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Reweigh of classification of face bows and articulators with virtual reality - an innovation for perfection

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Abstract

Introduction: Any mechanical device used for patient simulation purpose ought to replace the exact structure which it simulates but it is not possible due to mechanical constraints. To overcome these problems, 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 and facebow.

Objectives: To assist the process and to execute the treatment plan, the mounting of a patient's diagnostic casts remains an important step, as it allows the assessment of critical factors such as occlusion for which the commonly used gadgets of dentistry are face bow and articulators.

Materials and Methods: An electronic search in Pub Med, Medline, Google search and Cochrane databases was performed up to December 6, 2019 for the pertinent literature concentrating on virtual technologies in dentistry.

Results: The literature available on the virtual articulators and face bows focusing to avoid the errors and limitations of the conventional mechanical instruments. The main advantage of using the virtual facebows and articulators is they provide six degrees of freedom.

Conclusion: These virtual articulators and facebows are not included in any of the existing classifications hence there is a need to readdress the existing classifications of facebows and articulators based on the aspects of virtual reality.

Key Words: Articulators, Classification, Face bow, Prosthodontics, Virtual.

INTRODUCTION

In a prosthodontic rehabilitation, the development of the occlusion- that is, the development of an occlusal scheme incorporating an appropriate number and location of occlusal contacts with the condyle /disc assembly in an optimum position - is paramount for the transmission of the functional and para functional forces generated. This should be done regardless of the extent of the restoration [1]. The primary reasons for this are: To avoid damaging the TMJ, teeth and muscles, since what is done at the tooth level can have consequences at the level of all these structures and to design and manufacture long-lasting rehabilitations.

In general, the clinician is always looking for ways to simplify the procedure for the fabrication of prosthesis and to decrease the time necessary to integrate it into the mouth of the patient [1]. It is often said that the patient's mouth is the best articulator. However, it is not mechanically possible to perform intra orally many of the procedures involved in the construction of fixed or removable prosthesis. Hence, for the convenience of the patient, the dentist and the dental laboratory technician it is imperative to use an analogue for jaw movements. Articulators are mechanical instruments that represent the maxilla, mandible and TMJs. Their main task is to provide a frame where it is possible to relate, in the three planes of space, the maxillary cast with the mandibular cast relative to the hinge axis of the patient and of the instrument [2,3].

An articulator serves as a patient in the absence of the patient because it can be programmed with patient records that allow the operator to fabricate a restoration that will be physiologically and psychologically successful [2,3]. Some of these devices make no attempt to represent the temporomandibular joints (face bow transfer) or their paths of motion (eccentric registrations). Some instruments allow eccentric motion determined by inadequate registrations (positional registrations).

Some utilize average or equivalent pathways. Some attempt to reproduce the eccentric pathways of the patient from three dimensional registrations [2,3]. The dentist should understand the differences between these articulating devices, and determine which would be most satisfactory for the patient. There is a need to transfer the exact terminal hinge axis position of the patients to functionally simulate the patients [4]. The device used to transfer the hinge axis of the patient to the articulator is Facebow and it is a caliper-like instrument used to record the spatial relationship of the maxillary arch to some anatomic reference point or points and then transfer this relationship to an articulator; it orients the dental cast in the same relationship to the opening axis of the articulator (GPT 9) [5].

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 and facebow. So far, the virtual Face bows and Articulators are not included in any of the existing classifications. Hence through this article we would like to readdress the present classification of the facebow and articulators by applying the advancing virtual technologies.

SEARCH STRATEGY:

An electronic search in Pub Med, Medline, Google search and Cochrane databases was performed up to December 6, 2019 for the pertinent literature concentrating on virtual technologies in dentistry by using key words like Articulator, Facebow, Virtual, Classification, Advancements, Prosthodontics etc. Full articles and articles in English language considered. Abstract are not considered for the study. Hand searched the selected references. Time restrictions not applied in the search.

DISCUSSION

Virtual reality (digitalization) refers to "immersive, interactive, multi-sensory, viewer centered, three-dimensional (3D) computer generated environments and the combination of technologies required to build these environments". Dentistry is no way exceptional to virtual reality. The use of digitalization can make carrying out dental procedures more efficient than using mechanical tools, both for restorative as well as diagnostic purposes like cad/ cam & intra-oral imaging, intra- oral scanners, digital radiography, tekscan etc [1,6].

Currently, the facebow and mechanical articulator is used for the functional simulation of the effects of dysmorphology and disocclusion. However, this mechanical scenario, so very different from the real-life biological setting, poses a series of problems. In effect, the movements reproduced by the mechanical articulator follow the margins of the structures that conform the mechanical joint, which remain invariable over time, and which cannot simulate masticatory movements that are dependent upon the muscle patterns and resilience of the soft tissues and joint disc [6].

Moreover, tooth mobility or the flabby tissue cannot be simulated by plaster models; as a result, the latter are unable to reproduce the real-life dynamic conditions of occlusion. There are also other problems derived from the procedures and materials used for assembling the models in the articulator: precision in orienting the model, expansion and contraction of the plaster, deformation of the bite-recording material, the stability of the articulator etc. Because of these basic problems, the reproduction of dynamic, excursive contacts seems to lower the reliability [7].

Virtual facebow and articulator offers the possibility of significantly reducing the limitations of mechanical devices, due to a series of advantages: accurate transfer of terminal hinge axis, full analysis can be made of static and dynamic occlusion, of the inter-maxillary relationships, and of the joint conditions, thanks to dynamic visualization in three dimensions (3d) of the mandible, the maxilla or both, and to the possibility of selecting section planes allowing detailed observation of regions of interest such as for example the temporomandibular joint. This tool incorporates virtual reality applications to the world of dental practice with the purpose of replacing mechanical articulators and thereby avoiding the errors and limitations of the latter combined with cad/cam technology, this tool offers great potential in planning dental implants, since it affords greater precision and a lesser duration of treatment [7,8].

The main advantage of using the virtual facebows and articulators is they provide six degrees of freedom.[7]

SIX DEGREE OF FREEDOM:[7]

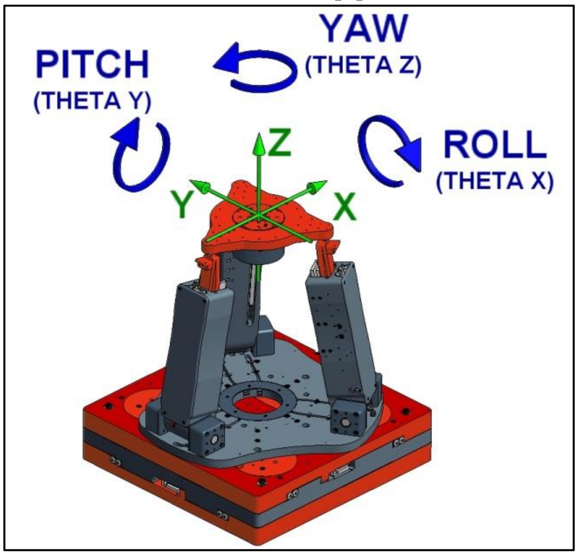


Fig 1: six degrees of freedom

Refers to the **freedom of movement of a rigid body in three dimensional space**. Specifically, the body is free to move forward / backward, up / down, left / right (translation in three perpendicular axes), combined with rotation about three perpendicular axes, often termed pitch, yaw, roll. These six degrees of freedom helps us in visualizing the all the possible movements of a rigid body in 3-dimensional space.

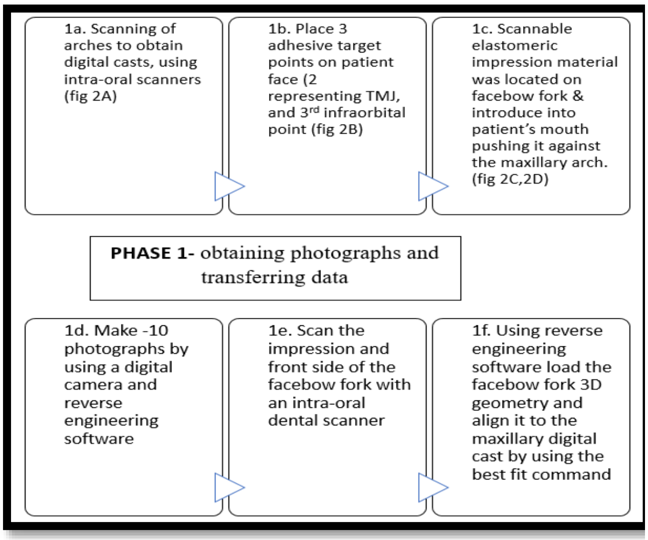
CLASSIFICATION OF FACE BOWS- to READDRESS:

FACEBOW:

Facebow is used to record the terminal hinge axis position and transfer it to the articulator which indicates it transfers the orientation of the maxillary cast to the articulator, as maxillary arch is oriented to the cranium, which is the first level of programming of an articulator, which is followed by the centric record and mounting the mandibular cast orienting it to maxilla based on terminal hinge axis position. Generally, facebows are discussed under the two main classes i.e, arbitrary and kinematic based on the accuracy they record and transfer the terminal hinge axis to the articulator. With the advancements in the ideologies and treatment planning using the virtual reality there is a need to look back and modify the previous classification.

1. Based on arbitrary location of hinge position - **Arbitrary face bow**
   - ✓ Facia type
   - ✓ Ear piece type
   - ✓ Hanau face-bow (spring bow)
   - ✓ Slidematic (Denar)
   - ✓ Twirl bow
   - ✓ Whip mix
2. Based on accurate and exact location of hinge position **-Kinematic or hinge bow**
3. Based on virtual reality **- Virtual facebows**.

TECHNIQUE OF USING THE VIRTUAL FACEBOW: [4,8,9]

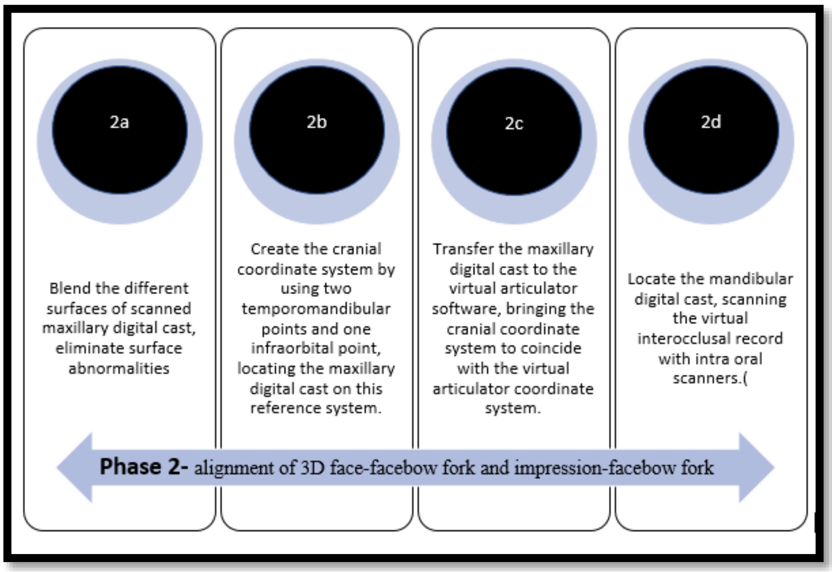


Flow chart: functioning of virtual facebow : Phase 1.

Fig 2 Functioning of facebow. 2A. Intraoral scanning using scanners, 2B. Adhesive target points, 2C. facebow fork, 2D. Impression made using Scannable elastomeric impression material was located on facebow fork.

Phase 1: obtaining photographs and transferring data
1a. Scanning of arches to obtain digital casts, using intra-oral scanners [Fig 2A]
1b. Place 3 adhesive target points on patient face (2 representing TMJ, and 3rd infraorbital point ([Fig 2B].
1c. Scannable elastomeric impression material was located on facebow fork & introduce into patient's mouth pushing it against the maxillary arch [Fig 2C,2D).
1d. Make -10 photographs by using a digital camera and reverse engineering software
1e. Scan the impression and front side of the facebow fork with an intra-oral dental scanner
1f. Using reverse engineering software load the facebow fork 3D geometry and align it to the maxillary digital cast by using the best fit command.

Phase 2: alignment of 3D face-facebow fork and impression-facebow fork
2a. Blend the different surfaces of scanned maxillary digital cast, eliminate surface abnormalities
2b. Create the cranial coordinate system by using two temporomandibular points and one infraorbital point, locating the maxillary digital cast on this reference system.
2c. Transfer the maxillary digital cast to the virtual articulator software, bringing the cranial coordinate system to coincide with the virtual articulator coordinate system [Fig 3]
2d. Locate the mandibular digital cast, scanning the virtual interocclusal record with intra oral scanners [Fig 3]



Flow chart2 : functioning of virtual facebow- Phase 2

FIG 3: Transfer to virtual articulator. A, Location of maxillary digital cast on virtual articulator. B, Maxillary and mandibular digital casts on virtual articulator.

CLASSIFICATION OF ARTICULATORS:
The range of articulators with different principles of design is so great that a system of classification is indispensable to using and teaching the theory and practice of articulation. The large number of articulators that have been developed and the wide range of adjustments involved make a classification difficult and confusing. There are many classifications given by many authors like Gillis (1926), Boucher (1934), Kingery (1934), Beck's (1962), Weinberg (1963), Posselt's (1968), Hamish Thomson , Tamura, Thomas (1973), Sharry (1974), Halperin et al, Rihani (1980), Boucher, Heartwell CM, and by The international prosthodontic workshop on complete denture occlusion in 1972 (University of Michigan) [2,3].

CLASSIFICATION TO READDRESS - ARTICULATORS:
Most widely accepted classification of articulators is by the international prosthodontic workshop on complete denture occlusion in 1972 (University of Michigan). According to this classification articulators are classified into four classes. According to the international prosthodontic workshop on complete denture occlusion in 1972 (University of Michigan) classified as:
Class-I: Simple holding instruments capable of accepting a single static registration. Vertical motion is possible, but only for convenience.
Examples: Slab articulators, Hinge articulator, Barn door hinge.
Class- II: Instruments that permit horizontal as well as vertical motion but do not orient the motion to the temporomandibular joint via a face-bow transfer.
Class II-a: Eccentric motion permitted is based on arbitrary values.
Examples: Gritmann articulator, Gysi simplex, Means value articulator
Class II-b: Eccentric motion is based on theories of arbitrary motion.
Examples: Monson articulator, Hall articulator
Class II- c: Eccentric motion permitted is determined by the patient using engraving methods.
Examples: House articulator
Class-III: Instruments that simulate condylar pathways by using average or mechanical equivalents for all or part of the motion. The instruments allow for joint orientation of the casts via face-bow transfer.
Class III-a: Instruments that accept static protrusive registration and use equivalents for the rest of the motion.
Examples: Hanau model H and H2, Dentatus, Bergstorm
Class III-b: Instruments that accept static lateral protrusive registrations and use equivalents for the rest of the motion.
Examples: Hanau Kinoscope, Ney articulator, Panadent
Class-IV: Instruments that will accept three dimensional dynamic registrations. These instruments allow for joint orientation of casts via a face-bow transfer.
Class IV-a: The cams representing the condylar paths are formed by registrations engraved by the patient. These instruments do not allow for discriminating capability.
Examples: TMJ articulator
Class IV- b: Instruments that have condylar paths that can be angled and customized either by selection from a variety of curvatures, by modification, or both.
Examples: Stuart gnathological computer, Denar model 5a

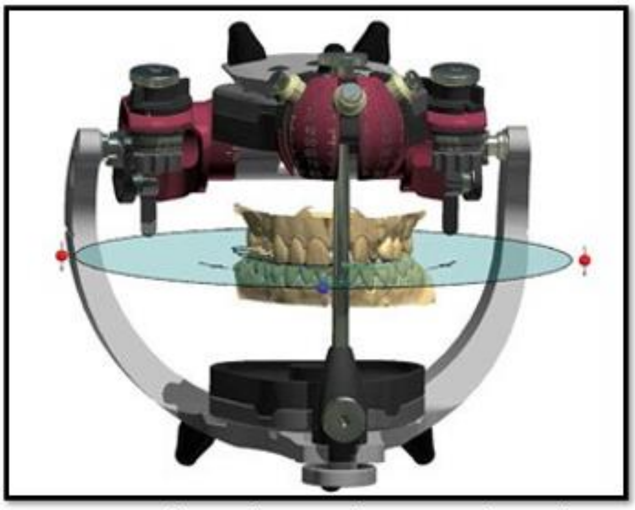
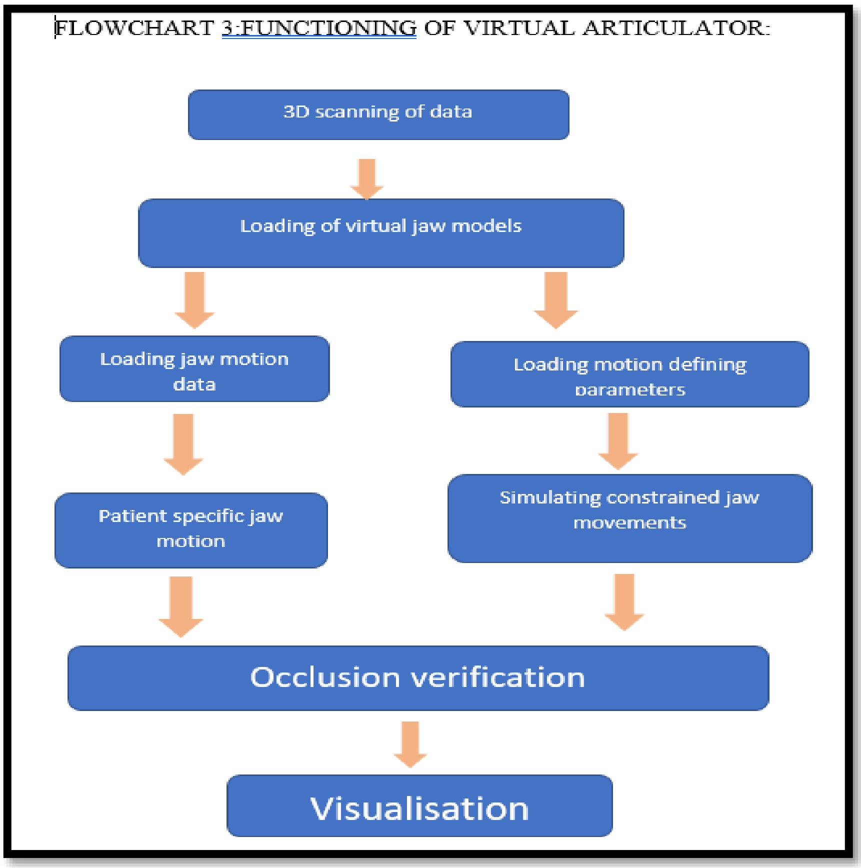


FIG 4: Virtual articulator with mounted maxillary cast

Based on the advancing science there is a need for revisiting the classification by adding the virtual articulators as class V.
Class V : articulators based on virtual reality [Fig 4],
Class V a: records exact movement paths of mandible by using jaw motion analyzer (jma)
Examples: Koidass and Gartner virtual articulators, Dent CAM virtual articulator
Class V b: It records / reproduces movements of the articulator based on mathematical simulation of articulator movements. Allow additional settings such as curved Bennett movement or other movements for adjustment in ideal settings.
Examples: Stratos 200, Szentpetery's virtual articulators.

PROGRAMMING AND FUNCTIONING OF VIRTUAL ARTICULATOR: [10],



Flowchart 3: Functioning of Virtual Articulator.

The programming and adjustment methods of the virtual articulator were described by Kordass and Gärtner in 1999. First a digital image is obtained of the surfaces of each tooth, of the global dental arches, and of the bite registries. To this effect a three-dimensional laser scanner is used, such as for example the laser scan 3D (Willytec, Munich, Germany). This scanner projects a vertical laser beam onto the surface of the object. A 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 visualization and computerized manipulation. In this phase, the real geometry of the mouth and its relation location are reconstructed in a cad system using face bow [6,9].

LIMITATIONS OF VIRTUAL ACEBOW AND ARTICULATOR: [7,10].

1. Cost effective as it requires the digital sensors, digital scanners, software's
2. Lacking knowledge about the CAD/ CAM technology, designing and modeling of virtual articulators etc.,
3. Lacking technical skills regarding interpretation of data recorded from scanners, sensors etc.,

CONCLUSION:

This article proposes a new classification system built on facebow and articulators (by the international prosthodontic workshop on complete denture occlusion in 1972). With the contemporary technology and material science advancements, the new classification system considers the role of virtual reality and its effects on modern dentistry. The value of this new classification is its effectiveness when applied to clinical scenario. The laboratory work world of dentistry today has shifted to virtual basis i.e., computer aided designing and manufacturing (CAD-CAM). 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 facebow and articulator are a precise software tools dealing with the functional aspects of occlusion along with CAD/CAM systems substituting mechanical devices and thus avoiding errors. Through this article we would like to readdress the classifications of facebow and virtual articulators based on virtual reality. May be prosthodontic speciality discuss on this classification in bigger flat forms to consider this newer classification system.

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