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Simulating mandibular movements and articulator design

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ABSTRACT

Establishing new dentition and occlusal schemes requires a thorough understanding of the principles of occlusion, mandibular movements, phonetics, and esthetics. This presentation is designed to help understand the dynamics of mandibular movements, form and function of the dentition, occlusal schemes, patient simulation, and the interaction of those factors on occlusal rehabilitation. Special emphasis is laid upon articulator design and the current innovations utilizing digital technology in the development of this instrument from an articulator to a patient simulator. (J Prosthet Dent 2023;129:377-9)

The video presentation is divided into 7 chapters for ease of reference discussing early attempts for simulating mandibular movements, characteristics of ideal occlusion, and current innovations in articulator design for prosthodontic rehabilitation.

Complex 3-dimensional (3D) mandibular movement can be divided into 2 basic components, rotation and translation and is better understood using 3 reference planes. On the sagittal plane, the human mandible is capable of rotation and translation movements. Rotation occurs around the terminal hinge axis or transverse horizontal axis (THA), an imaginary line connecting the centers of the 2 condyles. On the horizontal plane, the whole mandible can make a straight protrusive movement. In lateral movements of the mandible, the nonworking condyle travels forward and medially while the working condyle exhibits a slight lateral translation (Bennett movement). This may be slightly forward or slightly backward. Viewed in the frontal plane, both condyles will move downward, in a straight protrusive movement, as they slide along the bony eminencies. For lateral movements, the nonworking condyle will move downward and medial. The working condyle, however, will rotate and move lateral and upward or lateral and downward.[1-3]

The various mandibular movements have limits and occur within a certain range. Posselt described this range of movement in the 3 planes of orientation using a starting reference point between the mandibular central incisors. This range of movement is referred to as the envelope of motion. When the mandible is guided into centric relation, the arc traced by the midpoint between the mandibular central incisors is referred to as the centric relation arc of closure. At any point along this arc the mandible is in centric relation (CR), a spatial relationship of the mandible to the maxilla or cranium. CR can be located without any tooth contact and has been considered to be a reliable, repeatable, and reproducible reference position. If the mandible is manipulated upward on the centric relation arc of closure until tooth contact occurs, the mandible is now said to be in centric occlusion (CO). In approximately 90% of the population, this contact occurs between only 1 or 2 maxillary and mandibular teeth, referred to as the initial points of contact. These contacting surfaces are usually located on the distal inclines of the mandibular tooth (teeth) and the mesial inclines of the maxillary tooth (teeth). From this point, if the mandible closes further, it must slide out of CR along a path dictated by the inclines of the contacting posterior teeth. The mandible continues to close and slide forward or laterally until all the teeth intercuspate (articulate) together as best as they can, the maximal

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intercuspal position (MIP) of the dental arches. MIP is tooth-determined and is susceptible to change throughout life. The slide between CO and MIP is referred to as the centric slide. If the initial point of contact (CO) coincides with MIP, reconstructive treatment can be readily accomplished. However, if there is a slide between CO and MIP, it is necessary to determine whether occlusal adjustment is first required before reconstructive therapy can be accomplished.[4-19]

Whereas in the patient, the maxilla, mandible, mandibular condyles, and condylar axis are all anatomically related to each other, this is not the case in the dental laboratory. In the laboratory, the maxillary cast and the mandibular casts are not anatomically related, nor are they related to the intercondylar axis. In order to relate the patient parts back together, the ear bow transfer has been traditionally the means by which this can be accomplished. Records of the patient's anatomical relation of the maxillary dental arch (via impressions of teeth) and the patient's intercondylar axis are obtained. This record is then used to mount the maxillary cast first on the articulator. The mandibular cast is then related to the maxillary cast and mounted using a centric relation record obtained from the patient. So now that the 3 pieces of the puzzle; maxillary arch, mandibular arch, and the condylar axis are related once again anatomically to each other onto the articulator.[20-37]

For oral rehabilitation and reconstructive therapy, the occlusal treatment goals are summarized as: (1) To direct the occlusal forces along the long axes of teeth in order to achieve stable posterior contacts, (2) In maximal intercuspal position (MIP), all mandibular teeth should contact their maxillary opponents at the same time and with the same intensity, that is, CO should be coincident or in harmony with MIP, (3) To furnish a smooth protrusive path guided by the anterior teeth without any interference from occlusal contacts between the posterior teeth, and (4) To furnish smooth working side contacts, whether canine-protected or group function through elimination of nonworking side interferences.[38-40]

The process of simulating the human mandibular movements to fabricate complex prosthodontic restorations involves several technique sensitive procedures for optimal mounting of patient casts. The currently available dental articulators have limitations for reproducing all mandibular movements. For about 2 centuries, the dental articulator has been modified to better simulate mandibular movements and hence render dental prostheses with better function.[41-46] The custom patient-specific anatomical articulator is an innovative device which accurately simulates the patient anatomy and eliminates all technique sensitive mounting procedures as well as mounting errors and articulator settings. Utilizing 3D printing technology, the maxilla (maxillary teeth and edentulous ridge) is printed with the correct spatial relationship to the condylar complexes and the Frankfort horizontal plane (FHP). Those printed structures are then mounted onto a modified articulator frame to render it anatomical. This recently introduced custom anatomical articulator, which accurately mimics the patient anatomical movements rather than rely on average values, represents the first truly fully adjustable articulator that is far more precise than can be generated with a pantographic tracing. It saves money, time, and effort, eliminating ear bow transfers and mounting errors.[47]

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