 DOI: 10.18231/2455-8486.2017.0013

Mandibular Movements: Record and analysis from time immemorial

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Introduction

We are blessed with a dynamic masticatory system which allows us to function and exist. It is a highly intricate unit and primarily related to chewing, speech and swallowing. The ever so delicate balance between the various components of the system is monitored by the neuromuscular control.(1) Maxillo-mandibular relationships establishment has got the attention of prosthodontists ever since the dynamic and static positions of the condyles in the glenoid fossa were interpreted and understood. In an edentulous patient, the teeth along with periodontal nerves are lost.

Mandibular movement is defined as "any movement of the lower jaw" and is determined by the simultaneous activities of the TMJ. The form of the bilateral temporomandibular joints and their function facilitate the mandible in making a variety of movements mainly carried out in three different planes namely the sagittal, the frontal and the horizontal planes. Mainly these movements produce rotational (turning) and translational (sliding) motions. The rotatory or the hinge like movement occurs between the condyle and the articular disc. Basically, there are a couple of movements of the mandible:

- The functional movements which are characteristic naturally occurring movements that occur during mastication, speaking and yawning.
- The parafunctional movements which are non-characteristic movements like clenching, tapping etc.

The maximum movement in a plane or direction is termed the *border movement*. There is a wide range of movement called *intraborder movement* that occurs within the confines of the border movements. Border movements are reproducible. Hence, they can be measured mechanically. Intraborder movements cannot be measured with accuracy as they are not reproducable. Just a precise mandibular movement is required to move the teeth efficiently across each other. It is, therefore, very important for a clinician to know thoroughly the various movements of the mandible.

History

A lot of research and studies have been conducted to study the movements of the mandible right from 18th century.

Phillip Pfaff [1756](2) studied mandibular movements and designed plaster articulator known as slab articulator. Jb Gariot [1805](3) stated that mandible moves in a hinge like fashion and designed the "Hinge joint articulator "to simulate mandibular movements. WGA Bonwill[1858](2) designed and developed the first articulator with a effort to mimics the mandibular movements in eccentric positions. He gave the equilateral triangle theory, in which there was a distance of 4 inches between the condyles and between each condyle and incisor point. It was proposed that the teeth movement is in relation to each other guided by the condylar controls and the incisal point. It is known "Bonwill theory of occlusion." Gilmor [1862] proposed individual orientation on an articulator by the measurement of individual distances between the joints and the incisors. Hayes [1889](2) noticed the condylar path and introduced sloping joint paths in an articulator. Later, Snow [1889] introduced "face bow "for the reproduction of the upper jaw position with respect to the condyles and Luce(5) photographed the sunlight reflection from beads placed opposite to the condyles in the same year. WE Walker [1896](5) stated that the absence of condylar inclination is the dictating factor and said that the dentures balanced using Bonwill's articulator did not balance in the mouth. He gave "facial clinometer" for the measurement of the condylar movements.

In the beginning of the 20th century, Norman Bennett [1908](5) traced the light pathway positioned opposite the condyles. He gave a direct immediate shift of the working side condyle known as *Bennett shift* as he studied the lateral mandibular movements. He also gave a Bennett angle on the balancing side [angle between sagittal axis and medial movement of balancing condyle]. Alfred Gysi of Zurich [1908] devised Gysi adaptable articulator having the condyles at lower member, condylar paths inclined at 30 degree, and incisal guidance fixed at 60degree. Later in 1914, "Gysi simplex articulator"(3) was introduced as an mean value articulator which has fixed condylar guidance at 33 degree. RE Hall [1915] devised "Hall automatic articulator" based on conical theory of occlusion. This theory stated that lower teeth move over the surfaces of upper teeth as over the surface of a cone, producing an angle of 45 degree having the central axis of the cone tipped 45 degree to the occlusal plane. A maxillo-mandbular instrument based upon spherical theory of occlusion was given by GS Monson [1918] which said that the lower teeth move over the surface of upper teeth as over the surface of a sphere with a Diameter of 8 inches (20cm). The center of the sphere was situated

in the area of glabella, and the surface of the sphere passed through the glenoid fossa or concentric with the articulating eminencies. A mechanical engineer, Rudolph Hanau [1923][(3)] designed Hanau model H articulator, most widely used for fabrication of complete dentures. Alfred Gysi [1929] recorded condylar paths with his instrument. He used extraoral tracings for recording left and right posterior border movements, which were similar to a Gothic arch in shape. Hildebrand [1931] studied condylar movements by roentgen fluoroscopy. Boucher [1934] and also Kingery [1934] studied various mandibular movements and classified the articulators into two categories: non-adjustable and adjustable. Mc Collum [1939] devised Gnathoscope based on the principle of Granger gnatholator. Bergstrom [1950] devised an instrument called Arcon. Few years later, Charles Stuart [1955] studied mandibular movements in three dimensions and devised a fully adjustable articulator. "Kile Dentograph" was given in the same year by Kile [1955] to simulate mandibular movements. A true arcon instrument, Ney articulator was designed by AJ De'Petro [1960][6]. Beck [1962] classified articulators into three categorized namely suspension instrument, axis instrument and tripod. Masserman and Gibbs [1962] devised Gnathic replicator and jaw motion replicator. Then in the year 1963, Weinberg classified articulators into four categories: arbitrary, positional, semi adjustable and fully adjustable. In the same year, "Whipmix" semi adjustable Arcon articulator was introduced by Charles Stuart. An year later, Richard Ben and James Janik designed Hanau 130-21 series of articulators. Kenneth Swanson [1965] studied TMJ movements and gave the TMJ approach to articulator. He gave TMJ articulators and made stereographic recordings and produced fossae in auto-polymerizing acrylic resin which sere an accurate analogue of the patient's TMJ function. Niles Guichet [1968][(6)] designed the Denar D4A fully adjustable articulator. Robert Lee [1973] designed Panadent articulators based on the premise that it is possible to classify individual condylar movements into groups based on the amount of precurrent side shift. Thomas [1973] classified articulators into four types: simple, hinge type, fixed guide type and adjustable. Denar [1982] studied mandibular movements and devised the "pantronic articulator", an electronic pantograph that provides a computer print out of numerical condylar measurements. Hobo [1984] found that the progressive phase of orbiting condylar movements was about 12 degree at 55 mm from medial plane. Widmen [1989] made use of the surface electromyography for diagnosing and treating of cranio-mandibular disorders. Mensini [1989] recorded habitual masticatory movements by computer based equipment.

Recent advances in recording mandibular movements

Three Dimensional Pantographs: Three-dimensional motion can be reproduced if simultaneous pantographs are obtained containing the three planes. To reproduce the original motion, the pantographs have to be in the same relationship to each other and to the styli on the instrument as they were on the patient. The simultaneous tracing of these pantographs on the instrument effectively recreates the motion.

Cadiax Compact: The Cadiax Compact axiographic device was designed to produce a fast joint analysis for articulator programming and also to aid in diagnosing the functional mandibular disorders. It allows computerized recording of the opening, protrusion, and mediotrusion tracings, and it calculates the sagittal and transversal condylar inclination angles for the adjustment of articulators.

Computerized Analysis of Mandibular Movements: This digital system has been devised to analyze and duplicate jaw motion in an accurate manner. The hardware consists of these components: a sensor that senses the movements in all the directions, an analogue Tape Recorder that stores the processed incremental data from the electronic module, duplicator that receives impulses from the electronic module, sigma 2 computer used to count and store the incremental pulses from the electronic module and digital plotter used for the graphic display of the mandibular motion.

Electromagnetic Articulograph (EMA)

This device measures displacements of the structure in real time, as well as the acoustics and mechanics of speech using a microphone connected to the measurement system. It has transmitter coils that determine magnetic fields to collect information about movements from sensors located on various structures (tongue, palate, mouth, incisors, skin, etc.). After measurement, the information is passed on to a computer and read to visualize the recording of the mandibular movements registered by the EMA.[(7)]

Conclusion

A prosthodontist designs a prosthesis to replace lost teeth. For replacement of teeth and restoring function, it is important to have a knowledge of the mandibular movements as it aids in selection and programming of articulators, understanding occlusion, fabricating dental restorations and arranging artificial teeth.[(8)]

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