DISCUSSION OF "A METHOD FOR REPRODUCTION OF MOVEMENTS OF THE MANDIBLE"*

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ACCORDING TO THOSE who are qualified to examine this electronic system critically, it should operate without vibratory movements and with an accurate response. This is a servomechanism system. Like all servomechanisms, it is controlled by an input function. Whatever happens at the input of the system controls the output function exactly and precisely. The science of servomechanism systems has reached a very high point of development.

The basis of the entire principle of the system is that the position of a body can be determined by the instantaneous position of three of its points which do not lie on the same straight line. The control of three such points on a sphere means control of all points on the sphere. The described system is so designed that the patient has free movement of the mandible in all directions.

The authors state that this investigation could be of clinical value and that information could be produced which would be of aid in the design of articulators. The present system is strictly an electronic system. All movements of the articulated casts are accomplished electronically. The authors may have intended that in the future, if it was determined that this system was of value, a similar mechanical articulator might be set up on which the casts could be moved mechanically by a set of dials which would correspond to this electronic machine.

One probable objection to the present design is that the series of six graphs cannot be interpreted visually. They must be fed back into the machine manually so that various positions of the casts may be determined. If some corresponding number system could be determined from these curves that could be fed into a set of dials on a mechanical articulator, it would be possible to determine the different positions of the casts without using the etched copy of the recording. It is very difficult to tell from the graph the actual movement of the mandible at a specific time. One can only do this by observing the casts.

ADJUSTMENT OF ARTICULATORS

Some of the statements of the authors may be challenged. For example, they state that most articulators accept and duplicate initial and terminal positions of the mandible and that they do not duplicate intermediary positions. However, some articulators employ functional chewing relations as well as terminal and initial

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positions. All functional techniques, such as those of Pankey and Mann and of Rouza with rigid instruments and functional cores, work on this principle of recording the results of all chewing movements. Some other complicated articulators are reported to record intermediary movements.

The authors also mention that pantographic tracings are used to make the articulator conform to the tracing at the initial and terminal positions and that such tracings may help in a visual interpretation of the selected movements of the mandible and in the intuitive use of the instrument by the dentists. One joint distance is usually used. The answer to this is that pantographic tracings are made to adjust the transverse, vertical, and sagittal axes. Once the articulator is set and these axes are located, the instrument is supposed to copy not only the initial and terminal movements of the mandible but all intermediary movements. Such articulators are the Gnathoscope, the Stuart, the Gnatholator, and the Transograph. There are probably others. In addition, all of these instruments have adjustable intercondylar distances.

ACCURACY OF THE DYNAMIC DUPLICATOR

There is no way except by extensive engineering tests to determine the accuracy of this electronic system. Interpretation of information presented by these instruments is sometimes difficult. This results from several factors: (1) the clinician may be unfamiliar with the signals which are being presented, (2) false signals may be generated from artifacts that result from movement or from signals generated by other equipment in the area, and (3) equipment failures may occur as a result of interference or dislodgment of leads or cables.

There might be some question concerning the weight and inertia of the rectangular aluminum framework and ball bearings and as to whether the ball bearings are able to operate freely in all directions. The problem might be rectified by using some form of electronic stylus with a small wire or a smaller stylus. This wire would have to be rigid and firmly attached to the teeth.

In addition, the head must be held rigid. An attempt is made to immobilize the head completely by bracing. Such fixation immediately prevents normal functional chewing. Hence, mastication and deglutition become artificial and voluntary. This problem could be eliminated by the use of two identical servomechanisms instead of one. One system would control the mandible and the other the maxillae. In this way, freedom of movement would be given the patient. The components of the system would not be changed.

The large clutches which are placed upon the upper and lower teeth prevent normal functional chewing regardless of whether or not they permit interocclusal contacts. The metal rods which emerge from the mouth break the natural vacuum produced by the lips. The subject must change his chewing pattern to one which functions in artificial surroundings.

DESIGNING AN ARTICULATOR

It is assumed that an articulator based upon this electronic system will reproduce the natural functional movements of the subject that should be used to form

cusps for his occlusal reintegration. The question may be asked: What articulator do we first use to obtain a suitable prescription of interocclusal coordination in order to insert a suitable prosthesis in the patient's mouth so that he can reveal his correct functional pattern of mandibular movement? For this electronic system to provide the knowledge we wish to obtain, we must initially have normal function. Otherwise, the machines designed by the information given by this servomechanism will be based upon chewing patterns of subjects with mutilated occlusions and abnormal chewing patterns.

This is also true with complete dentures. From what reference line do we start "functional" chewing? With the subject's old dentures? With the dentures removed and the mouth empty? Must we first introduce prescription dentures made with conventional articulators so that the electronic system may take over from this vantage position?

MANDIBULAR MOVEMENTS

Premature and initial contacts are important in studying mandibular movements and functional chewing. Interocclusal records are placed in conventional articulators, and contacts as small as parts of a millimeter are observed and may be corrected in subsequent equilibration by grinding or by reconstruction. The ability to reproduce these contacts with casts in this electronic system is questionable because there is no way to completely immobilize the head. If the head moves a millimeter or so in any direction, and it does, the maxillomandibular relations for this system will be inaccurate in disclosing faulty contacts of the teeth. This discrepancy must occur if the head can move these small amounts while the upper cast is completely immobilized by its rigid metal frame and attachments.

The possibility of errors of contacts in the terminal functional orbit, as a result of the movement of the head, makes the ability to record contact of the teeth during mastication also questionable. The direct method used by Brewer[1] seems much more accurate for this phase of research.

The importance of the spatial relationship of the mandible to the maxillae at a specified time during a movement of the mandible is stressed by the authors. However, this seems to be an extremely elaborate and complex method of determining mandibular position. Other research on mandibular movements employing small styli on upper and lower teeth and using the cinematic method of study can establish both the time and direction of functional movements in the three planes of space. These diagrams can be read and understood by dental students and dentists inasmuch as such diagrams are similar in their particular plane to the movements which they represent. This is not true with the pen recordings from the dynamic duplicator.

To demonstrate functional chewing by means of casts placed outside the mouth, Christensen and Krol[2] have used a simple, inexpensive procedure of attaching these casts to the teeth by clutches on the teeth with metal rods emerging from the mouth. While this method has inaccuracies, still it adequately demonstrates functional chewing and may be photographed and studied over and over again without the subject being present. The method consumes little time in the demonstration.

COMBINED DENTAL AND ENGINEERING RESEARCH

Servomechanisms have rarely, if ever before, been used in dentistry to study human mastication, except perhaps in the pioneer study of Brewer[1] on recording contact movement during the entire day and night. Dentists, by virtue of their special training in the dental sciences, are not equipped to undertake this type of development by themselves. Engineers are equally unable to produce satisfactory solutions because they lack understanding of the problems of the dentist. There are two obvious solutions to this dilemma. One is to educate a number of dentists in the engineering sciences. As instrumentation becomes more commonplace in dentistry, this undoubtedly will become a common procedure. However, it will at best be a slow process. A more immediate solution is to bring engineers into dental research centers and schools where they can become acquainted at first hand with the problems and, even more important, can participate in the field trials which determine whether or not a given line of development is feasible. This method has been used in this study. The Russians[3] have shown the practicality of such units with their successful Institute of Experimental Surgical Apparatus.

There has been only isolated and sporadic activity among clinical researchers to develop devices for the study of human mastication at the clinical level. Freedom from entangling wires and metal framework and all other baggage must be attained, together with the ability to make long recordings. In addition, the rapid analysis of these recordings and the highlighting of eccentric movements without spending many hours examining material are obvious necessities. Human beings will be "wired" for research.

I admire Dr. Beck because, although physics and engineering are not his chosen professions, he was able to initiate an electronic instrument that stirs our imagination and opens up great possibilities of future research in dentistry. I wish to personally thank the authors for their most stimulating article.

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