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KEY WORDS:

VIRTUAL ARTICULATORS: A DIGITAL SUPREMACY IN PROSTHETIC AND RESTORATIVE DENTISTRY.

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ABSTRACT

The up folding of dentistry is linked strongly to the use of computer technology. Virtual reality technologies have a robust impact on research, development and industrial production. Virtual reality is the simulation of real and fancied environment that can be experienced visually in 3-dimension of width, height and depth. In addition it provides associate interactive expertise with sound, motion, tactile and and other forms of feedback. In dentistry, the use of computer aided design (CAD) systems and Reverse engineering tools permits the introduction of kinematic analysis in virtual design processes. 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, prosthetic dentistry has become easier, meticulous and time saving. This article reviews aspects of virtual articulators regarding their need, advantages, usage and limitations in the field of prosthetic dentistry

INTRODUCTION

Articulator enable technicians to carry out a study of occlusal relations between dental arches and to detect harmful occlusal interferences on models before more sophisticated occlusal equilibration procedures are performed on the patient1. Mechanical articulators are necessary for this environment, technician uses it for checking jaw movement and relationship between upper and lower jaw and using it as the holder for fabrication. But as dental environment is changing, as the computer system develops, With developing digital impression and dental CAD/CAM system, today's dentistry has the use of virtual articulator above mechanical articulator. The transformation from numerous mechanical articulator designs to latterly developed virtual articulators is a breakthrough in the development of the articulator design[2].

Virtual dental articulators assimilate virtual reality applications to the world of clinical dental practice for scrutinizing of complex static and dynamic occlusal relations. Virtual reality is a clone of physical reality constituting a virtual environment to replace the real world. The equipment's and technologies by which we can collaborate reality are known as virtual reality equipment's and virtual reality technologies3.

Definitions: (acc to GPT9)

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.

Exigency for virtual articulator:

The main intention of virtual articulator is to improve the design of dental prosthesis, adding kinematic analysis to the design process5. The mechanical articulator which is currently used in the fabrication of fixed dental prosthesis has diverse limitations. As the mechanical articulator pursue 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[6].

Types of Virtual Articulator:

- Completely Adjustable Virtual Articulator
- Mathematically Simulated Virtual Articulator.

Completely Adjustable Virtual Articulator [1,8,9:]

- It records or reproduces exact movement paths of the mandible 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 exact movements of the arches from different planes.
- The software visualises and calculates both static and kinematic occlusal collisions and is used in designing and correction of occlusal surfaces in computer aided designing (CAD) systems. Eg: Kordass and Gartner virtual articulators.

The software of the DentCAM virtual articulator which was 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:

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 obsetving the antagonistic teeth coming close to the intercuspidation position during chewing movements.

Occlusion window:- Depicts the static and dynamic occlusal contacts sliding over the surfaces of the upper and lower jaw as a function of time.

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.

Slice window:- Shows any frontal slice throughout the dental arches. This tool helps to analyse the degree of inter-cuspidation and the height and functional angles of the cusps. With this window, the analysis of balancing and guidance becomes easy9.

Mathematically Simulated Virtual Articulator 8,10:

- It records or reproduces movements of the articulator based on mathematical simulation of articulator movements.

- A well fully adjustable 3D virtual articulator is capable of reproducing all articulator movements.
- These virtual articulators allows for additional settings such as curved bennett movement or other movements for adjustment in ideal settings.
- The major disadvantage is that it behaves as an average value articulator and it is not possible to obtain individualised movement paths of each patient.

Eg: Stratos 200, Szentpetery's virtual articulators.

DEVELOPMENT AND DESIGNING OF VIRTUAL ARTICULATOR

The designing of dental virtual articulator is achieved by means of computer aided design (CAD) systems and reverse engineering tools. The evolution is made at the product design laboratory (PDL) in the faculty of Engineering of Bilbao (The University of the Basque Country) in collaboration with the department of prosthetics of the Martin-Luther University of Halle as follows:

- Various mechanical articulators are selected first to be modeled through CAD systems (Solid Edge and CATIA).
- The design process will then be carried out using measuring tools and reverse engineering tools that are available at the PDL. The tools used are: Handyscan REVscan 3D scanner and its software (VXscan), Reverse engineering and computer-aided inspection software (Geomagic Studio and Qualify), Rapidform XOR, ATOS I rev.2 GOM 3D scanner.

After the virtual articulator is constructed, all the measurements are verified and checked. If any problem exists, that need to be rectified and redesigned accordingly [1,7] .

SELECTION OF THE ARTICULATOR

The selected articulator and even more importantly, the skill and care, with which it is used, have a direct effect/impact on the success of fixed or removable restorations. 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 enormously simplified,as the intercuspation position is static, the articulator will need to act only as a rigid hinge, which is little more than a handle for the model.

The mandible nonetheless does not act as a simple hinge. Rather, it is capable of rotating around axes in three planes. The occlusal morphology of restorations for the mouth must accommodate the free passage of the antagonist teeth without any interference with the movement of the mandible.

Because of their potentiality to produce pathologies, occlusal interferences must not be incorporated into restorations placed by the dentist. One way of averting this problem is the use of fully adjustable articulators which simulate mandibular movements with a high degree of precision. Treatments done by using these articulators are time consuming and demand a great skill from both dentist and technician. As a result, the cost of such treatments does not make it feasible for minor routine treatment plans. [1,6,8.]

Programming the Virtual Articulator

The adjusting and programming methods of virtual articulator were described by Kordass and Gartner in 1999.

a) Scanning/digitising – tooth or tooth surface or restoration or complete denture models or centric relation, 3D Laser scanner (Willytec, Munich, Germany) is used. The scanner projects a vertical laser beam onto the surface of the object. 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 manipulation8.

b) The scannings can be done in 2 ways:

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

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

c) Patient Specific Motion Data of Temporo mandibular joints (TMJ).

i) Jaw motion analyser (JMA) tool (Comp Zebris, Isny, Germany) has reference points fixed on the patient mandible.

- This kind of 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.
- Special digitising 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).
- An ultra sound is then used to measure the position of these points in space describing physiological masticatory motion of the patient.
- Hence simulating the patient specific movement patterns with the attached scanned/digitised virtual models constructed in the virtual articulator.
- 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 hence 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 (Protar 7, KaVo).

- Following the selected movements are: 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 or closing movement (maximum opening angle).
- After defining the motion parameters, collision detection are triggered to recognise the motion constraints, which results in upper and lower jaws gliding on each other.
- For the collision detection, a ray based algorithm is used that is executed in a pre processing step.
- For the 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 6,8.
- Other systems for the detection of mandibular movements available newly which were 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. Fang and Kuo, presented a new model using this system for assessment of mandibular dynamics. They have designed a customised device for each patient, fixed in the same position in both the plaster models and in the oral cavity. After scanning of models, the patients performed mandibular movements (aperture/closure, protrusion/retrusion, and lateral excursions) for 20min. The data recorded were later processed by mathematical models to reconstruct customised dynamics for each patient for visualization and computer based analysis8.

Selection of the articulator1: 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 movements will be sufficient for the designing of the prosthesis. But, 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 restorations for the mouth must accommodate the free passage of the antagonist teeth without interfering with the movement of mandible. So, the selection of the suitable articulator is important stage in the designing of virtual articulator by this approach.

Hanau H2: 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 complete articulator was constructed combining both measured and scanned parts. In the final step, the models are 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 models 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.

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 with the Hanau H2 the models were located in correct positions, 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 were present corrected accordingly.

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 3D visualization of region of interests.
- Possible to modify or introduce the new setting according to patient and helpful for patient's education.
- Simulating real patient specific data.

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 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 etc6.

HAPTIC BASED FIRST TOUCH ENABLED VIRTUAL ARTICULATOR

Sensable Dental Technologies has developed the newest versions of its Intellifit™ TE (Touch-Enabled) Digital Restoration System that offers dental labs even more choice, performance and flexibility in digitally designing and fabricating a wide range of dental restorations. The system supports for both fixed and removable restorations including full ceramic monolithic crowns, bridges and prepped veneers, produced faster and with heightened precision though its unique touch enabled technology, allows dental labs of all sizes to gain a competitive advantage[8,11].

Also, Intellifit's unique 3D 'Virtual Touch' interface and integrated touch-enabled articulator allow lab technicians to actually feel how teeth – including the new restoration they are producing – will fit together in the patient's mouth. Articulators are essential for testing the occlusion of almost every type of dental restoration and lab technicians have long used them, as well as their sense of touch, to assess whether a restoration will allow the patient to function with correct amount of contact and excursive movements. Intellifit's virtual articulator mimics the feel and function of physical articulators, yet allows dynamic settings to meet patient specifications and freedom of movement in three dimensions. Touch enabled, virtual articulator allows technicians to test occlusion of restoration – before it is produced and enabling them to actually feel the fit.[8,11].

CONCLUSION

The virtual reality technologies 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 that deals with the functional aspects of occlusion with CAD/CAM systems substituting mechanical articulators and thus avoiding their errors. Haptic based virtual reality systems touch enabled virtual articulators allow lab technicians to actually feel how the teeth, including the new restorations produced will fit together in the patient's mouth. The concept of virtual articulator will change conventional ways of production and communication in dentistry, and will replace the mechanical tools.

REFERENCES:

1. Solaberrieta E, Etxaniz O, Minguez R, Muniozguren J, Arias A. Design of a virtual articulator for the simulation and analysis of mandibular movements in dental CAD/CAM. Cranfield, England: Proceedings of the 19th CIRP Design Conference – Competitive Design; Cranfield University; 2009. pp323.
2. Gugwad, R. S., Kore, A., Basavakumar, M., Arvind, M., Mahoorkar, S., & Choudhary, R. (2011). Virtual Articulators in prosthodontics. International Journal of Dental Clinics, 3(4).
3. Pandita, A., Dod, A., & Bhat, R. (2016). Virtual articulators: a digital excellence in prosthetic and restorative dentistry. J Appl Dent Med Sci, 2, 110-117.\
4. Prosthodontics, T. (1994). The glossary of prosthodontic terms. Journal of Prosthetic Dentistry, 71, 72.
5. Solaberrieta, E., Arias, A., Barrenetxea, L., Etxaniz, O., Minguez, R., & Muniozguren, J. (2010). A virtual dental prostheses design method using a virtual articulator. In DS 60: Proceedings of DESIGN 2010, the 11th International Design Conference, Dubrovnik, Croatia (pp. 443-452).
6. Padmaja, B. I., Madan, B., Himabindu, G., & Manasa, C. (2015). Virtual articulators in dentistry: a review. Int J Med Appl Sci, 4(2), 109-14.
7. Luthra, R. P., Gupta, R., Kumar, N., Mehta, S., & Sirohi, R. (2015). Virtual articulators in prosthetic dentistry: A review. Journal of Advanced Medical and Dental Sciences Research, 3(4), 117.
8. Koralakunte, P. R., & Aljanakh, M. (2014). The role of virtual articulator in prosthetic and restorative dentistry. Journal of clinical and diagnostic research: JCDR, 8(7), ZE25.
9. Kordaß, B., Gärtner, C., Söhnel, A., Bisler, A., Voß, G., Bockholt, U., & Seipel, S. (2002). The virtual articulator in dentistry: concept and development. Dental Clinics of North America, 46(3), 493-506.
10. Szentpétery, A. (1997). Computer aided dynamic correction of digitized occlusal surfaces. J Gnathol, 16(1), 53-60.
11. http://www.businesswire.com/news/home/20110224005406/en/Sensable-Dental-Debuts-Industry%E2%80%99s-Touch –Enabled –Virtual –Articulator#.U7mUGfmSw20.