Review Article

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Articulators: A Review

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ABSTRACT

Background: An articulator can be called as a guide of the dental professionals. It gives the provision for adjusting the maxillary and the mandibular cast in three planes of space relative to the hinge axis of the patient and the instrument. articulators are an extremely important tool in many dental procedures since their invention in the early 19th century. Patients mouth is the best articulator, but it is not practical and convenient to work exclusively in the patients mouth at all times, thus, articulators have been designed to enable the dental surgeon and technician to study the patient's dentition and construct the prosthesis without the continued presence of the patient. The design of these instruments has proved considerably. Developments in the reliability and accuracy of these devices have revolutioned many dental techniques.in modern day dentistry a wide range of different articulator designs and models are available for the dentists although many of these require some degree of skill and knowledge to be used effectively.

Keywords: Articulator, mandibular movements, face bow, prosthesis.

INTRODUCTION

An articulator is a mechanical hinged device to which plaster models of the maxillary and mandibular jaw are fixed, reproducing some or all the movements of the mandible in relation to the maxilla. The maxilla is fixed and the scope of movement of the mandible is dictated by the position and movements of the bilateral temporo-mandibular joints, which sit in the glenoid fossae in the base of the skull.

In a rehabilitation, 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. The primary reasons for this are:

1. To avoid damaging the TMJ, teeth and muscles, since what is done at the tooth level can have consequences at the level of all thesestructures.
2. To design and manufacture long-last in rehabilitations.

In general, the clinician is always looking for ways to simplify the procedure for the fabrication of a prosthesis and to decrease the time necessary to integrate it into the mouth of the patient. An

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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. Regardless of how simple or complex the articulator may be, its effectiveness depends on how well the operator understands its features, the accuracy of registering and transferring jaw relations and how the operator uses it.[1]

Definition:

Glossary Of Prosthodontics Terms - 7: **JPD July 1997**

"It is a mechanical device which represents the temporomandibular joint and jaw member to which maxillary and mandibular casts may be attached to simulate some or all of the mandibular movements".[2]

HISTORY OF ARTICULATORS

The history of articulators parallels that of the varying concepts of occlusion. Attempts were made to record anatomic relationships or reproduce functional movements of the mandible and transfer this to the mechanical devices to simulate the conception of natural movements.

The plaster articulator devised by *Philip Pfaff* in 1756 consisted of plaster extension on the distal portion of the maxillary and mandibular casts grooved to each other. This was commonly known as 'slab articulator'.

J.B.Gariot described the first mechanical articulator in 1805. He designed the hinge joint articulator, which consisted of two metal frames, to which the casts were attached, a hinge to join them and a setscrew to hold the frames in a fixed vertical - position.

In 1840, James *Cameron and Daniley T. Evans* made attempts to device the 'plane line' articulator. The first US patient for dental articulators.

Bonwill, a mathematician, in 1858, developed an articulator based on his theory of occlusion or the theory of equilateral triangle with which he demonstrated the anatomic and balanced occlusion.

W.E Walker in 1896 said that dentures, which balanced on Bonwill's articulator, didnotbalanceinthemouthandpointedtheabsenceofc ondylarinclinationas thedictatingfactor.Hedevisedthe'Clinometer'whichh adprovisionforGothic

arch tracings.

Later every investigator tried to reproduce the individual movements of the patients' mandible. They said that the condyle path varied from person to person and even in the same person, it differs.

George B. Snow in 1899 first devised the face—bow. Later in 1906, articulator known as 'New Century instrument' was developed. He improved the Gritmann articulator of 1899 by adding the adjustable condylar paths and a tension spring for a greater range of movement. This articulator was developed in accordance with Bonwill's theory. In the modified version of the New Century Articulator, incisal pin was incorporated.

The 'Acme' articulator was an elaboration of *Snow's* New Century Instrument, which had straight condylar path, adjustable condylar inclination and provision for Bennett movement.

*Alfred Gysi*in 1910 introduced the 'Gysi Adaptable articulator'. In 1914, the 'Gysi Simplex' was introduced as a mean value articulator, which had fixed condylar guidance at33º.

Hall (19l5) and *Monson* (1918) developed the Anatomic articulator and Maxillo- mandibular instrument based on Conical theory and the theory of Spherical articulation respectively.

According to Monson-Hall school, the articulation of teeth during mastication guides the mandibular movements. Failure ofthese articulators based on theories is because provision was not made for variations from theoretical relationship that occurs in different persons.

Rudolph L. Hanau, an engineer during the time of First World War in 1921 developed' a research model called the' Hanau - Model C Articulator' which had provision for controlled movement with more accurate and accessible controls, and its adjustments and operation simplified. Later in 1923, he devised the 'Kinoscope', which provided

exact measurement of mandibular movements. In the later years, Hanau introduced more instruments such as Model 110, which had individual condylar guidance adjustments in both sagittal and horizontal planes, and the lateral condylar angle calculated by the formula L = H/8 +12, where H = Horizontal condylar angle.

In 1927, he modified the model 110 with the introduction of. Incisal guide table.

Wadsworth believed in Monson's Spherical theory but did not accept the bilateral condylar symmetry. In 1924, he developed the articulator for which facebow was used to mount the cast. It had an adjustable inter-condylar distance and the condylar paths were slightly curved.

*Stansberry*in 1929 designed the 'Tripod Articulator'. It did not accept all positional records. This instrument does not have a hinge nor mechanical equivalent or representation of condyles. This articulator reproduces positions but not movements.

Charles Stuart in 1955 designed the Fully adjustable Articulator. Later, in 1964 he introduced the Whip Mix Semi adjustable Arcon Articulator with three intercondylar adjustments — small, medium and large.

Later, *Granger, Stuart, Ney* and *Guichet* introduced the Pantographic Tracings.[3,4,5 and 6]

PURPOSES

The primary purposes of an articulator are

(1) To hold opposing casts in a predetermined fixed relationship.

(2) To open and close, and

(3) To produce border and interborder diagnostic sliding motions of the teeth similar to those in the mouth.7

USES

The uses of an articulator are

Diagnosis –used for mounting of dental casts for diagnosis, treatment planning and patient presentation in both the natural and artificial dentitions.

1. To plan dental procedures that involves positions, contours, and relationships of both natural and artificial teeth as they relate to each other.
2. To aid in the fabrication of dental restorations and lost dental parts.
3. To correct and modify completed restorations.
4. Articulators can be helpful in the teaching and studying of occlusion and mandibular movements.
5. To hold opposing cast in predetermined fixed relationship.
6. To produce border and intra border diagnostic sliding motion.
7. To diagnose dental occlusal condition in both natural and artificial dentions.[8]

IDEAL REQUIREMENTS OF AN ARTICULATOR

1. The articulator must accurately maintain the correct horizontal and vertical relationship of the patient's casts. In other words, the articulator must accurately maintain centric position.
2. The patient's casts must be easily removable and attachable to the articulator without losing their correct horizontal and vertical relationship. This is desirable for many laboratory procedures.
3. The articulator should have an incisal guide pin with a positive stop that is adjustable and calibrated. This provides positive control over the patient's occlusal vertical dimension by the dentist and laboratory technician.
4. The articulator should be able to open and close in a hinge-like fashion
5. The articulator should accept a face-bow transfer utilizing an anterior reference point. The face-bow transfer relates the maxillary cast to the horizontal axis of the articulator in the same manner that the patient's maxilla relates to the opening axis of the temporomandibular joints.
6. The construction should be accurate rigid and of a non-corrosive material.
7. The design should be such that there is adequate distance between the upper and lower members and that vision is not obscured from the rear. The articulator should be stable

on the laboratory bench and not too bulky and heavy.[9,10]

ADVANTAGES OF AN ARTICULATOR

1. Properly mounted casts allow the operator to better visualize the patient's occlusion, especially from the lingual view.
2. When articulating teeth for complete dentures, the lingual view as provided with the articulator is essential if a proper occlusal scheme is to be developed.
3. Patient cooperation is not a factor when using an articulator once the appropriate interocclusal records are obtained from the patient.
4. The refinement of complete denture occlusion in the mouth is extremely difficult because of shifting denture bases and resiliency of the supporting tissues. Interocclusal records can be obtained and complete denture occlusion can easily be refined outside the mouth on an articulator.
5. Considerably more chair time and patient appointment time is required when utilizing the mouth as an articulator.
6. More procedures can be delegated to auxiliary personnel when utilizing an articulator for development and refinement of the patient's occlusion.
7. The patient's saliva, tongue, and cheeks are not factoring when using an articulator.

LIMITATIONS

1. Articulators are made primarily of metal, although some have plastic parts. Articulators are subject to error in tooling and to error resulting from metal fatigue and wear. Even the best instrument is of little value if inaccurate casts or improper jaw relations are transferred to the articulator.

2. Any articulator does not duplicate the condylar movements in the temporomandibular joints. The condylar elements and guidance surfaces should be thought of as cams that create equivalent- like motion in the area of the teeth. The movements simulated are empty-mouth sliding motions, not functional movements. It might appear that because the articulator may not exactly reproduce intraborder and functional movements, the mouth would be the best place to complete the occlusion.

3. Regardless of how simple or complex an articulator may be, its effectiveness depends on

4. How well the operator understands its construction and purpose;

5. How enthusiastic the dentist is for the particular instrument;

6. How well the dentist understands the anatomy of the joints, their movements, and the neuromuscular system;

7. How much precision and accuracy are used in registering jaw relations;

8. How sensitive the instrument is to these records.[11]

CLASSIFICATION OF ARTICULATORS

WEINBERG (1963)12 classified the articulators into arbitrary, positional, semi adjustable, and fully adjustable.

Arbitrary - this type of articulator followed Monson Spherical theory.
Positional - this one followed Stanberry tripod concept.
Semi adjustable and Fully adjustable - these two classes are based on 29the amount they mimic the mandibular movements.
Semi adjustable – followed Hanau H concept
Fully adjustable – followed Hanau Kino scope concept, Gysi Trubyte concept and McCollum concept.

TAMURA [13]classified the articulators into three types.

i. *Fully adjustable articulators* - they have the capability of adjusting the condylar paths in three planes and can accept a kinematic axis transfer. The lateral condylar path on the working side can be customized for Bennett movement.

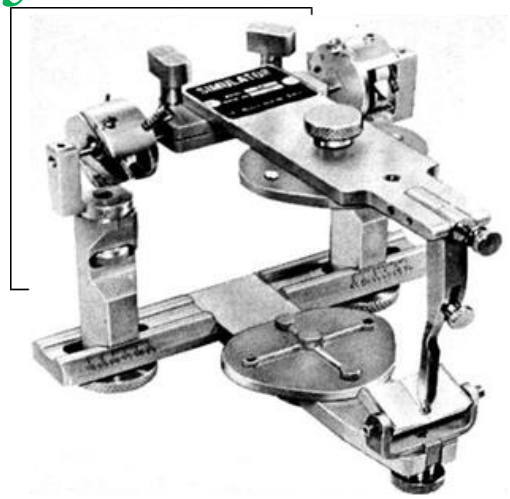

Fig 1: Simulator.

ii. Semi-adjustable articulators - permit adjustments of the sagittal condylar path and the lateral condylar path on the non-working side only reproduce these paths by a straight-line.

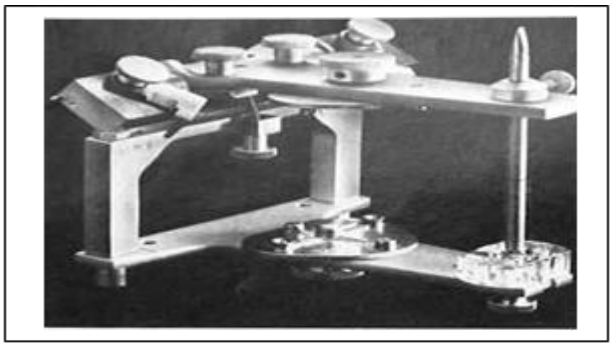

Fig 2: whip- mix.

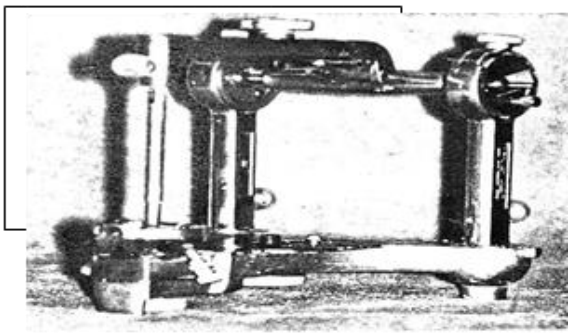

Fig 3: Hanau H2.

BOUCHER14 ,15classified the articulators based on

1. the theories of occlusionand
2. the types of records used for theiradjustment.

Based on the theories of occlusion Boucher classified the articulator into three.

1. The Bonwill theory of occlusion proposed that the teeth move in relation to each other as guided by the condylar controls and the incisal point and there was a 4-inch distance between the condyles and between each condyle and the incisor point. This theory was known as theory of equilateral triangle. The articulator designed by Bonwill allows lateral move men sonly.
2. The Conical theory of occlusion proposed that the lower teeth move over the surfaces of the upper teeth as over the surface of a cone, generating an angle of 45 degrees, with the central axis of the cone tipped 45 degrees to the occlusal plane. The Hall Automatic articulator designed by R.E. Hall conforms this theory.
3. T+he spherical theory of occlusion by G.S. Monson proposed that the lower teeth moving over the surface of the upper teeth as over the surface of a sphere with a diameter of 8 inches. The center of the sphere was located in the region of the glabella, and the surface of the sphere passed through the glenoid fossa along or concentric with the articulating eminences. The maxillo mandibular instrument and the Hageman Balancer follow this theory.

CHARLES M. HEARTWELL Jr16, classified the articulators into two classes.

ClassI- These instruments receive and reproduce three dimensional graphictracings. These can be adjusted to permit individual condylar movement in three planes and can reproduce timing of the side shift of the orbiting side and its direction on the rotating side. These are called four dimensional instruments. Some of the examples are Stuart Gnathologic instrument, TMJ articulator, Hanau Modular system, Denar D5A.

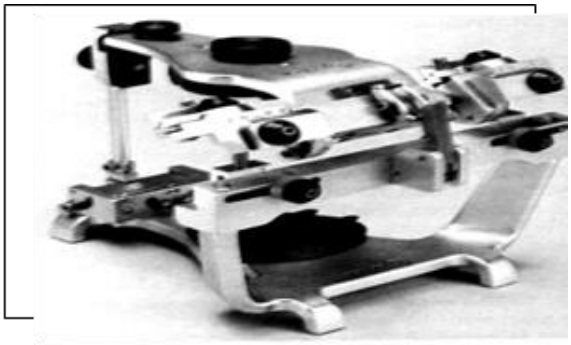

Fig 4: Denar D5A.

Fig 5: Modular articulator system.

Class II- These instruments will not receive three-dimensional graphic recording. Some have fixed controls; others are adjustable in no more than two planes. Most are set to anatomic averages or with some type of positional records. Condylar fossa analogs are used. The Class II is subdivided into four types:

Type 1 (Hinge) can open and close in a hinge movement. Few permit limited excursive movements. They do not accept face-bows.

Fig 6: Gariot.

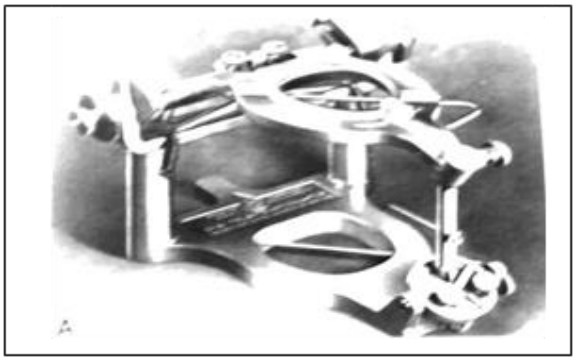

Fig 7: Gysi trubyte.

Type 2 (Arbitrary)These articulators are designed to adapt to specific theories of occlusion or are oriented to a specific technique. Examples :Verticulator, Monson, Transograph

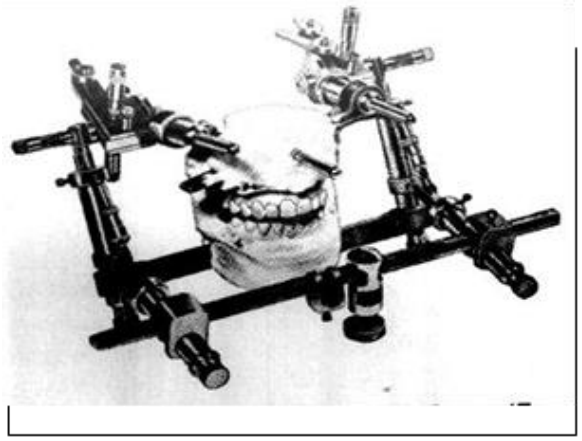

Fig 8: Transograph.

Type 3 (Average) are designed to provide condylar element guidance by means of averages, positional records, or minicorder systems. Most permit adjustments of both horizontal and lateral guidance. Accept face bow transfer.

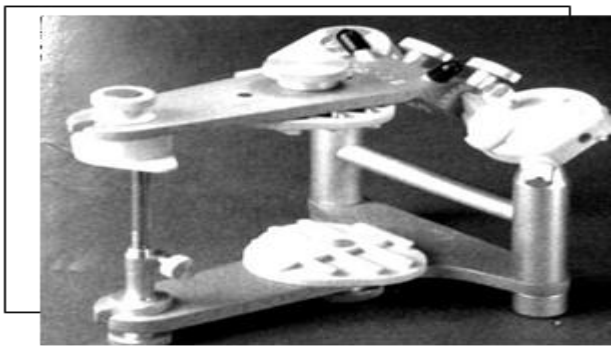

Fig 9: SAM

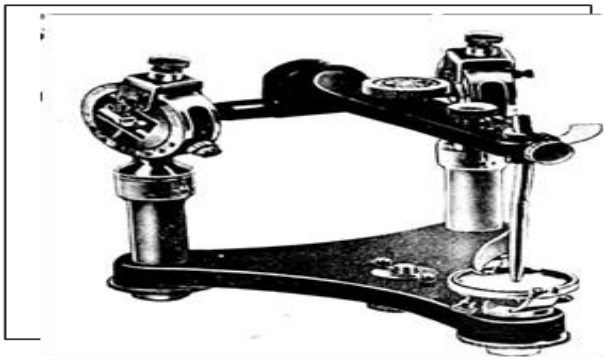

Fig 10: Dentatus.

International Prosthodontics Workshop (University of Michigan in 1972) on complete denture occlusion proposed an articulator classification based on instrument function as given in WINKLER. This is considered best classification

till date as the maximum no. of articulators can be included in this.

It classified the articulators into four classes and several subclasses based on the instrument capability, intent, registration procedure and registration acceptance.

Class I- Simple holding instrument capable of accepting a single static registration. Vertical motion is possible, but only for convenience.

Some of the examples are the Plaster articulator more commonly known as Slab articulator, Gariot's articulator, Barn Door hinge articulator.

Class II- Instrument that permit horizontal as well as vertical motion but do not orient the motion to the temporomandibular joints via a face-bow transfer.

A - Instruments in this class permit eccentric motion based on averages and will not accept a face-bow transfer. Cvondyles are on the lower member and inclined at 15.

A typical example is Grittman articulator, Gysi Simplex

B - Instrument in this class permit eccentric motion based on arbitrary theories of motion and will not accept a face-bow transfer.

Example is Maxillo mandibular instrument designed by Monson.

C - Instruments in this class permit eccentric motion based on engraved records obtained from the patient, and will not accept a face - bow transfer.

Example being the House articulator designed by M.M.House.

ClassIII- Instruments that simulate condylar pathways by using average or mechanical equivalents for all or part of the motion. These instruments allow for joint orientation of the casts via a face-bow transfer. Don't accept static, protrusive or lateral movements. Typical articulator for this category is Hanau Mate. It is an arcon instrument and will accept face bow transfer. They have an Av. condylar guidance of 300, Bennett angle of 150, incisal guidance100. It has two subclasses A and B.

A - Instruments in the class accept a face-bow transfer and a protrusive interocclusal record. Most popular one in this class is Hanau Model H articulator. Another one in this class is Dentatus articulator

B - Instruments in this class accept a face-bow transfer, a protrusive interocclusal record and some lateral interocclusal records.

Examples are GysiTrubyte articulator, Kinescope, Stansberry articulator, Ney articulator, Hanau Model H 130-21 articulator, Teledyne articulator, Whip-Mix articulator, Denar Mark II articulator, Panadent

*Class IV*Instruments that will accept three - dimensional dynamic registrations.

These instruments allow for joint orientation of the casts via a face-bow transfer.

A - The cams representing the condylar paths are formed by registrations engraved by the patient. These instruments do not allow for discriminating capability of the condylar pathways.

Example is the TMJ instrument designed by Kenneth Swanson.

B - Instruments that have condylar paths that can be angled and customized either by selection from a variety of curvatures, by modification, or both. The three-dimensional dynamic registration procedure utilized in this class is the pantographic tracing procedure. The tracings produced by the pantograph are called pantograms. All articulators in this class are arcon instruments with adjustable intercondylar distances. Fourth dimension i.e. time of starting of Bennett movement is also incorporated. They are often referred to as *Gnathologic instruments*.

One of the older instruments in the class that is still utilized is the Gnathoscope designed by Charles

Stuart. Other articulators in this class are Denar D4A, Pantronic by Denar and Simulator.[17]

Recent advances:

- The virtual articulator (VA) is intended for use as a tool for the analysis for the complex static and dynamic occlusal relations. Its chief application is in individual diagnosis and the simulation of the mechanical articulator
- The future of dentistry is linked strongly to the use of computer technology specifically virtual reality, which allows the dental surgeon to simulate true life situations inpatients.
- Virtual reality 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 the mechanical articulator.
- Virtual articulators also known as "software articulators" 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-freemovements.[18,19]

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.
- 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 inmouth.[20]

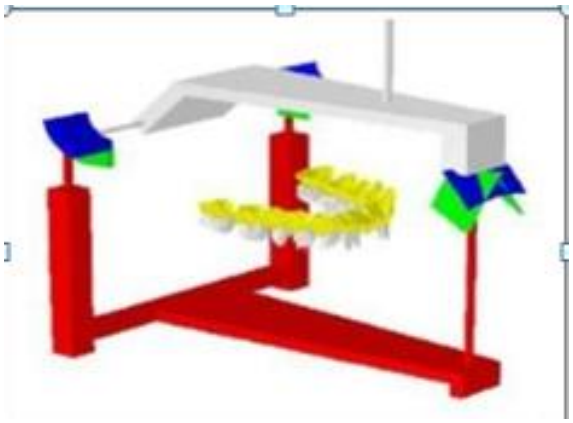

Fig 12: Szentpetery's virtual articulator

DISCUSSION

Early articulators were based on individual theories of occlusion. However, the normal variation in mandibular movement between patients, and even the variable movement of the joints within one patient, soon made it necessary to design adjustable articulators. An emerging understanding of the neurophysiology of mandibular movement and the influence of several morphological and behavioral considerations led to the notion that each patient is his or her own best articulator. Therefore, the diverse, and frequently subtle, variations required for each individual occlusion could be more easily achieved with an adjustable articulator that accepted a variety of records. The final "individualization" of an occlusion can then be done intraorally as required.

SUMMARY & CONCLUSION

Dentists have over 300 different articulators to choose from, and their Evolution through the years has given an insight of the researchers trying to develop a mechanical device that simulates the jaw movements.

The history of the development of Articulators is filled with many interesting theories and conflicting concepts.

In the last two or three decades, there have been concurrent tendencies either to reduce the articulator to a simple hinge or to make them more and more complex so that to record all Mandibular movements.

Many dentists argue that the best articulator is the patient's mouth, because that is where the

prosthesis ends up and that is where it "has to be adjusted anyway."

The success or failure of the final restoration is more dependent on the operator of the Articulator than on the Articulator itself. In other words, a semi adjustable articulator in the hands of a knowledgeable clinician may be of greater assistance in treatment than may a fully adjustable articulator in the hands of an inexperienced operator.

The Late Carl O Boucher summed up the articulator controversy by stating, "It must be recognized that the person operating the instrument is more important than the instrument. If dentists understand articulators and their deficiencies, they can compensate for their inherent in adequacies".

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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