detection of tooth wear or bruxism

A module that semi-automatically analyzes the teeth for signs of wear or bruxism is available. The algorithm searches for wear facets and separates them from the surrounding surface using special segmentation algorithms [10].

3) For Orthodontic Virtual Set up

The latest version of Dent CAM software, a special orthodontic CAD module was added to simulate the therapeutic result by repositioning single teeth and reforming the dental arch (virtual set-up).

Figure 1. Dental Laboratory procedure for Virtual Articulators
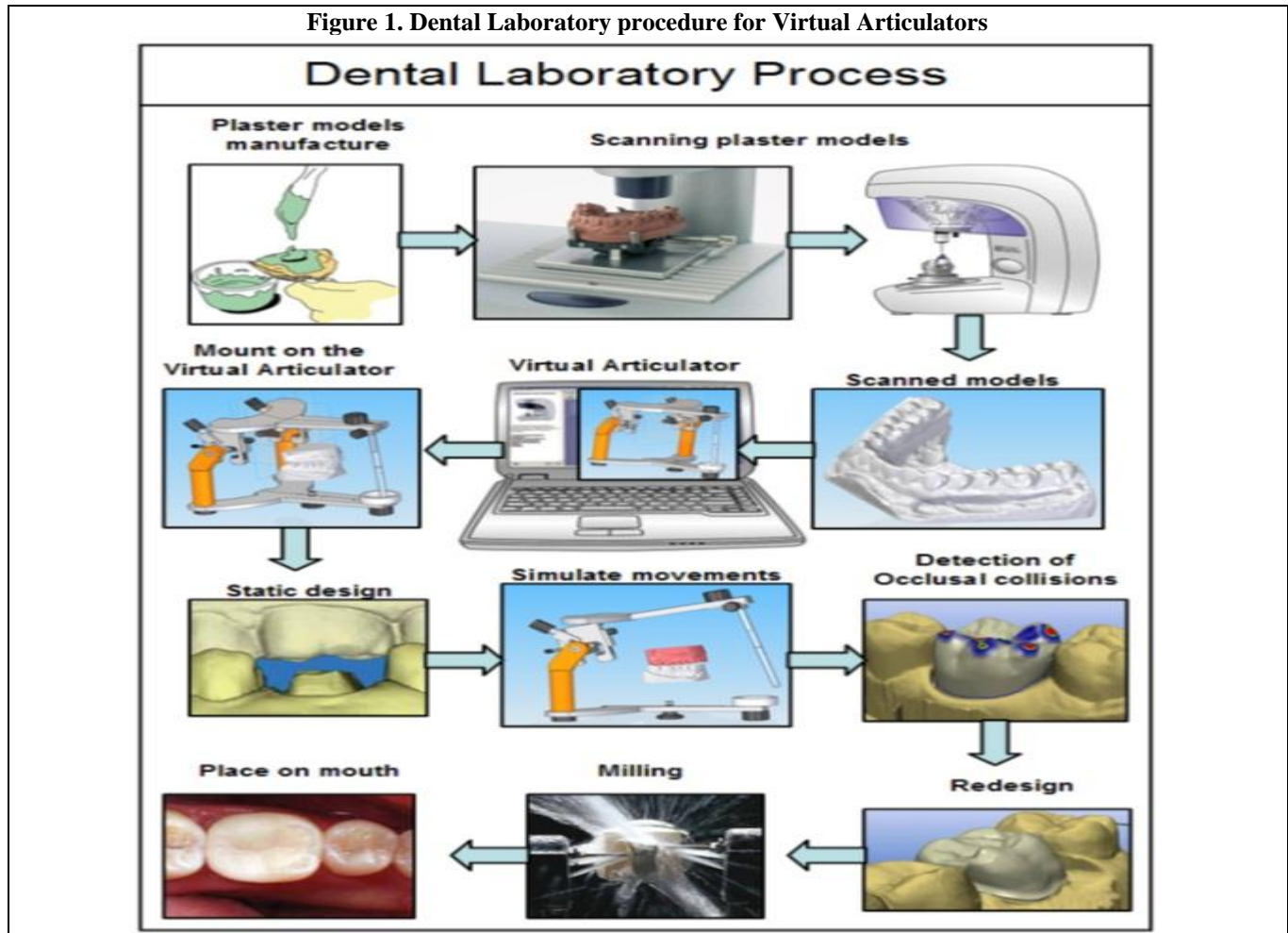
CONCLUSION

The virtual reality technology has opened door for dental professionals towards successful diagnosis and treatment planning with virtual articulator in day to day clinical practice. The virtual articulator is a precise software tool dealing with the functional aspects of occlusion along with CAD/CAM systems substituting mechanical articulators and thus avoiding their errors.

However, it also can be regarded as a core tool in many diagnostic and therapeutic procedures and in the cad/cam manufacture of dental restorations.

CONFLICT OF INTEREST: NIL

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