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Jaw movements engraved in solid plastic for articulator controls. Part I. Recording apparatus

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Jaw movements made by each patient differ from those made by other patients. Therefore, jaw movements provide a very interesting subject for scientific study. Dentists record the jaw motions of their patients and use the information to help them make occlusal forms of teeth and restoration that harmonize with each other and with other controlling factors.[1]

Studies of jaw movement patterns have been made possible by the discovery of a method for locating the hinge axis for each patient[2] and by the reproducible nature of centric relation.[†] The hinge axis location is reproducible in the centric relation position of the mandible, and an axis-orbital reference is necessary for properly mounting dental casts in articulators.[3] There are several schools of thought regarding the movements of the jaws and regarding the best method to record and reproduce these movements in articulators.[4]

This article reports a research effort extending over a period of seven years in which a series of new instruments were built, tested, discarded, redesigned, and retested to develop the equipment shown in this article.[‡]

The primary objective of the study was to obtain a scientifically accurate and practical method of duplicating jaw movements that could be used within the economic limitations of dental practice. Therefore, this article also reports some suggestions for dental practice which have been gathered from this research. Another objective was to obtain the jaw movement information in a form that can be statistically evaluated.

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[†] Centric relation as used in this article refers to the rearmost midmost position of the mandible from which a purely hinge axis rotation can be made.

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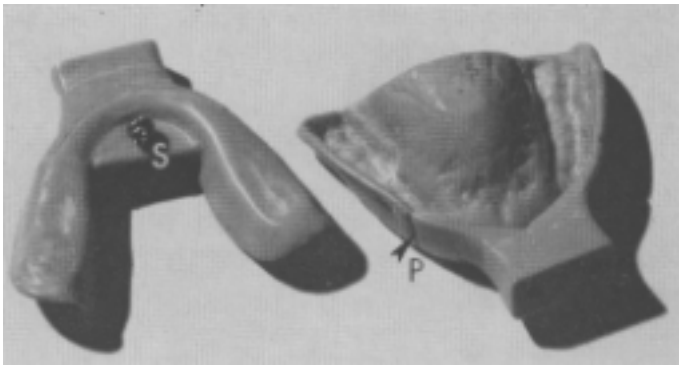

Fig. 1. Resin clutches made for a dentulous mouth. Note the screws (S) which serve as an adjustable anterior bearing point at the center of the lower arch, and the pry slot (P) and score line over the anterior teeth which facilitate the removal of the clutches.

PRELIMINARY PREPARATIONS FOR RECORDING

Clutches. Central bearing screw clutches of plastic tray resin are made for each patient (Fig. 1). The only metal part of the clutch is the center bearing screw on the lower clutch, which slides on a smooth plastic plate that is part of the upper clutch. To aid in the removal of the clutches, they are scored over the incisal edges of the anterior teeth, and pry slots are cut vertically just mesial to the premolars for fracturing the clutches apart when they are removed from the patient's mouth. The clutches are cemented over the teeth with a zinc oxide and eugenol impression paste. The purpose of the clutches is to provide a means for attaching the recording device to the patient's jaws.

Premedication. The patients are routinely premedicated intravenously with odium nembutal, meperidine and atropine.[5] These drugs relax the patient and reduce apprehension, fear, gagging, claustrophobia, joint and muscle pain, excessive saliva, etc.

Hinge axis location. A face-bow with adjustable side arms is attached to the lower clutch and the hinge axis is located and tattooed on each side of the patient's head in the usual manner.[2] The axis locating device is then removed.

APPARATUS FOR RECORDING JAW MOVEMENTS AND METHODS OF ALIGNMENT

The upper recording face-bow. The upper face-bow is a rigid lightweight metal structure (Fig. 2). It holds three record blocks, one on each side of the patient's head covering the region of hinge axis movements and one centered in front of the face. The blocks are made of clear polyester resin. Each record block is ½ x 1 ¼ by 1 ½ in. in size, and each one is held securely in place on the face-bow with a capscrew. An orbital pointer is located on the right side of the face-bow for orienting the recordings made in the three plastic blocks to the orbital-axis plane of the patient's head. There are two vertical attachment rods for supporting the upper face-bow from its attachment frame on the upper clutch.

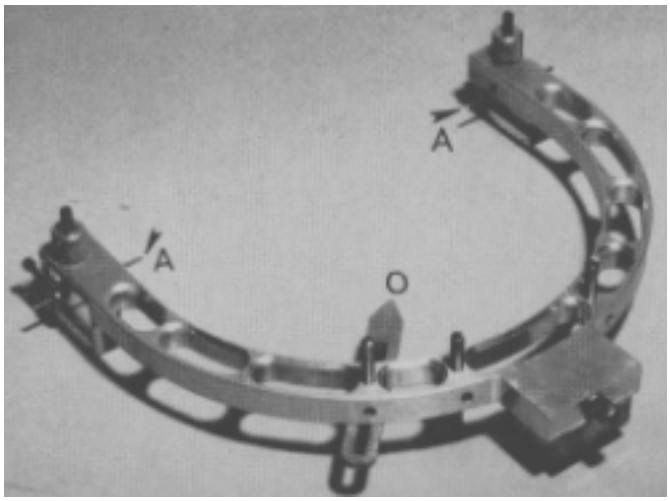

Fig. 2. The upper recording face-bow. Note the axis alignment ins (A) and the orbital indicator (O).

Attachment of the upper face-bow. The upper face-bow is aligned to the patient's axis orbital plane by first removing the recording blocks that cover the hinge axis region and substituting a pair of alignment blocks for them. These blocks are identical to the axis recording blocks to be used later, except that each contains a predrilled 1/16 inch diameter horizontal hole. An alignment pin is inserted into each of these two holes. When the two pins are in their holding blocks on the face-bow, their long axes lie in the same straight line. The place formed by these two pins together with the orbital pointer coincides with the horizontal plane of reference made by the three tattoo spots on the patient's head. The axis alignment pins are set with their points protruding toward the head at equal distances from their holding blocks, so that the point of each pin just contacts its axis tattoo spot but does not deflect the skin (Fig. 3). Two attachment cups are adjusted and tightened to a U-shaped frame on the upper clutch. The lower ends of the two vertical attachment rods of the face-bow are inserted into the cups. Two adjustable support arms which extend from the upper attachment frame are used to hold points of the two alignment pins to their axis marks on the head. These two support arms hold the weight of the two posterior ends of the face-bow. The anterior part of the bow is supported by the two attachment rods in the attachment cups. During this time, the patient is sitting in the same upright position that he was in when the axis tattoo marks were made. The occiptal part of the patient's head is touching the back rest in only one small spot. This position supports the head and prevents the skin from moving at the tattoo spots. The patient's eyes should be closed and the face should be expressionless so that the skin will not move. The two attachment cups are filled with quick-setting plaster from a plaster gun (syringe). The patient is instructed to not move the head for about two minutes while the plaster sets around the ends of the attachment rods. After the plaster has set, the two adjustable

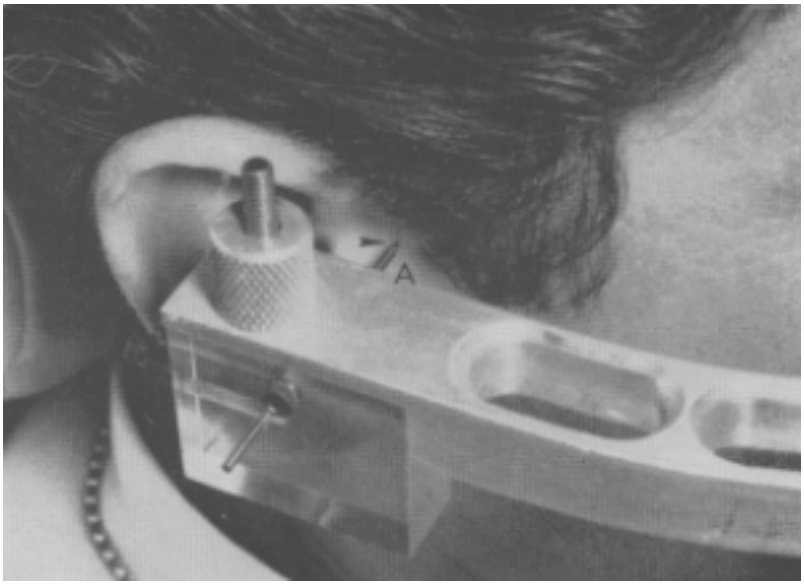

Fig. 3. The upper face-bow showing the close proximity of the right axis alignment pin to the axis tattoo mark (A).

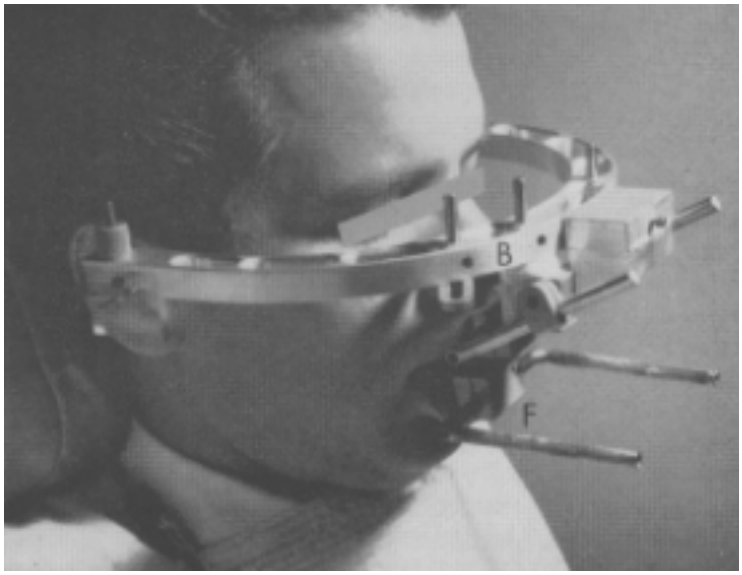

Fig. 4. The upper face-bow (B) is attached to its clutch and oriented to the orbital axis plane. Note the lower attachment frame (F) has been joined to the lower clutch, so the mandibular face-bow can be attached to it.

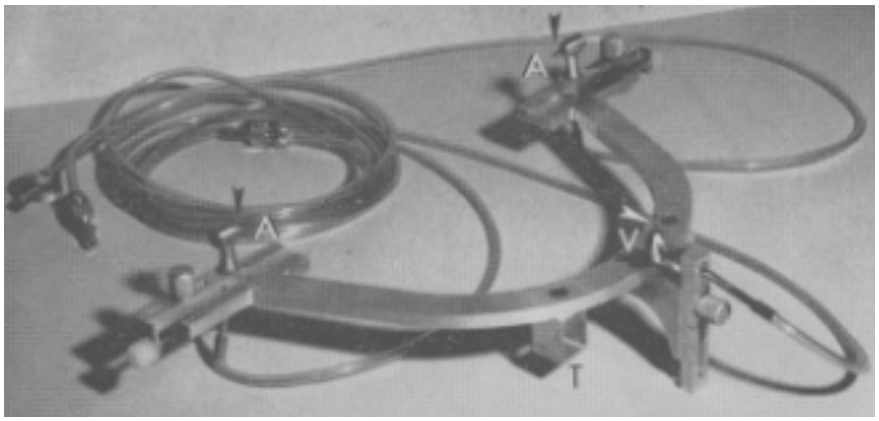

Fig. 5. The lower face-bow showing the axis recording styluses (A) and the anterior vertical stylus (V). Note the right attachment tube (T) for connecting with the lower attachment frame (F) in this figure is on the lower edge of the lower face-bow.

support arms are removed from the upper attachment frame thus leaving the face-bow completely supported by the maxillae through the two vertical attachment rods to the clutch (Fig. 4). The two axis alignment pins are removed so that the holes that held them are free to be used for aligning the axis-recording styluses (drills) of a lower face-bow (Fig. 5).

The lower recording face-bow. The lower face-bow is also a rigid lightweight metal structure. It supports three recording styluses which are driven by high-speed air turbines (Fig. 5). The styluses are nontapered carbide drills, 1/16 in. diameter, with hemispherical cutting ends. Two of the drills are horizontally aligned on a common axis for recording the movements of the hinge axis of the mandible. The anterior drill, which is positioned vertically, is precisely centered between the two axis recording drills, and in combination with the axis recording drills forms a recording tripod. Two attachment tubes are located on the undersurface of the face-bow for joining the face-bow to an attachment frame on the lower clutch.

Each recording drill is mounted in a air turbine that is taken from a dental air-turbine handpiece. Each air turbine is mounted on a slideable carriage which has a fixed advanced position used during recording and a retracted position for disengagement of the drill from the recording block. Each drill carriage has scale markings to indicate its depth of recording position, and also a thumb screw for locking it in either the advanced or retracted position. There is an individual air line to each air turbine so that during recording the three turbines may be energized simultaneously or one at a time, as needed. The air lines are attached to an air compressor by separate quick-disconnect attachment devices and the air flow is controlled by a foot-operated air valve.

Attachment of the lower face-bow. The dental chair is adjusted so that the patient is changed from a sitting position to a horizontal position. Gravity then helps to keep the mandible in its most retruded position, and it also takes little effort for the patient to hold his jaws closed.

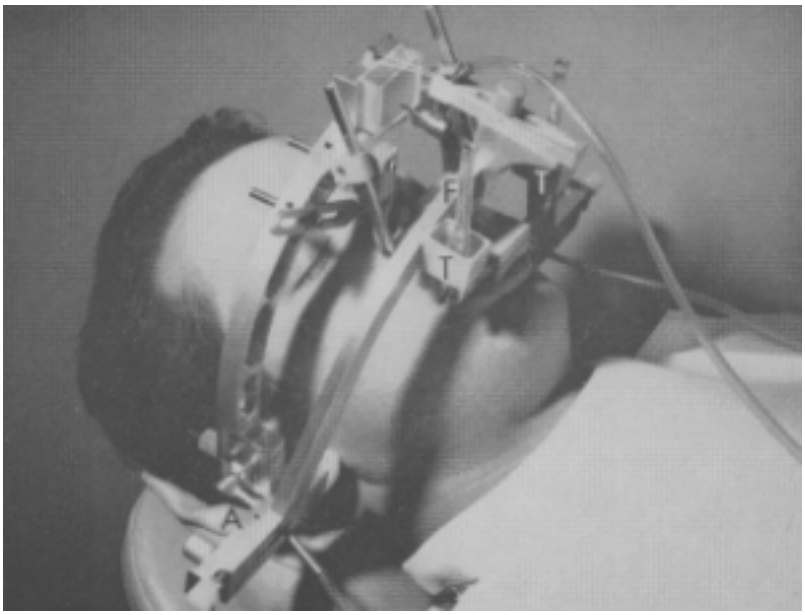

Fig. 6. The lower face-bow is being held in relation to the upper face-bow by the axis recording styluses (A) which are held by the horizontal holes in the axis alignment blocks. The protruding ends of the lower attachment frame (F) do not touch the plaster tubes (T) at this time. The mandible is free to move.

Each end of a U-shaped attachment frame extending from the lower clutch is inserted through an associated attachment tube on the lower face-bow. The axis drill carriages are both moved toward the head so that each recording drill slides into the hole in its associated alignment block on the upper face-bow (Fig. 6). These holes were previously occupied by the alignment pins. This procedure aligns the two axis recording drills with the hinge axis of the mandible when the jaws are in centric relation. The lower face-bow is centered relative to the upper face-bow so that the cutting ends of the axis recording drills are equal distances from each side of the patient's head. This is accomplished by means of a small set-screw in each axis alignment block, which was originally used to hold the axis alignment in in place but is now inserted into the opening so that each axis recording drill is stopped in the center of the block. At this stage, the anterior recording stylus is resting against the surface of the anterior record block and this position is retained by a small elastic band which fastens the anterior drill carriage to the anterior record block. The upper face-bow (which is solidly fixed to the cranium by its attachment to the maxillae through the clutch on the maxillary teeth) is now completely supporting the lower face-bow. It is also aligning the common axis of the two axis recording drills so that it coincides with the position in which the axis of the mandible will be when the jaws are placed in centric relation.

The attachment U-frame of the lower clutch is adjusted and tightened so that, when the patient slides his jaw forward and backward, the ends of the frame pass through the

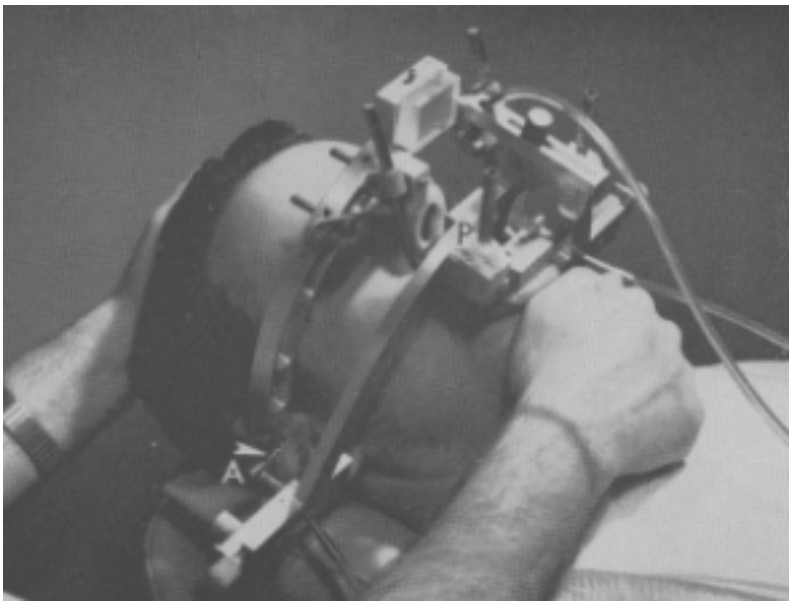

Fig. 7. The mandible is being held in centric relation which quick setting plaster (P) hardens between the attachment frame of the lower clutch and the attachment tubes on the lower face-bow. Thus, the common axis of the recording styluses (A) becomes fixed to the axis of the mandible in precise colinear alignment.

Attachment tubes without striking the walls (see Fig. 8). The tubes are filled with quick-setting plaster from a plaster syringe. While the plaster is still soft, the patient's mandible is retruded into the centric relation position and held for a few minutes for the plaster to set around the ends of the attachment frame (Fig. 7). The hinge axis of the mandible now coincides with the long axes of the two hinge axis recording drills. The desired alignment of the lower face-bow relative to the mandible has now been achieved. As soon as the plaster has been set, the axis drill carriages are retracted to free the drills from the alignment blocks. The elastic band is removed from the anterior drill carriage and the carriage is retracted from its record block. An alignment test is then made by having the patient retrude the jaw several times into centric relation, to see if the two axis recording drills are aligned with the holes in the alignment blocks.

METHOD OF RECORDING AXIS MOVEMENTS

The axis alignment blocks are removed and replaced with the blank record blocks (Fig. 8). A thin, clear plastic shield is placed over the patient's head to cover the eyes, nose, and ears. The purpose of this shield is to protect the patient from the fine plastic particles that are generated by the cutting action of the drills.

The protrusive movement is recorded first because it is simpler for the patient to execute and gives him a chance to become accustomed to the equipment. It is preferred that the protrusive movement be guided in a precisely straight forward path.

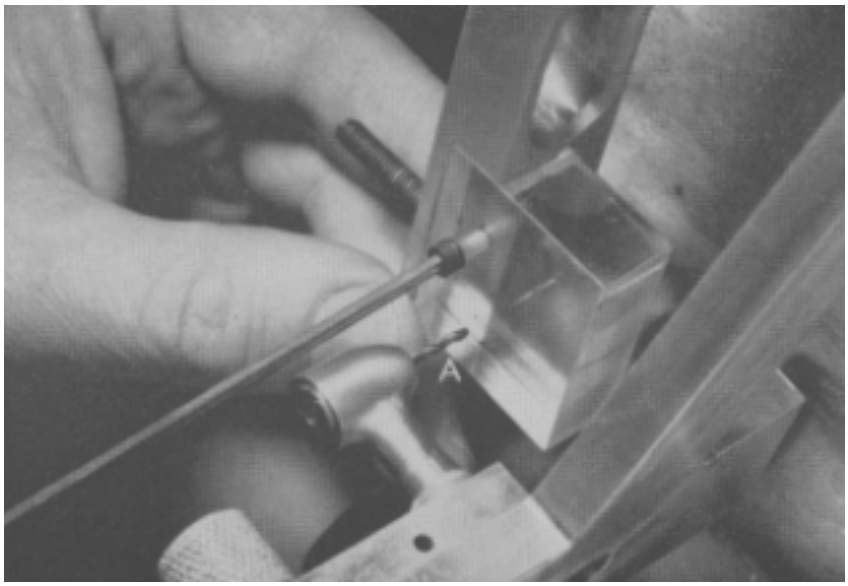

Fig. 8. A blank axis record block is being placed in the position previously occupied by the right axis alignment block on the upper face-bow. Note that the axis stylus (A) must cut the opening at the position of centric relation.

This is accomplished by preparing an anterior record block with a guide slot in advance of the recording procedure. Then during the recording of the protrusive movement the anterior drill is not activated and it acts simply as a guide pin. In order to prevent any binding action of the anterior drill in the guide slot the deeper part of the slot is widened. In this way the drill is guided by only the part of the slot at the lower surface of the record block. Thus any twisting action of the mandible as it protrudes is accommodated and recorded by the axis drills during the recording of the protrusive movement.

The patient is rehearsed through the protrusive movement only with the drills inactive and out of contact with the record blocks. He is instructed to maintain contact between the upper and lower clutches at all times with the center bearing screw sliding on the smooth concave surface of the upper clutch. When the patient has learned the protrusive movement well, the mandible is placed in its rearmost hinge axis position (centric relation) in preparation for the actual recording. In order to be sure of achieving this position, the dentist guides the patient's lower jaw with his hand (Fig. 7). The anterior drill is moved upward into the guide slot in the anterior record block. The two axis air turbines are activated and the two drills are made to penetrate their associated record blocks. The depth of penetration is controlled by a set-screw and a calibrated scale provided for each drill carriage. A set of two centric relation openings are thus created. The drill carriages are locked and the patient is instructed to protrude the mandible slowly while the two axis drills are cutting. The anterior drill is not activated but is acting in the guide slot to help the mandible move straight forward.

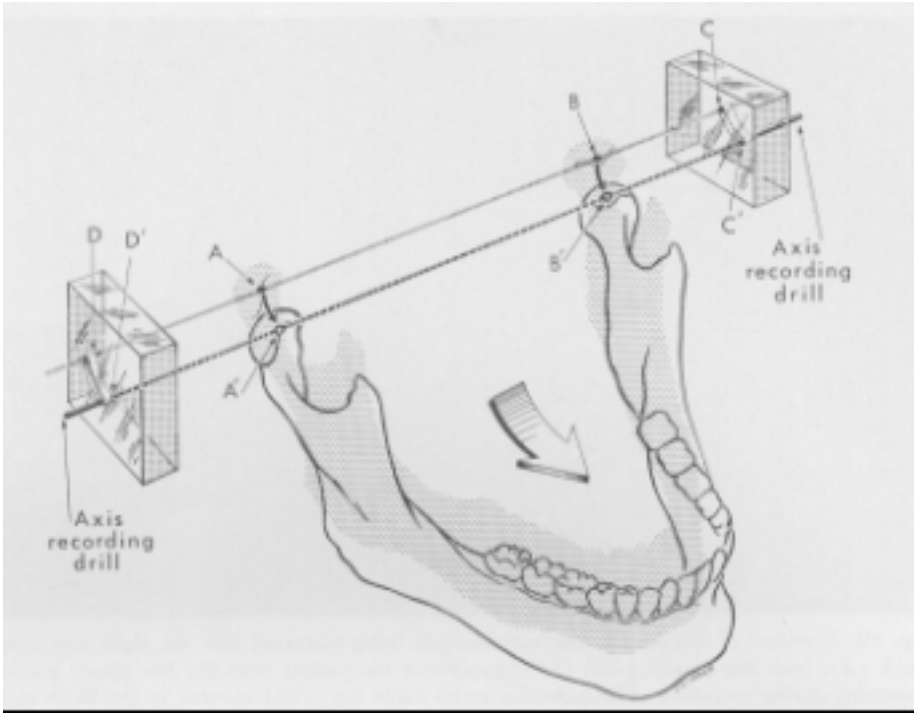

Fig. 9. A diagram showing the relationship of the hinge axis to a protrusive recording. The shadowed area represents the position of the mandible when it is in centric relation. Points (A), (B), (C), and (D) represent the position of the hinge axis in centric relation, and points (A), (B'), (C"), and (D') represent a hinge axis position with the mandible protruded. The paths of points (C) to (C") and (D) to (D') are represented by grooves in the plastic blocks at the tips of their respective recording styluses.

During this movement the two axis drills are cutting predominantly in a sideways direction, hence are acting as engraving mills (Fig. 9). Although the protrusive movement is primarily a two-dimensional one, any lateral shifting or twisting movement of the mandible while it protrudes is also recorded by the two axis drills.

After the protrusive recording has been completed, the drills are retracted and the mandible is returned to its centric relation position. The patient is instructed to repeat the protrusive movement in order to verify the constancy of the recording. The drills are then retracted, and the two axis record blocks are removed and reattached to the upper bow with the unused (the reverse) sides exposed to the drills. The anterior guide slot block is replaced by a blank anterior record block in preparation for recording the right and left lateral border movements.

For the lateral border movement recording, the patient's mandible is again guided into its centric relation position. The dentist selects either the left or the right lateral border movement to be recorded first, and rehearses the patient in that movement only. The patient's mandible is again guided to the centric relation position. While the mandible is in that position, the anterior drill is activated, leaving the two axis drills

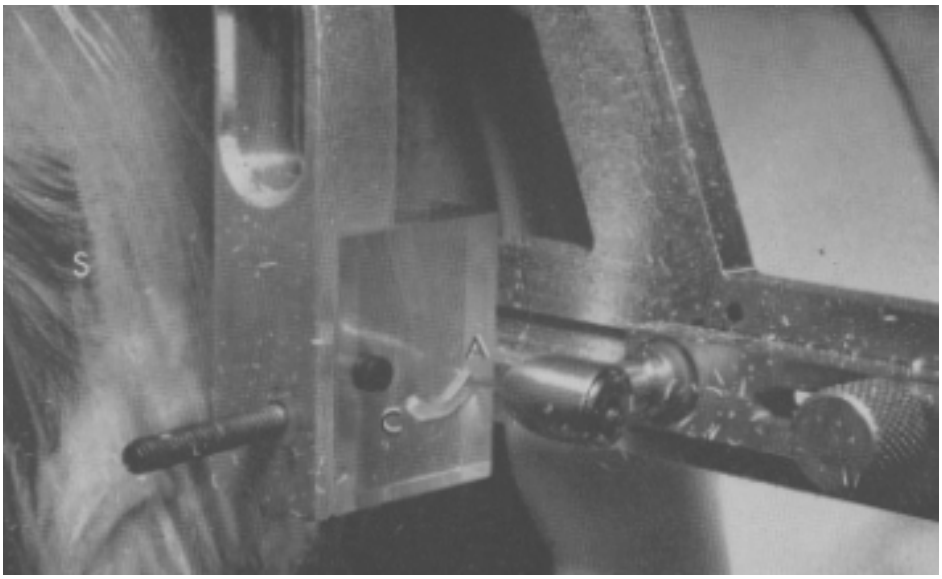

Fig. 10. A record of left lateral jaw movement is being engraved into the right axis record block (A). Note the plastic shield (S) that protects the patient from the fine plastic particles generated during recording. The recording stylus made the initial opening in the block at the centric relation (C).

inactive and out of contact with their record blocks. The anterior drill carriage is moved upward to drill a centric relation opening in the anterior record block. The depth of penetration is noted on the calibration scale for the anterior drill carriage and is later inscribed manually on the anterior record block. With the drill activated, the patient is instructed to move his jaw in the specified lateral direction previously rehearsed (Fig. 10). As soon as the patient has completed the lateral movement the drill is stopped and retracted and the mandible is returned to its centric relation position. The patient is instructed to repeat the movement in order to verify the constancy of the recording.

If the dentist has chosen the left lateral border movement to be recorded first, then at this time that specific movement is recorded in the right axis record block. With the mandible in centric relation, the right axis drill is activated and made to penetrate 1/16 in. into the record block. This initial opening in the record block represents the centric jaw relation. The patient is now instructed to move his jaw in the left lateral movement while the right axis drill engraves the path of motion in the right record block. As soon as the end of the left movement is reached, the drill is stopped and retracted and the mandible is returned again to its centric relation position. With the jaws in centric relation, the right axis drill is again activated and placed 1/16 in. deeper into the block. The patient repeats the same lateral border movement while the drill re-records at the new depth. When the maximum drill depth has been achieved, the movement is repeated again in order to verify the constancy of the recording. During these repetitions of the same recording operation, the dentist can visibly observe through the

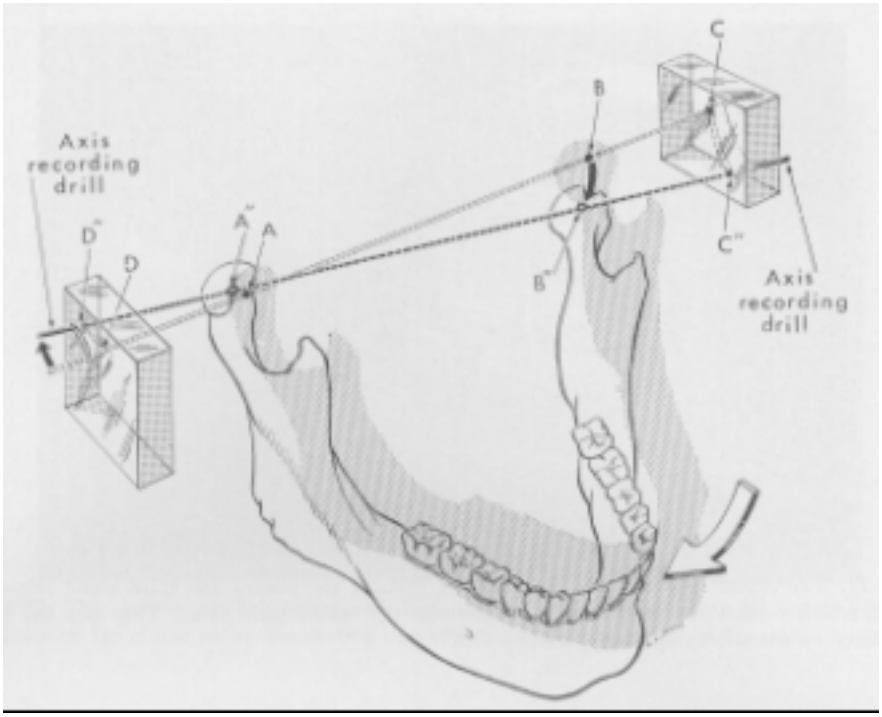

Fig. 11. A diagram showing the relationship of the hinge axis to a right lateral recording. The shadowed area represents the position of the mandible in centric relation. Points (A), (B), (C), and (D) are identical to those of (A), (B), (C), and (D) in Fig. 9, and represent the axis in centric relation. Points (A"), (B"), (C"), and (D") represent an axis position during the right lateral mandibular movement recording. The paths of points (C) to (C") and (D) to (D") are represented by the grooves in the axis record blocks at the tips of the respective recording styluses.

the clear plastic block the characteristic pathway of the axis movement. What is actually being observed is the movement of a point on the hinge axis represented by the drill tip (Fig. 10).

After the dentist is satisfied that he has achieved a constancy of the left lateral movement he then returns the mandible to centric relation position. The left axis drill is activated and the drill carriage is moved inwardly to make a centric relation opening in the left axis record block. Progressive steps are not necessary for this procedure, and the drill is simply moved to its maximum depth setting position. With the left axis drill activated, the patient is again instructed to execute a left lateral border movement, and the movement is recorded in the left lateral record block as a "backlash" (Fig. 11, D-D"). During this recording, the constancy of the jaw movement is verified by the movements of the anterior drill and the right axis drill in their previously recorded grooves.

The same procedure as described above is used to record the right lateral border movement on the same surface of the three record blocks (Fig. 11). The two lateral movement recordings coincide only at the centric relation position. Although a separate set of record blocks can be used for recording the right lateral border movement, there appears to be no crossing over or confusion between the two lateral movement recordings and the use of a single set of record blocks is satisfactory.

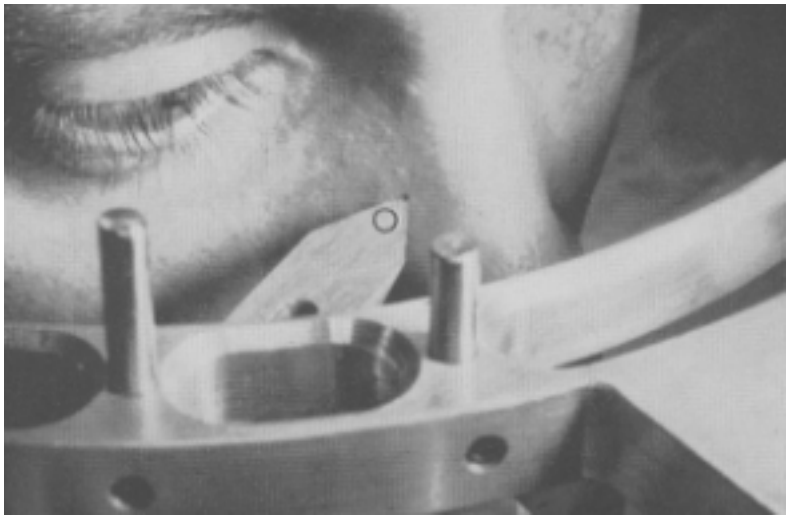

Fig. 12. The orbital pointer (O) indicates the position for placing the third static reference point which orients the recordings in relation to the orbital axis plane. This spot has been darkened on the photograph for clarity.

After the recording of both of the lateral boarder movements has been completed, another procedure is used to verify the constancy of the recordings for various degrees of vertical opening of the jaws. This is accomplished by raising the center bearing screw in small increments up to a total of about 10 mm. and the patient is instructed to repeat the border movements while the two axis drills are activated and are fully engaged in the previously recorded grooves. If the two axis drills to not create new pathways in the record blocks, the recordings are considered to be constant and also valid for those degrees of jaw openings tested. The protrusive recording is also tested in this way.

As soon as the recordings of the jaw movements have been completed, the orbital reference pointer on the upper face-bow is brought into contact with the skin on the right side of the patient's nose, and the orbital spot is tattooed there (Fig. 12). The position of the upper face-bow relative to the cranium was fixed throughout the entire procedure, hence, the orbital spot could have been tattooed prior to making the recordings. The orbital spot is the third of the three static reference marks which form the horizontal plane of reference on the head. (The other two reference marks are the hinge axis marks on the skin). These spots will be used at a later time for transferring the casts of the patient's teeth to an articulator.

The face-bows are removed from the patient's head by removing two screws which hold each attachment device to its associate clutch. Then, the clutches are removed (Fig. 13).

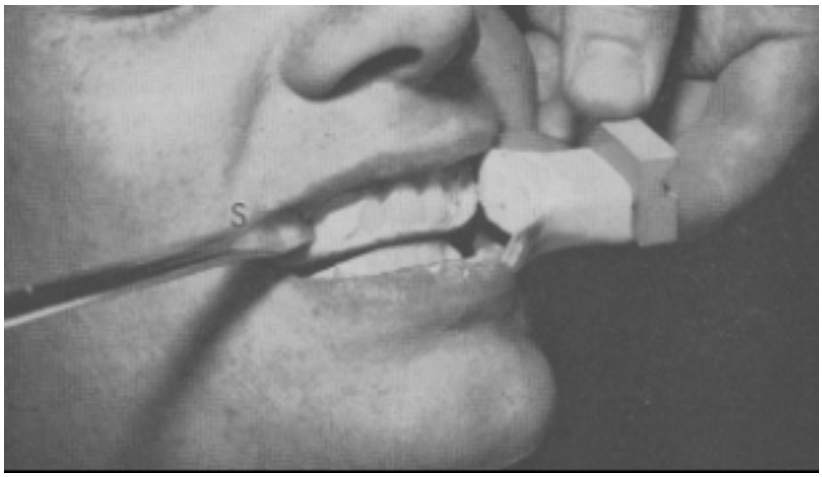

Fig. 13. The clutches are being removed. Note the use of the screw driver (S) in the pry slot to fracture the clutch along the parting line opposite the incisal edges of the teeth.

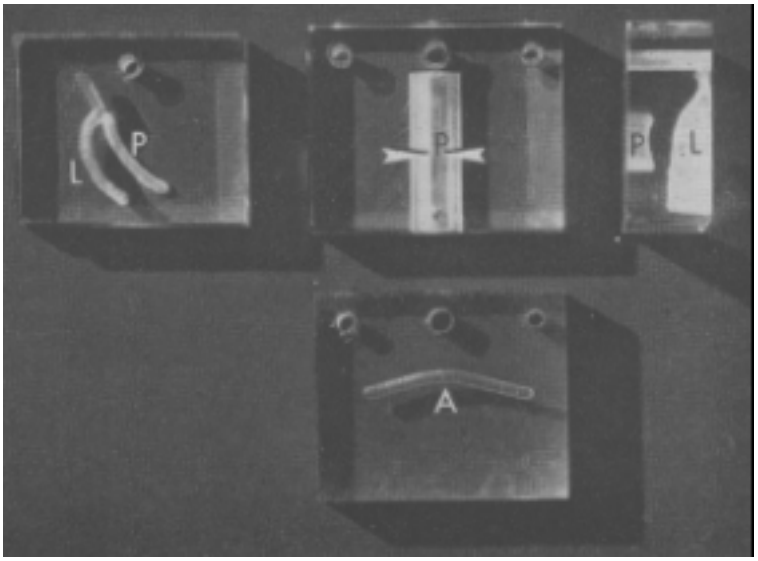

Fig. 14. A set of patient's recordings. The axis record block (upper right) is on its end for a frontal view to show the characteristic path that the axis made in this record. The third point of recorded information for lateral movements is at (A) in the anterior record block (below). The anterior guide slot for the protrusive (P) record is shown between the two arrows in the center block (above). The records of lateral movements (L) are on one side of the axis record blocks (right and left above) and the protrusive movement (P) is on the other side of the blocks.

DISCUSSION

In order for the jaw movement recordings to achieve maximum usefulness, it is necessary to record at least the right and left lateral border movements, and a protrusive movement. It is possible to record other movements intermediate to the straight protrusive and the lateral border movements and some dentists may desire to do this. An additional set of record blocks is required for this procedure. Only the straight protrusive and the border movements were recorded in the record blocks shown in Fig. 14.

Some important considerations in this method of recording jaw relations and movements are: (1) Errors due to variations in jaw opening during recording are essentially eliminated by measuring the movements at points which are precisely located on the hinge axis, rather than at some other locations. (2) When hinge axis recordings are used, the record members (recording blocks) are fixed in relation to the upper jaw and cranium, and the axis recording styluses move with the inge axis of the mandible. (3) Interferences between the engravings of the protrusive movement and the lateral movements are avoided by recording them in separate sets of recording blocks.

EFFECTS OF CHANGING THE VERTICAL RELATION

The vertical jaw separation of 50 patients was changed by adjusting the center bearing point between the clutches while the recordings were made. In 49 of these patients, there were no visual changes in the characteristics of the recordings made at different vertical levels. There were, however, changes in the paths of the recorded grooves in one patient when the center bearing pin was raised. In this patient, it was difficult to locate the hinge axis, and the changes in the recordings might have been due to our inability to locate the axis of the patient for proper alignment of the recording equipment. The initial impression from our tests conduced so far is that the hinge axis is constant to the mandible at the various degrees of the jaw opening tested.

PROBLEMS IN MAKING THE RECORDINGS

A few patients seem unable to move the mandible laterally in both directions. These patients are sent home with the clutches so that they can place them in their mouths and practice moving the lower jaw in the various directions to be recorded. Most of these patients are able to execute the movements when they return for recording a few days or a few weeks later. Splints and other treatments are instituted for patients who have sore and painful joints before attempts are made to record them.

Some of the special problems encountered during recording sessions are apprehension, fear, claustrophobia, subluxation (dislocation), pain the temporomandibular joints, muscle discomfort, noises such as cracking and popping, limitation or deviation of mandibular movements, and swallowing of excessive saliva. Many of these problems can be circumvented by the use of premedication and by the hands of a skilled dentist. The use of premedication also relaxes the muscles so that the hinge axis may be more easily located and recorded.

SKILL IS ESSENTIAL

The recording of mandibular movements, including the location of the hinge axis, is a very precise procedure that required the development of special skills by the dentist. One cannot hope to acquire the necessary skill and know-how by merely acquiring a set of recording instruments any more than one could expect to become a proficient pathologist by merely purchasing a microscope and looking through it. In the field of medicine, the general practitioner is not expected to do such sophisticated procedures as radioactive isotope studies or protein-bound iodines. These complex procedures are carried out in laboratories by specialists. It seems impractical to expect all dentists to devote enough time to the study and use of complex instruments of the type described in this articule which they may need to use only occasionally.

RECORDING CENTERS

The research effort described in this article has led to the conclusion that this branch of dentistry should be in the hands of well-qualified dentists. These specially trained dentists can serve the needs of their colleagues by making recordings for them. The use of recording centers in metropolitan areas and university dental schools can be the means whereby dentists may refer patients for this special service. The patient would have three inconspicuous reference spots of pigment on his head so the dentist could orient his face-bow properly for the purpose of transferring dental casts to an articulator. The recordings made at the recording center would be sent to the referring dentist just as a set of dental radiographs are sent from laboratories today.

The paths of points located precisely on the hinge axis of the mandible are valid sources of recording information for jaw movements because a given point in space relative to the jaws can be relocated and the path of the specific point retraced at another time. The primary recordings are valuable from a research standpoint because they are made in transparent plastic blocks; therefore, grid analysis or optical scanning of the axis recordings can be performed. Statistical studies can be made to determine various movements of the hinge axis. Recordings can be repeated on various group or individuals over a period of time and under changing physiologic or anatomic conditions; guided by these, studies can be planned and carried out to determine whether there are significant variations or changes in jaw movement characteristics.

SUMMARY

A new apparatus and method for measuring and recording jaw movements was described. All jaw movement information is recorded directly from the patient in the form of engravings in solid plastic. These engravings are related to the hinge axis.

Part II of this article will describe a method and apparatus for transferring the information recorded directly from the patient, through a mechanical device, directly into a pair of plastic blocks to form a second set of hinge axis engravings. This paid of transferred recordings will constitute the total information needed to guide the two styluses of the mandibular part of an articulator.

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