ARTICULATORS IN DENTISTRY

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ABSTRACT

Selection of articulator has a direct bearing on the success of fixed or removable restorations. To avoid problem with fixed or removable restorations the use of fully adjustable articulators which duplicate the mandibular movements with a high degree of precision is recommended. Articulator simulates equivalent movements of the TMJ but does not duplicate or produce identical movements as in the human mouth. It forms an important instrument to the dentist as it can be programmed with certain patients records allowing the operator and laboratory technician to fabricate a restoration that will be physiologically and psychologically acceptable. Properly mounted cast allow the operator to better visualize the patient occlusion from the lingual side. Chair side appointment is reduced and more work can be designated to the auxillary personnel.

KEYWORLD Articulators, Semi-adjustable, Fully adjustable, Facebow.

INTRODUCTION

In the fabrication of indirect dental prosthesis a mechanical device is used to relate opposing casts called an articulator. An articulator is 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 movement (GPT 05). It is generally known that the mechanical articulator originated as a simple hinge. The first improvements to the simple hinge came in the form of vertical and horizontal adjustment features. Hand held casts can provide information concerning alignment of the individual arches but do not permit analysis of functional relationships. For an analysis, the diagnostic casts need to be attached to an articulator. Articulators simulate the movement of the condyles in their corresponding fossae.[1]

REVIEW OF LITERATURE During the last two decades of 18th century, the profession was heavily influenced by the pervasiveness of Bonwill's philosophies and his so-called "Anatomical" articulator. As the new century approached, investigators began to have a much better understanding of the nature of mandibular movement. This was substantially due to breakthrough contributions like those of William E. Walker (the first adjustable condylar guide articulator, 1896), George Snow (the facebow, 1899), and Carl Christensen (the intraoral "check bite" technique, 1901). For the first time, a practical and accurate method for taking information from the patient and transferring it to an adjustable articulator was possible.[2] Some aspects of jaw physiology have been easy to duplicate mechanically on an articulator, such as the hinge movement, relation of casts to the hinge, and inclination of the condylar path. Consequently these features appeared first on the instruments. Other movements have been more difficult to reproduce mechanically. Among them are the Bennett movement in three dimensions, the timing of the Bennett movement, the exact curvature of the condylar path, and a determination of the intercondylar distance. The problems involved in duplicating these features have been solved by modern instrument design[3]. Articulators with improved functional features, such as those designed by Bonwill, Gysi (the "Simplex"), Snow, Gritman, and Kerr, were readily available but were regarded as too complicated. Even more troubling, the average practicing dentist was apathetic to the deplorable state of artificial teeth available. Realistically, most dentists did not have a clue as to why 90% of their removable prostheses were failures. Over the last 120 years, hundreds of different articulators have been constructed. Throughout these years there has been no remarkable development on articulators. Today's articulators are handy, functional and more precise in both construction and operation. An articulator can simulate but they cannot duplicate all mandibular movement. They are classified according to how closely they can reproduce mandibular border movements. Dental restorations should be fabricated on an articulator that can accurately reproduce the mandibular movements in order to minimize the need for intraoral occlusal adjustments[4]. Most single crowns and simple fixed partial dentures are fabricated on small hinge articulators that have limited ability to duplicate mandibular movement or none at all. While many of the inaccuracies produced by this type of instrument may be corrected in the mouth using valuable chair time, the end result is an

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occlusion that is less than optimal. Unfortunately, many of these inaccuracies are not recognized and are allowed to remain in the mouth as occlusal interferences which frequently produce symptoms of occlusal disease[5]. Semiadjustable articulators are commonly used for the fabrication of occlusal surfaces of crowns, fixed partial dentures, implant prostheses and conventional complete and removable partial dentures during diagnoses and treatment planning[4] The success of fixed or removable restoration directly depends on the articulator selected as well as the skill and care with which it is used. An articulator classification was developed based on the instruments function, instrument capability, intent, registration procedure and registration acceptance were considered

Classification of Articulators:

An articulator classification was developed based on the instruments function, instrument capability, intent, registration procedure and registration acceptance were considered. Gillis' divided articulators into two classes: (1) the adaptable or adjustable type and (2) the average or fixed type. Boucher classified articulators as nonadjustable or adjustable. He also subdivided the adjustable type into two groups: (1) a two-dimensional instrument and (2) a three-dimensional instrument. Based on the design of articulators, another classification was devised by Beck. He divided articulators into three categories: (1) the suspension instrument, (2) the axis instrument, (3) the tripod instrument. Posselt classified- articulators as plain line, mean value, and adjustable. Sharry classified- articulators as simple, hingetype, fixed-guides type, and adjustable. Heartwell and Rahn: emphasizing the role of pantographs in record registration, divided articulators into two classes:

(1) instruments that will receive and reproduce pantographs and graphic tracings.

(2) instruments that will not receive panto- graphs, which are subdivided into four types: (a) hinge type, (b) arbitrary, (c) adjustable, and (d) instruments designed and used for complete denture construction.

Thomas, attempting to simplify the classification of articulators, devised a new classification based on the type of records used. He divided articulators into three types:

(1) arbitrary (not adjustable),

(2) positional (axis and nonaxis types, static records)

(3) functional (axis and nonaxis types, functional records).

Classification Of Articulators Using The New System:

• *A nonadjustable articulator* can accept one or two of the following records: Face bow, centric jaw relation or protrusive record. Gariot, 1805; Evans, 1840; barn door hinge, 1858; Bonwill, 1858; Walker, 1896 (has adjustable condylar guidance, but does not accept the facebow record); Gritman, 1899; Snow, 1906; Gysi Simplex, 1912 Monson, 1918; Stansbery, 1929 (based on the tripod theory, where there is no condylar control); Philips Occlusoscope, 1931 (based on the tripod theory also, and does not accept the face-bow record); Kile Dentograph, 1945 (based on the principle of the tripod); Transograph, 1952 (contains two face-bows, upper and lower, connected to each other; there is no condylar guidance); and Pankey-Mann, 1955 (based on the spherical theory using special face-bow to mount the mandibular cast).

• *A semi adjustable articulator* can accept all three of those records. Snow Acme, 1910; Gysi Adaptable, 1910 (does not accept lateral records); Hanau H, 1922, Wadsworth, 1924; Gysi Trubyte, 1926 (does not accept the intercondylar distance record); House, 1927 (does not accept the intercondylar distance record, satisfies Bonwill principles); Dentatus, 1944 ; Berg strom Arcon, 1950; Hanau 130-28, 1963; and Whip- Mix, 1968.

• *A fully adjustable articulator* can accept the following five records: Face bow,centric jaw relation, protrusive, lateral records, and intercondylar distance record Hanau Kinescope, 1923; McCollum Gnathoscope, 1935; Granger Gnatholator, 1950; Stuartarticulator, 1955; Ney-Depietro, 1962; Hanau 130-2 1, 1963 ; Simulator, 1968; and Denar D4-A,1968. The non adjustable articulator incorporate average patient values to represent the inclination of the glenoid fossa and the codyle fossa relationship and so cannot accurately reproduce an individual's mandibular excursive movements[7]. Ideally, *a semi-adjustable* articulator should simulate mandibular movements in three planes in order to develop occlusal morphology of restorations that permit the passage of opposing cusps without interfering with mandibular movements[8]. Anatomical determinants, recorded by interocclusal check records, are transferred to semi-adjustable instruments to program the mechanical components that control the movements and influence the occlusal morphology of restorations[9-13]. The greater the accuracy in reproducing mandibular movements, the less will be the occlusal correction required when the restorations are seated in the mouth[14]. Semiadjustable articulators are commonly used for the fabrication of occlusal

surfaces of crowns, fixed partial dentures, implant prostheses and conventional complete and removable partial dentures during diagnoses and treatment planning[4].

A fully adjustable articulator has a wide range of positions and can be set to follow a patient's border movements. The final step in the progression of articulators is the fully adjustable instrument. Fully adjustable articulators have a large range of adjustability in three dimensions and are accordingly the most complex and expensive. The accuracy of reproduction of movement depends on the care and skill of the operator. They can be very useful as treatment complexity increases. When it is necessary to restore entire dentition, especially in the presence of atypical mandibular movement. A fully adjustable articulator can accept the following five records: Face bow, centric jaw relation, protrusive, lateral records and intercondylar distance record.

Bonwill theory articulators/theory of equilateral triangle: During the 1864 meeting of the American Dental Association, Bonwill demonstrated his "anatomical articulator," His design varied from others in that he recognized that the "condyles often move away from the position they occupy during hinge closure." Its simplicity and practicality led to quick acceptance and usage by the profession. His theories and fundamentals would become the basis for articulation of teeth and for subsequent articulator design. In Bonwills own words: "There can be no excuse for failure or unartistic work when this instrument is once understood, and the law controlling the human jaw.

• According to this theory the teeth move in relation to each other as guided by the condylar and incisal guidance's

• Distance between the condyles and distance between condyles and midpoint of central incisors is equal[15].

Function of articulators*:*

• The primary function of the articulator is to act as a representative in patients

•It is used to simulate the patients temporomandibular joint, muscles of mastication, mandibular ligaments, maxilla and mandible and the complex neuromuscular mechanism that programmes the mandibular movements.

•The articulator is made to simulate the equivalent movements of the TMJ but does not duplicate or produce identical movements as in the human mouth

•It forms an important instrument to the dentist as it can be programmed with certain patients records allowing the operator and laboratory technician to fabricate a restoration that will be physiologically and psychologically acceptable.

Requirements of articulators:[6]

(1) face-bow record
(2) centric jaw relation record
(3) protrusive record
(4) lateral records
(5) intercondylar distance record

Other requirements:

• It should hold casts in correct horizontal and vertical relationships i.e., centric relations.

• It should provide a positive anterior vertical stop.

•It should accept a face bow transfer record. It should open and close in a hinge movement.

•It should allow protrusive and lateral jaw motions

•Moving parts should move freely and accurately

•Moving parts should be often rigid construction

•Should be easy to fix and attach the maxillary and mandibular cast to the articulator and also to attach from the articulators

Four features are required of an articulator:

1. centric relation of the mandible
2. control of lateral incisor point movements
3. sagittal inclinations of the condylar path
4. incisor path

Four methods of adapting the articulator

1.The intra-oral checkbite method with plastic material
2. The intra-oral checkbite method with plaster
3. The extra-oral graphic method with the face-bow
4. The intra-oral dentographic method

Uses in Prosthodontics

1. Semiadjustable articulators are essential in planning fixed prosthodontic treatment.
2. To diagnose the state of occlusion in both the natural and artificial dentition.
3. To plan dental procedures based on relationship between opposing natural and artificial teeth e.g. evaluation of the possibility of balanced occlusion.
4. To aid in the fabrication of restoration and prosthodontic replacements.
5. To correct and modify completed restorations.
6. To arrange artificial teeth.

Uses in Restorative Dentistry

1. For most single restorations, a nonadjustable articulator with a fixed condylar path will produce an acceptable result.
2. When multiple restorations or fixed partial dentures are being fabricated, greater segments of the occlusion are being replaced, and there is a need for accuracy. If there has been no loss of the vertical

Table 1. Matching treatment with articulators

Treatment	Use	Articulator Manufacturer
Single restoration	1. Simplex articulator 2. Laboratory Technical 3. Steele's articulator	Dentsply International, Inc. York, PA Teledyne Dental (Hanau Div.) Buffalo, NY Columbus Dental Mfg. Co. Columbus, OH
Multiple restorations Fixed partial Dentures, and Mimimal occlusal Pathology	1. Mark II articulator 2. ARH articulator 3. H-2 articulator 4. New Occlusomatic Articulator 5. Teledyne articulator 6. Whip-Mix articulator	Denar Corporation, Anaheim, California A B Dentatus, Hagersten, Sweden (available through Almore Mfg. Co. Portland, Oregon Teledyne Dental (Hanau Div.) Buffalo, NY Shizai International, Inc. Tokyo, Japan (available through U.S. Shizai Corporation Los Angeles, CA) Teledyne Dental (Hanau Div.), Buffalo, NY Whip-Mix Corporation, Louisville, KY
Multiple restorations In opposing quadrants, Full-mouth reconstruc-Tion, and extensive Occlusal pathology	1. Aderer simulator 2. D 5-A articulator 3. Model P 4. Stuart articulator 5. TMJ articulator	J. Aderer, Inc. Long Island City, NY Denar Corporation, Anaheim, CA Panadent Corporation, Colton, CA C.E. Stuart, Ventura, CA TMJ Instrument Company, Inc. Thousand Oaks, CA14.

dimension of occlusion and no evidence of occlusal disease or an immediate side-shift, the use of a semiadjustable articulator is warranted. Use of a face-bow transfer further minimizes tooth-hinge axis errors, although some still exist if an arbitrary hinge axis us used as the point of reference. Lateral checkbites (interocclusal records) are used to set the condylar inclination, and adjustment for the Bennett angle is possible. This type of instrument will also provide incisal guidance. While errors still exist in the semiadjustable articulator, it is a definite step upward from the nonadjustable articulator.

3. The fully adjustable instrument is indicated for extensive treatment in which opposing quadrants are restored, for reconstruction of the entire occlusion, and for patients with a significant side-shift during lateral mandibular movements. Its use is particularly desirable when there is a need to restore lost vertical dimension or when there is evidence of occlusal disease and breakdown[14].

Uses in Surgery

1. Articulation of study models is an essential part of the presurgical preparation in patients undergoing orthognathic surgery. The articulator is used to support the study models on which the surgical moves are performed prior to the construction of inter-occlusal wafers. The crucial question for model surgery is whether it is necessary to use a facebow record to transfer the condyle tooth relationship to the articulator[7].

Uses in Orthodontics

1. Where a significant discrepancy (>2mm) exists between the retruded contact position and the intercuspal position. Diagnosis will be assisted by knowledge of the magnitude of the discrepancy, which can be measured on the articulator.

2. Orthodontic cases with multiple missing teeth, in which a stable inter-cuspal relationship cannot be recorded.

3. Cases undergoing maxillary and bimaxillary orthognathic procedures.

4. Articulator mounting of study models pre-orthodontic and pre debond in individuals with temporomandibular disorders[7].

Virtual Articulators-

Dental Virtual Articulator simulates and analyzes mandibular movements of the human jaw. This is achieved by means of CAD systems and Reverse Engineering tools. Different articulators have been selected to be modelled through different CAD systems (SolidEdge and CATIA). The design process has been carried out using measuring tools and Reverse Engineering tools available at the PDL. These tools are: Handyscan\REVscan 3D scanner and its software (VXscan), Reverse Engineering and Computer-Aided Inspection Software (Geomagic Studio and Qualify), Rapidform XOR, as well as ATOS I rev.2 GOM 3D scanner. Once the articulator is digitized, the next stage is to obtain the upper and lower dentures digitally. Apart from this, it is necessary to register the relative location of the occlusal surface referred to the intercondylar axis. This is achieved by means of the face bow. Afterwards, the design of the dental prosthesis is developed using the CAD system and finally, mandibular movements are simulated. Once the articulators are selected, their structures and shapes are analyzed in order to clarify how to use the Reverse Engineering and measuring tools. The general structure, this is, upper and lower bodies, is similar in both articulators, but the TMJ-s, which are the most important part of the articulators, present a great variety of configurations. The technician can choose the type and adjustment of the articulator. There are several advantages in producing computer-aided prostheses such as time, data registration, material resistance, control of several parameters, etc. Therefore, nowadays there is no doubt as to the vast potential offered by CAD/CAMsystems. Throughout the last years, thanks to 3D scanning and computing developments, some very relevant improvements have been made in digital dentistry.

Virtual Articulator Design Process

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 greatly simplified. Since 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, however, does not act as a simple hinge. Rather than this, it is capable of rotating around axes in three planes Once the articulators are selected, their structures and shapes are analyzed in order to clarify how to use the Reverse Engineering and measuring tools. The general structure, this is, upper and lower bodies, is similar in both articulators, but the TMJ-s, which are the most important part of the articulators, present a great variety of configurations The Virtual Articulators are able to design prostheses kinematically. They are capable of:

1. Simulating human mandibular movements,
2. Moving digitalized occlusal surfaces against each other according to these movements, and
3. Correcting digitalized occlusal surfaces to enable smooth and collision-free movements.

An educational module is constructed for didactic objectives in order to:

-demonstrate and illustrate the functions of dental articulators and the human masticatory system

-simulate different types of excursive movements and its influence on the occlusal surface.

-analyze the role and influence of different parameter settings on articulator movements.

-analyze of the occlusion of digitized occlusal surfaces of natural dental arches[16].

The two main practical implications of this research project are the improvement of existing dental CAD-CAM systems by adding the kinematics and the analysis of the simulations of different articulators, since each articulator has an individual pattern of movement.

Current popular articulators[17]

1. Mean Value Articulator

Also called as "Three Point Articulator or Free Plane Articulator", these instruments are routinely used in dental colleges to teach undergraduate students. These instruments are nonadjustable, non arcon type, designed using fixed dimensions. A spring is mounted within the condylar track to stabilize the condylar elements and hold them in their posterior most position.

Hanau H2 Articulator

These instruments are condylar or non arcon type. Its prototype, the model H, designed by Rudolph Hanau, was originally designed for complete denture construction, both models have received widespread acceptance throughout dental profession. The Hanau H2 articulator has a fixed Intercondylar distance of 110 mm and does accept a face-bow transfer. The lateral horizontal condylar inclinations are simulated by means of a protrusive interocclusal record. Hanau suggested the formula L = (H/8) + 12 (L = Lateral condylar angle in degrees and H = horizontal condylar inclination in degrees) to arrive at an acceptable side shift angle. The lateral adjustment for side shift range from 0-30 degrees. The mechanical incisal guide table is adjustable both in sagittal and frontal planes. The face-bows that can be utilized with the Hanau H2 articulator are the facia face-bow, the earpiece face-bow, the Twirl-bow and the adjustable axis or kinematic face bow

Whip Mix Articulator

The basic Whip-Mix is an arcon articulator. It was designed by Charles Stuart in 1955 so that restorative dentistry could be accomplished with greater precision without the use of very expensive equipment or more time consuming techniques. The intercondylar distance is adjustable to three positions: small (S), 96mm; medium (M), 110 mm; and large (L), 124 mm; by means of removable condylar guidance spacers along the instrument's horizontal axis. The horizontal condylar inclinations are set by means of a lateral or protrusive interocclusal record. The amount of Bennett movement is set by means of a lateral interocclusal record. The articulator is available either with a mechanical incisal guide table, adjustable in both sagittal and frontal planes, or with a plastic incisal guide table that can be individually customized. The face bows that can be utilized with the Whip-Mix articulator are Quick Mount or earpiece face-bow and the adjustable axis or kinematic face-bow. The bridge of the nose is utilized as the anterior reference point with the earpiece face-bow. The incisal guide in is straight and one end is flat and the other end rounded.

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