The Roentgenographic Study of Tongue Position*

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It is quite generally believed that the tongue is an important factor in the development of the jaws and dental arches. The adherents of this view offer such evidence as that presented by Sir William A. Lane.[1] In 1903 Lane brought forward evidence which Wallace[2] and others believed gave considerable support to the theory of the relationship between the size of the tongue and the dental arches. His evidence consisted of observations on syphilitic patients with gummatous tongues. The tongues slowly grew larger and there was an accompanying deformity of the occlusion.

Similar observations on deformities of the jaws and dental arches associated with abnormalities in the size of the tongue are found in the literature. Sir William McEwen,[3] who has done much research in the field of bone growth, stated in 1911 that "The tongue, physically at least, is a soft organ and yet its complete removal often produces in the course of years a marked alteration in the shape of the lower jaw, which generally falls inward toward the buccal cavity. Normally the form of the lower jaw is maintained by the soft tissues within the mouth."

While this view is generally accepted it is not without opposition. A. T. Pitts[4] discredits the observations of Lane by stating that he has seen in Mongolian idiots, who usually have enlarged tongues, narrow and crowded dental arches. He does not oppose the contention that the tongue is an important factor in the development of the jaws and dental arches, but he feels that it is the muscular strength of the tongue rather than the size of the tongue that is important.

Dr. J. C. Brash[5] is in complete opposition. He feels that the malocclusion and the enlarged tongues are both symptoms of a deeper and more obscure disturbance. Regarding the influence of the tongue he declares, "It is improbable that the tongue exercised any important direct mechanical influence in the general form and size of the mandible or in molding the form of the growing palate."

Dr. Mathew Cryer[6] also presents arguments in support of this opposite school of thought. He feels that the important factor in the development of the jaws and dental arches is the percussive force of mastication. He believes that, "Should the mandible be compressed and a narrow dental arch exist,

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the tongue would be forced backward into the pharyngeal space interfering with nasal respiration and other functions of the nasal cavity." He apparently believes that the shape and position of the tongue are influenced by the shape of the jaws rather than that the tongue influences the shape of the jaws. Whatever may be the truth of the matter, the literature reveals very little scientific evidence of the influence of tongue function and tongue position on the development of the jaws and dental arches.

Normal and abnormal tongue positions are frequently described in the literature dealing with normal and abnormal breathing. Dr. Martin Dewey[7] believed that in the normal breather the tongue should occupy all of the oral cavity and that after the individual ceases speaking he unconsciously swallows. This swallowing act brings the soft palate and tongue in contact with each other and a vacuum is created between the roof of the mouth and the tongue. He concludes by asserting that the suction of the tongue against the roof of the mouth pulls the vault downward.

O. Henry's[8] description of normal tongue position is more detailed. "In normal respiration the tip of the tongue is placed firmly against the lingual surfaces of the mandibular incisors. The tongue then presses against the cingula of the maxillary incisors; is arched up against the hard palate, at the center of which a vacuum is formed, by which the soft palate is brought into contact with the posterior portion of the tongue, thereby closing the cavity of the mouth from the respiratory tract, the lips being firmly closed."

Dr. C. C. Howard[9] writes, "In the case of the normal breather, the mouth being closed, the lower lip restrains the protrusion of the upper anterior teeth. The tongue, which lies equally between the upper and lower arches, stimulates lateral development of the teeth; while the vacuum created betwen the dorsal surface of the tongue and the roof of the arch contributes to the development of the vault of the mouth in a downward direction."

The importance of a negative air pressure in the oral cavity has been stressed by most of the authors. Lischer[10] expresses their common opinion when he says, "In normal breathing we find a positive air pressure in the nose and a negative pressure in the mouth. In mouth breathing we find the reverse condition and, hence, an abnormal balance between air, muscles, tongue and masticatory pressure." Figs. 1 and 2 are Lischer's diagrams of the relationship of the lips, teeth and tongue in the normal breather and in the mouth breather.

Prof. Emil Herbst[11] is of the opinion that, "The normal atmospheric pressure is effective only with one who really breathes through the nose. In this case the mandible is held firmly to the maxilla like a set of teeth to the suction disc. The weight of the mandible forms at the highest point

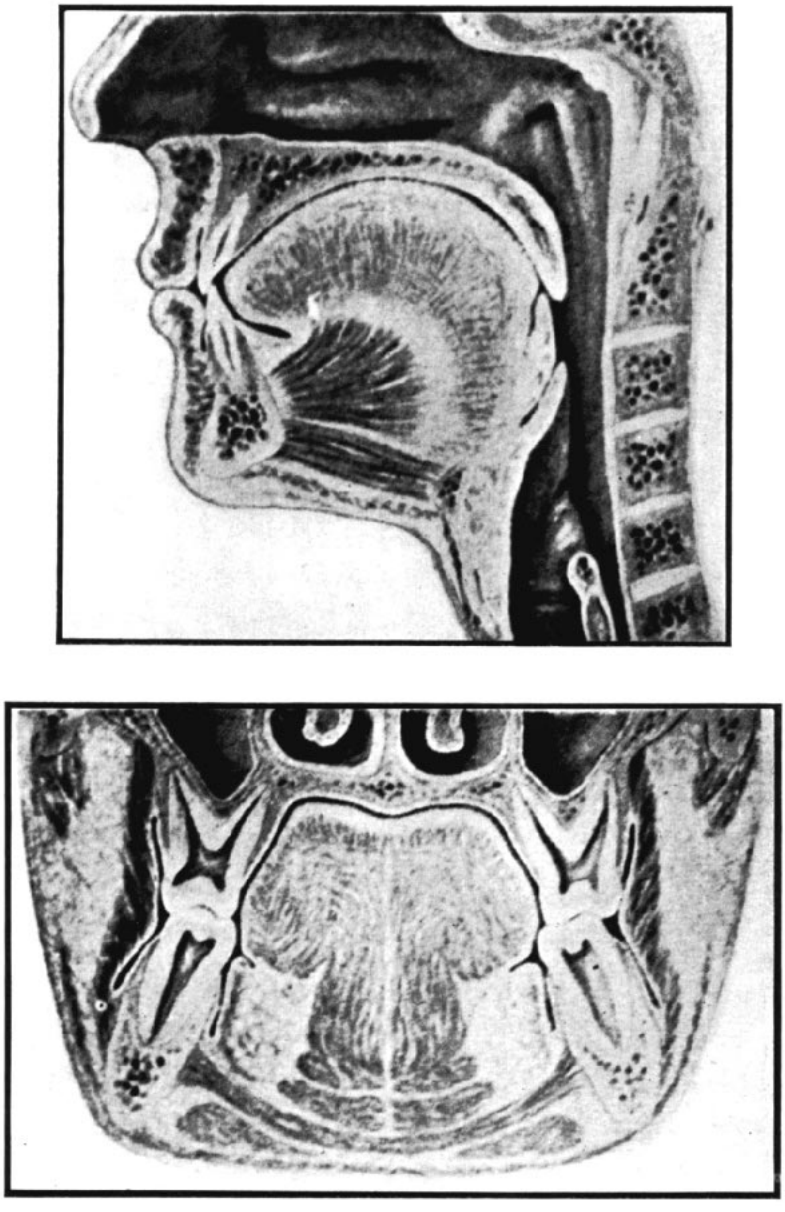
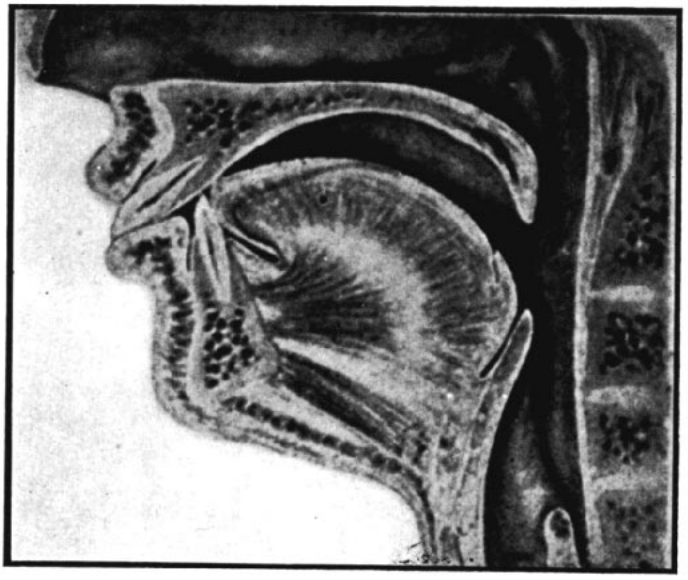


Fig. 1

(Figs. 43, 44 McCoy) The relationship of the lips, teeth and tongue in normal respiration (after Lischer).



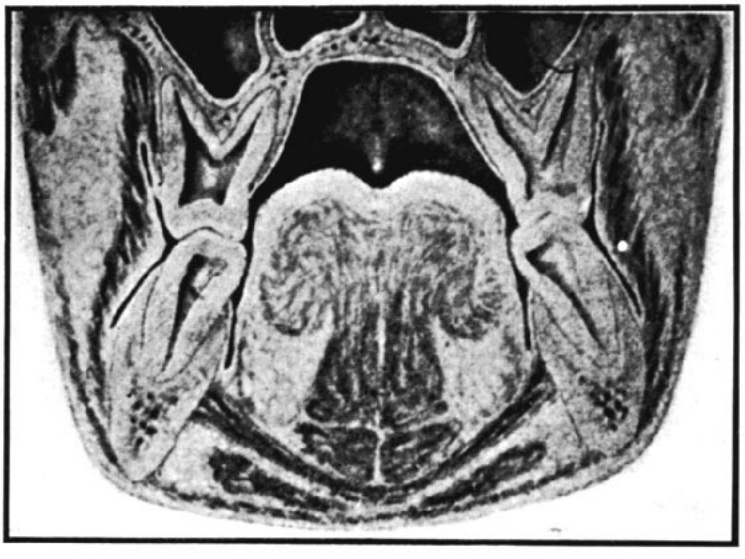


Fig. 2. (Figs. 45, 46 McCoy)

The relationship existing between the lips, teeth and tongue in the mouth-breathers with a well developed case of Class II, Div. 1 (after Lischer).

of the palate, the so-called Donder's suction space, in the same way as the suction chamber in the suction plate."

In 1875, F. C. Donders[12] used a manometer to demonstrate the existence of a negative pressure in the oral cavity of 2 to 4 mm. Hg. It is this investigation of Donder's that forms the basis for the belief of the existence of the vacuum space and negative pressure in the oral cavity. The vacuum space has been called the Donders' vacuum space.

This investigation was repeated by James and Hastings,[13] who found the negative pressure registered 10 cm. H_2O. They said that the negative pressure is dependent upon the position of the tongue, and that if the tongue drops to the floor of the mouth, the negative pressure is lost as air enters the oral cavity either from the anterior or posterior.

Regarding the abnormal tongue position in mouth breathing, Kelsey[14] asserts, "The muscles of expression and mastication are also functionally perverted and the influence of the tongue (the normal counterbalance of the external muscular pressure) is reduced to a minimum. As the tongue no longer fills the oral cavity in which it is ordinarily sustained when the lips are in normal contact by exclusion of the air, the slight partial vacuum formed between it and the posterior portion of the palate is no longer possible. Not only is the tongue not sustained in the roof of the mouth but it is actually depressed and maintained in that position to relieve it from contact with the soft palate."

These conceptions of normal and abnormal tongue positions are probably based on such evidence as Donder's investigation and also the observations made by Cryer,[15] as well as personal opinion. Cryer's observations were made on sections of cadavers frozen shortly after death. (Figs. 3 and 4 are Cryer's sections.) Concerning the normal tongue position he declares, "Normally the dorsum of the tongue lies against the hard palate, but, according to Donders, at the back part it is separated from the soft palate by a small space. Owing to the weight of the jaw, there is a negative pressure in this space of 2 to 4 mm. Hg." . . . "The jaw is maintained in position not by muscular effort, but by the pressure of the air; so that, if a tube from a manometer is placed in that area it shows a slight negative pressure corresponding to the weight of the jaw."

The anatomy text books do not clarify the problem of normal and abnormal tongue position. Cunningham,[16] in describing the oral cavity writes, "The roof is formed by the hard palate and the anterior part of the soft palate, the floor by the anterior of the tongue in the middle and on each side by the reflection of the mucous membrane from the side of the tongue to the gums. If the tongue is raised there is exposed a limited space, termed the sublingual space, or the floor of the mouth."

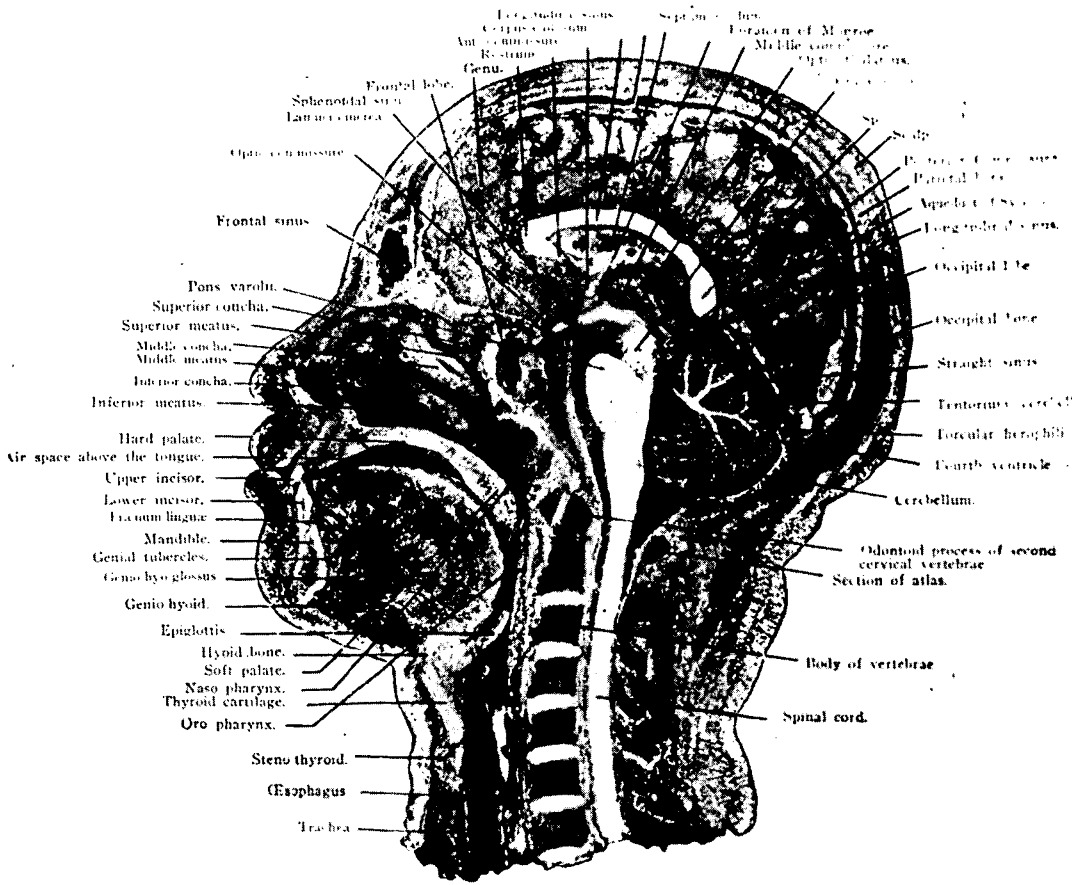


FIG. 301. Frozen section.

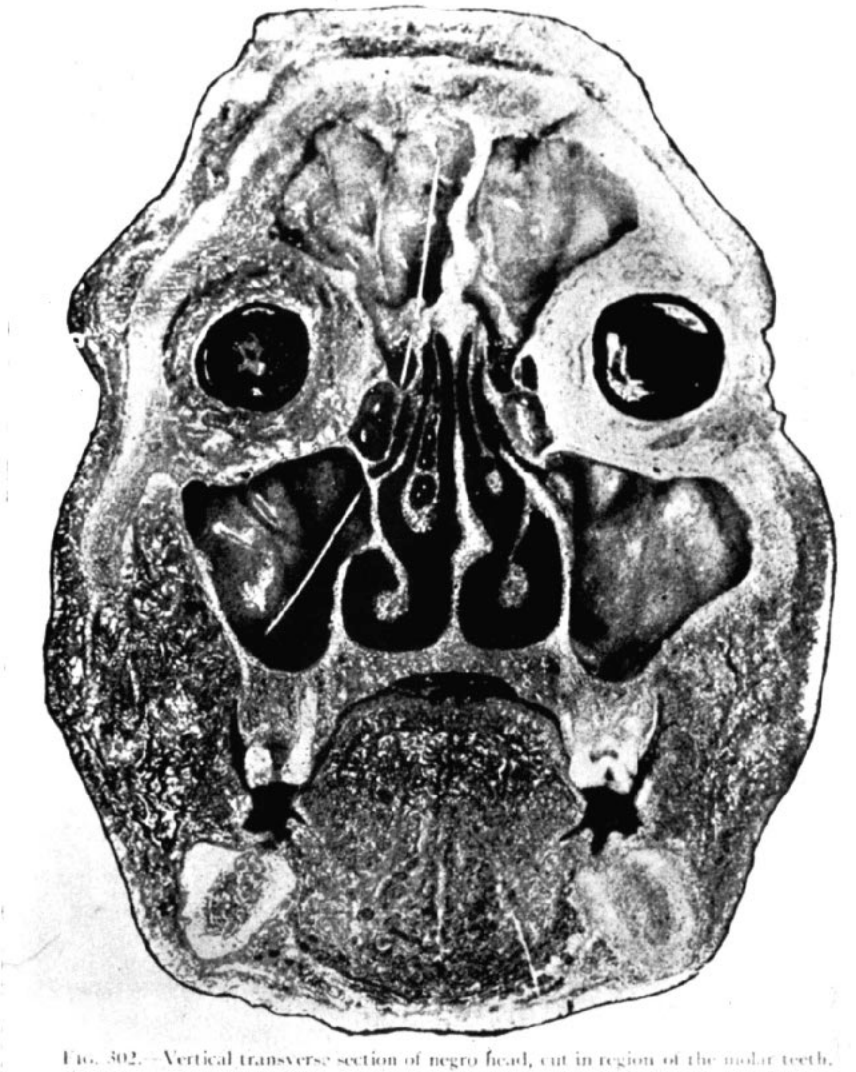


Fig. 302.—Vertical transverse section of negro head, cut in region of the molar teeth.

(CRYER)

Fig. 4

Vertical transverse section of negro head, cut in region of molar teeth (Cryer).

From this description of the oral cavity it could readily be assumed that the tongue normally lies in the floor of the mouth and that it does not fill the entire oral cavity.

This review of the literature naturally leads one to the question of what is the normal tongue position and what is its influence on the development of the occlusion. This investigation was limited to the tongue position, and the effect of the tongue on occlusion was not considered. Living subjects were used in an attempt to obtain direct positive evidence regarding the tongue position.

Subjects

The subjects for this investigation were fifteen individuals selected from the student body of the Northwestern University Dental School. These fifteen students were selected because they had excellent occlusions and were normal breathers. Their ages ranged between 19 years and 25 years, and none of these subjects has had orthodontic treatment.

Roentgenograms

In order to obtain the soft tissue outline of the hard palate and the outline of the median sulcus of the tongue on the roentgenograms, it was necessary to use a thin strip of tin foil and a small gold link chain. The strip of tin foil, approximately ¼" wide and 2½" long, was placed over the midline of the palate extending from the labial surface of the central incisors posteriorly onto the soft palate. Before placing the tin foil on the palate, a denture adhesive powder was sprinkled on the tissue side of the tin foil so as to prevent it dropping away from the palate.

The smallest gold link chain that was available without having one made up to order was used, one .790 mm. in diameter. Approximately four or five inches of this chain was placed on the tongue, and the patient was then given water to drink, by means of which the chain was washed down into the esophagus. The other end of the chain was attached at the center of the mental sulcus by means of a small strip of adhesive tape. The chain was placed so as to lie in the median sulcus of the tongue.

The swallowing of this chain caused very little, if any irritation. If it did cause an irritation, this was because there was a kink in the chain and drinking more water straightened it out. Only one of thirty persons who swallowed the chain complained of any irritation, and this individual was unusually susceptible to gagging.

The chain was found to be much less noticeable by the patient than was a coating of bismuth or barium paste. An advantage of using the chain instead of the paste was that sufficient time could elapse so that the patient was entirely accustomed to its presence and normal conditions were approxi-

mated before the exposure was made. Dr. Leland Johnson was the first orthodontist to use the chain to record tongue positions.

The patient, with the chain and tinfoil in place, was seated in the x-ray chair with the head in an upright and comfortable position and 8″x10″ profile roentgenograms were made.

Series of Roentgenograms

Two separate series of roentgenograms were made of each patient. The first series consisted of roentgenograms made immediately after the completion of the swallowing act. The second series was made up of a group of four roentgenograms for each patient and they were taken in the following order:

1. Immediately after completion of the swallowing act.
2. One-half minute after completion of the swallowing act.
3. One minute after completion of the swallowing act.
4. Two minutes after completion of the swallowing act.

The roentgenograms of this second series were all made at the same sitting. Separate swallowing acts were necessary for each roentgenogram, and the film was changed between exposures. If the patient accidentally swallowed during the timing of one of the exposures, the patient was instructed to swallow again and another timing was taken before the exposure was made.

Slides of the models and roentgenograms of one of the subjects are shown in Figs. 5, 6, 7, 8, 9 and 10. This subject is representative of those used in this investigation. The roentgenograms of a few others will be shown by means of composite diagrams.

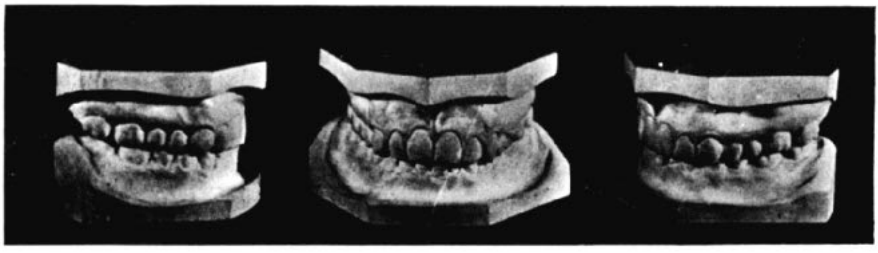


Fig. 5
Front and lateral views of occlusion.

Figs. 5, 6 and 7 are models showing the occlusion, arch form and shape of the palate.

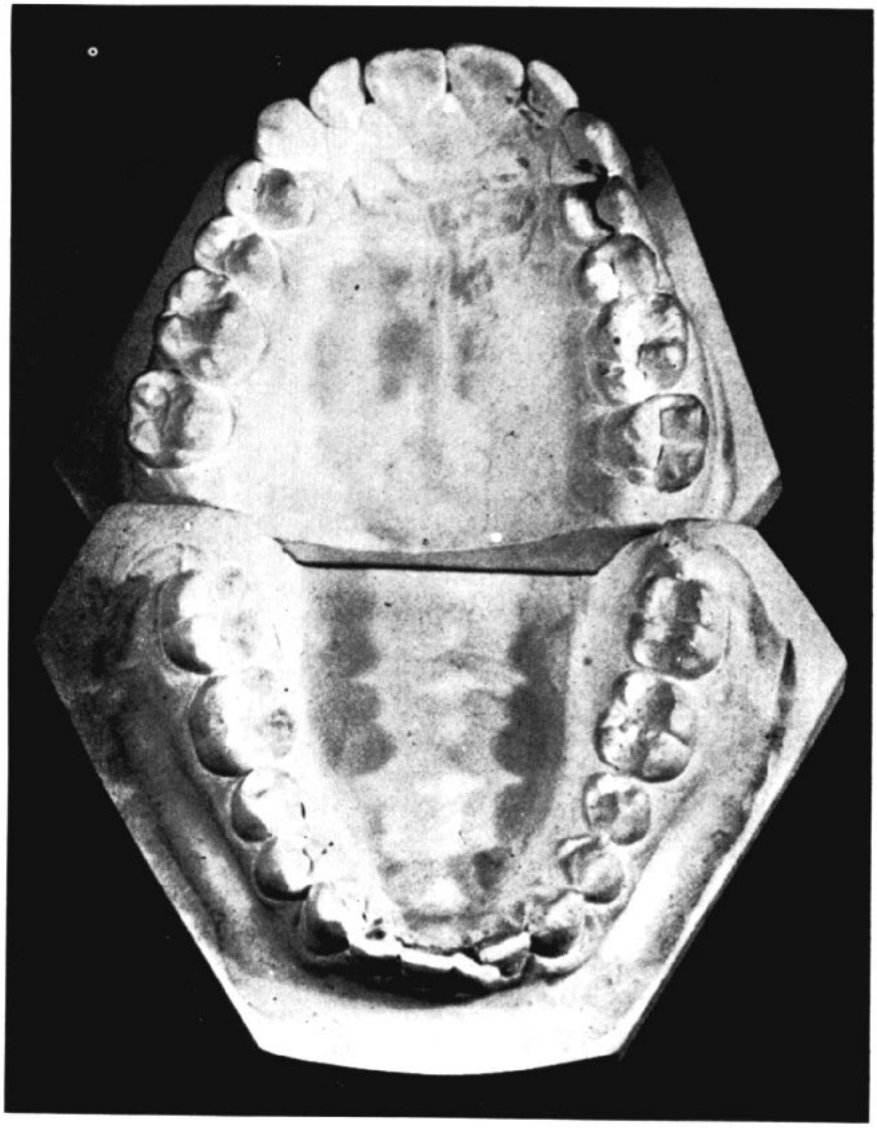


Fig. 6

Occlusal view showing arch form.

Fig. 8 is the roentgenogram made immediately after swallowing. The tongue was in contact with the hard palate and the soft palate was pulled down against its posterior portion. The second roentgenogram, made one-half minute after swallowing, is identical with the first roentgenogram (Fig. 8). Fig. 9 is the roentgenogram made one minute after swallowing. The tongue had dropped away from the hard palate just lingual to the maxillary incisors. The soft palate was raised away from the posterior portion of the tongue. Fig. 10 is the roentgenogram made two minutes after swallowing. The tongue had dropped further away from the palate than it was in the

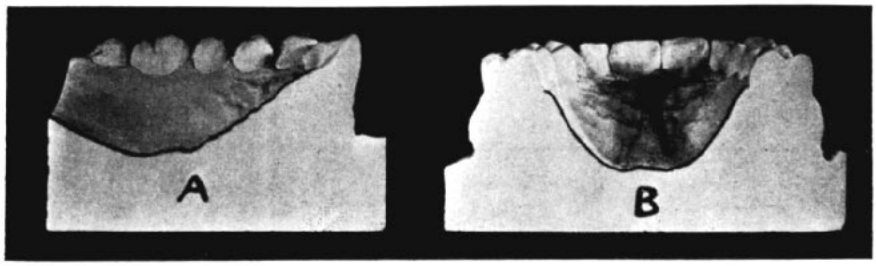


Fig. 7

View showing shape of palate. A: Anterior-posterior. B: Transverse section at first molars.

roentgenogram made one minute after swallowing and the soft palate was raised away from the tongue.

In the composite diagrams, the first roentgenogram, made immediately after swallowing, is indicated by a continuous line; the second roentgenogram, made one-half minute after swallowing, by a broken line of long dashes; the third, made one minute after swallowing, by a broken line of short dashes; and the fourth, made two minutes after swallowing, by a broken line of alternate long dashes and dots. If any of the positions of the tongue are identical to that in the first roentgenogram, then the designating broken line is eliminated.

Fig. 11 is a composite diagram of the tongue positions in subject 1. There was considerable variation in the tongue position in this subject and the tongue was not in contact with the palate, except for a short distance, in any of the roentgenograms. In the first roentgenogram, made immediately after swallowing, the tongue had in all probability dropped away from the palate before it was possible to make the exposure.

Fig. 8

Roentgenogram made immediately after swallowing.

Fig. 9

Roentgenogram made one minute after swallowing.

Fig. 10

Roentgenogram made two minutes after swallowing. (The tin foil had dropped away from the palate.)

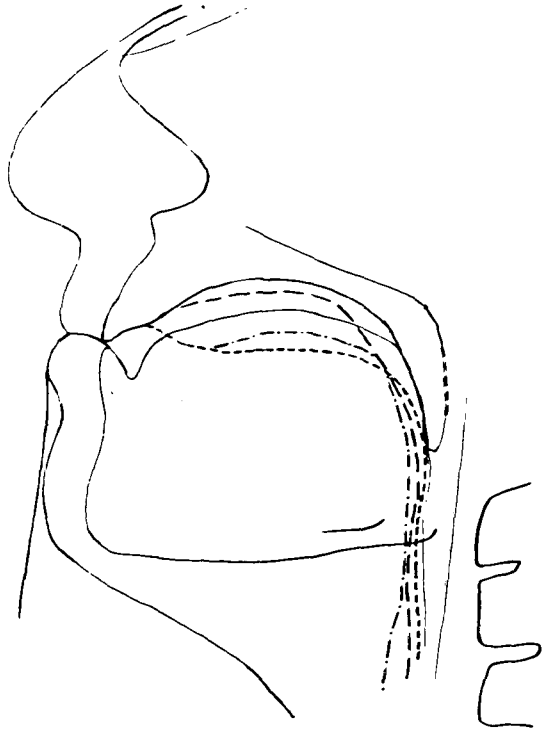


Fig. 11

Composite diagram of the tongue positions in subject No. 1.

Fig. 12 is a composite diagram of the tongue positions in subject 3. In this subject there was no variation in the position of the tongue and the tongue was in contact with the palate in all four of the roentgenograms. These two subjects, Nos. 1 and 3, represent the extremes found in this investigation. There was only one subject, No. 1, in whom the tongue was not in contact with the entire palate in one or more of the roentgenograms. As for the other extreme, there were only three subjects, Nos. 3, 7, and 9, in whom the tongue was in contact with the entire palate in all four of the roentgenograms. These subjects, as has already been stated, represent the two extremes. While the extremes found in any investigation must be definitely considered, the greatest value is derived from the average mean.

Fig. 13 is a composite diagram of the tongue positions in subject 5. The positions of the tongue in the successive roentgenograms are as follows:

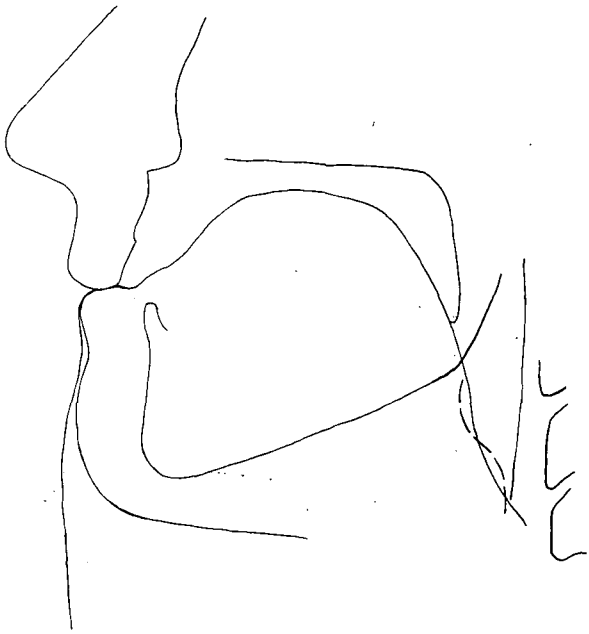


Fig. 12

Composite diagram of the tongue positions in subject No. 3.

1. (Immediately after swallowing.) The tongue was against the hard palate and the soft palate was pulled down against its posterior portion. There was no evidence of a space between the tongue and the palate.

2. (½ minute after swallowing.) The tongue was away from the hard palate and it broke contact with the hard palate just lingual to the maxillary incisors.

3. (1 minute after swallowing.) The tongue was away from the hard palate except in the anterior one-third. It was not as far away from the palate as it was in 2.

4. (2 minutes after swallowing.) The tongue was away from the hard palate except for a small area just to the lingual of the maxillary incisors.

In the third and fourth roentgenograms the soft palate appears to be in contact with the posterior portion of the tongue. In all probability they are not in absolute contact, at least in the median line, because of the arching of the palate. The soft palate is higher along the midline than at its edges.

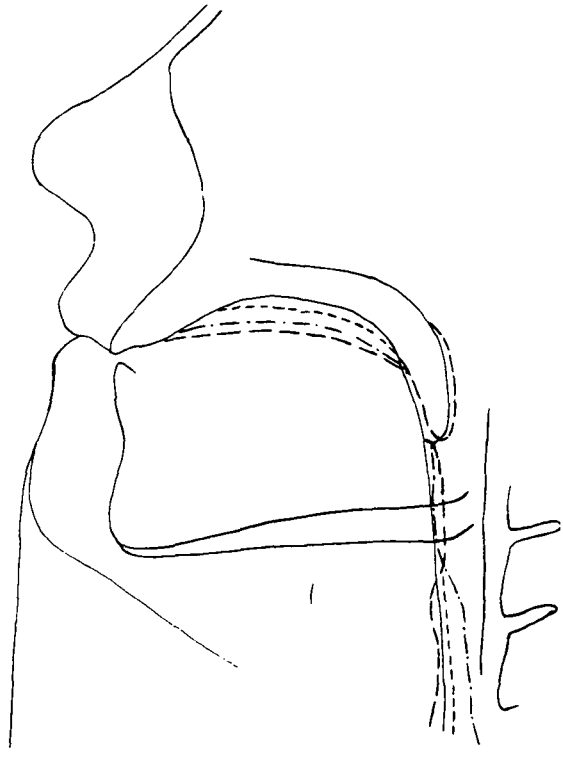


Fig. 13

Composite diagram of the tongue positions in subject No. 5.

Fig. 14 is a composite diagram of the tongue positions in subject 4. The positions of the tongue in the successive roentgenograms are as follows:

1. (Immediately after swallowing.) The tongue was in contact with the hard palate and the soft palate was pulled down against its posterior portion.

2. (½ minute after swallowing.) Identical with 1.

3. (1 minute after swallowing.) The tongue had dropped away from the hard and soft palates. It lost contact with the hard palate just to the lingual of the maxillary incisors at A. The soft palate was raised away from the tongue.

4. (2 minutes after swallowing.) The tongue had dropped further away from the hard palate and it did not contact the maxillary incisors or the hard and soft palate.

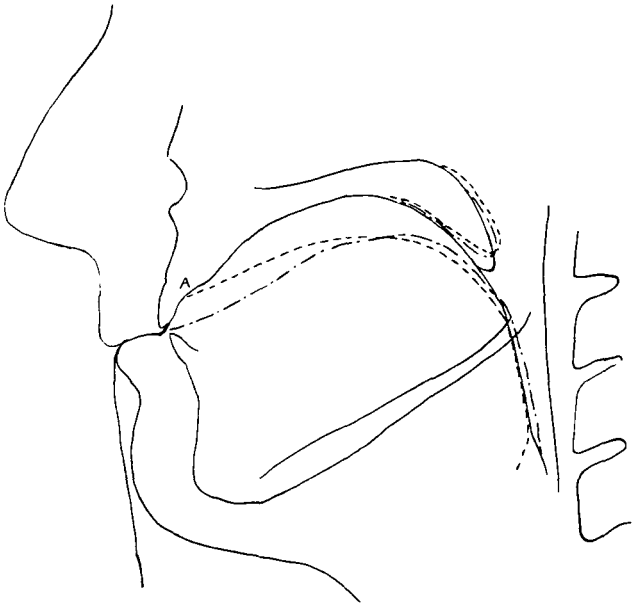


Fig. 14

Composite diagram of the tongue positions in subject No. 4.

Fig. 15 is a composite diagram of tongue positions in subject 12. The positions of the tongue in the successive roentgenograms are as follows:

1. (Immediately after swallowing.) The tongue was against the hard palate and the soft palate was pulled down against its posterior portion. There was evidence of a very small space between the tongue and posterior portion of the palate at A.

2. (½ minute after swallowing.) The tongue position in this roentgenogram was the same as in 1. However, the space at A was slightly larger. There was also evidence of a small space in the anterior at B.

3. (1 minute after swallowing.) The tongue dropped away from the hard palate. The anterior portion of the tongue was against the lingual surfaces of the maxillary incisors and the tongue then curved up toward the palate but it was not in contact with the hard palate.

4. (2 minutes after swallowing.) The tongue had dropped further away from the palate.

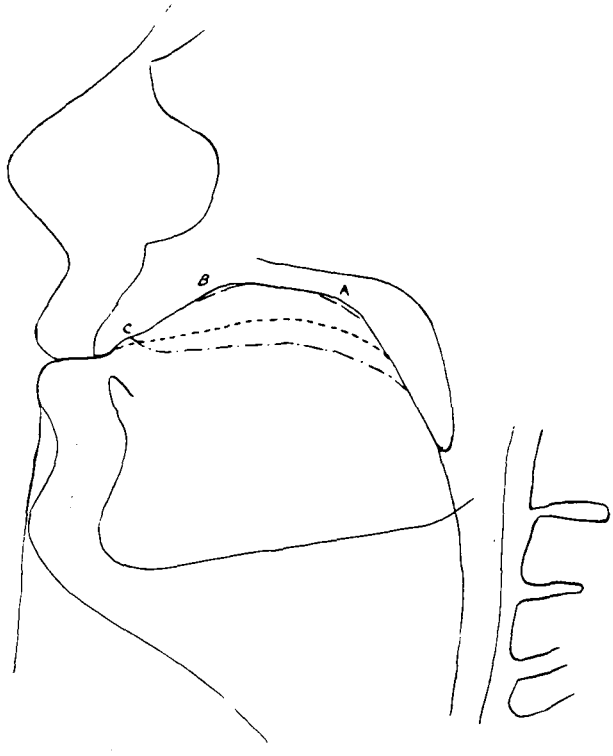


Fig. 15

Composite diagram of the tongue positions in subject No. 12.

Fig. 16 is a composite diagram of tongue positions in subject 15. The positions of the tongue in the successive roentgenograms are as follows:

1. (Immediately after swallowing.) The tongue was against the lingual surfaces of the incisors and was in contact with the hard palate and the soft palate was pulled down against the posterior portion of the tongue. There was no evidence of a space between the tongue and palate.

2. (½ minute after swallowing.) The position of the tongue and position of the soft palate were identical to that in 1.

3. (1 minute after swallowing.) The tip of the tongue was in contact with the lingual surfaces of the mandibular incisors. The tongue was in contact with the maxillary incisors but not with the palate.

4. (2 minutes after swallowing.) The tongue was in contact with the lingual surfaces of the mandibular incisors and it was away from the maxillary incisors and hard palate.

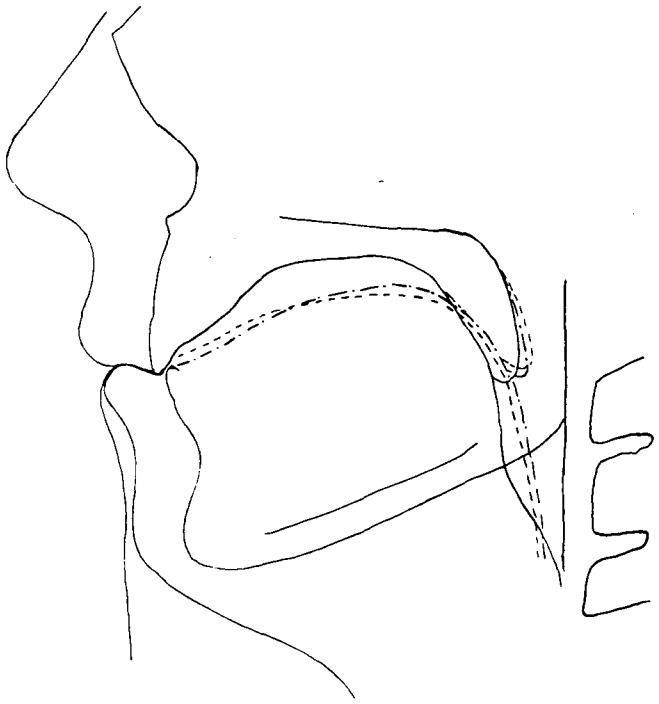


Fig. 16

Composite diagram of the tongue positions in subject No. 15.

Fig. 17 is a composite diagram of tongue positions in subject 10. The positions of the tongue in the successive roentgenograms are as follows:

1. (Immediately after swallowing.) The tongue was in contact with the hard palate and the soft palate was pulled down against the posterior portion of the tongue.

2. (½ minute after swallowing.) The tongue was against the hard palate, however, posterior portion of the tongue appeared to be slightly flattened and apparently moved downward and forward. The soft palate appeared to be definitely away from the tongue.

3. (1 minute after swallowing.) The tongue position was identical to that in 1 and the soft palate position was also the same.

4. (2 minutes after swallowing.) The tongue had dropped away from the hard palate at D, just to the lingual of the maxillary incisors. The posterior portion of the tongue did not appear to be in contact with the soft palate.

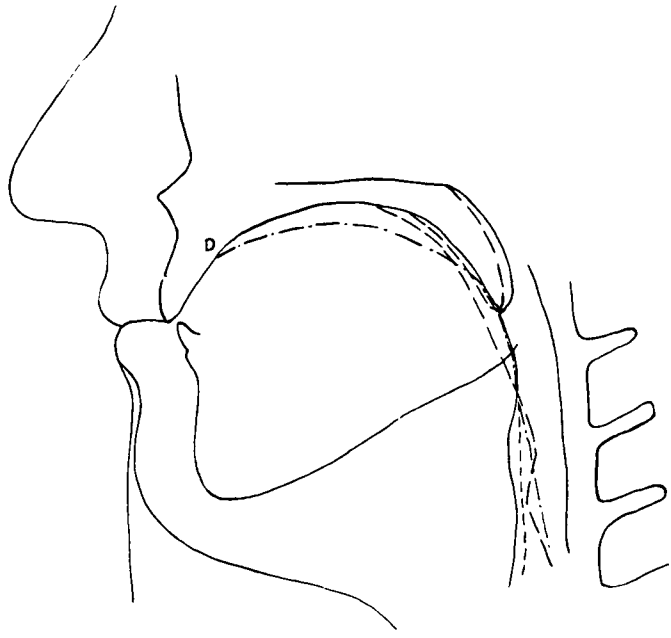


Fig. 17

Composite diagram of the tongue positions in subject No. 10.

Fig. 18 is a graphic representation of the successive tongue positions in the four roentgenograms of each subject in the second series. The graph is divided into five vertical columns. The first column on the left contains the subject's number; the second column, column No. 1, indicates the first roentgenograms, made immediately after swallowing; column No. 2, indicates the second roentgenograms, made ½ minute after swallowing; column No. 3 indicates the third roentgenograms, made 1 minute after swallowing, and column No. 4 indicates the fourth roentgenograms, made 2 minutes after swallowing. The heavy lines designate the position of the tongue in each roentgenogram. If the tongue was against the palate, a heavy line was drawn at the top of the section for that subject and if the tongue was away from the palate, the heavy line was drawn at the bottom of that section. The subjects were arranged in this graph according to the similarity of the tongue positions rather than by their numbers.

It seems logical to assume that if the normal position of the tongue be against the hard and soft palate, then all, or at least a majority, of the fifteen subjects examined should have maintained the tongue in such a position in

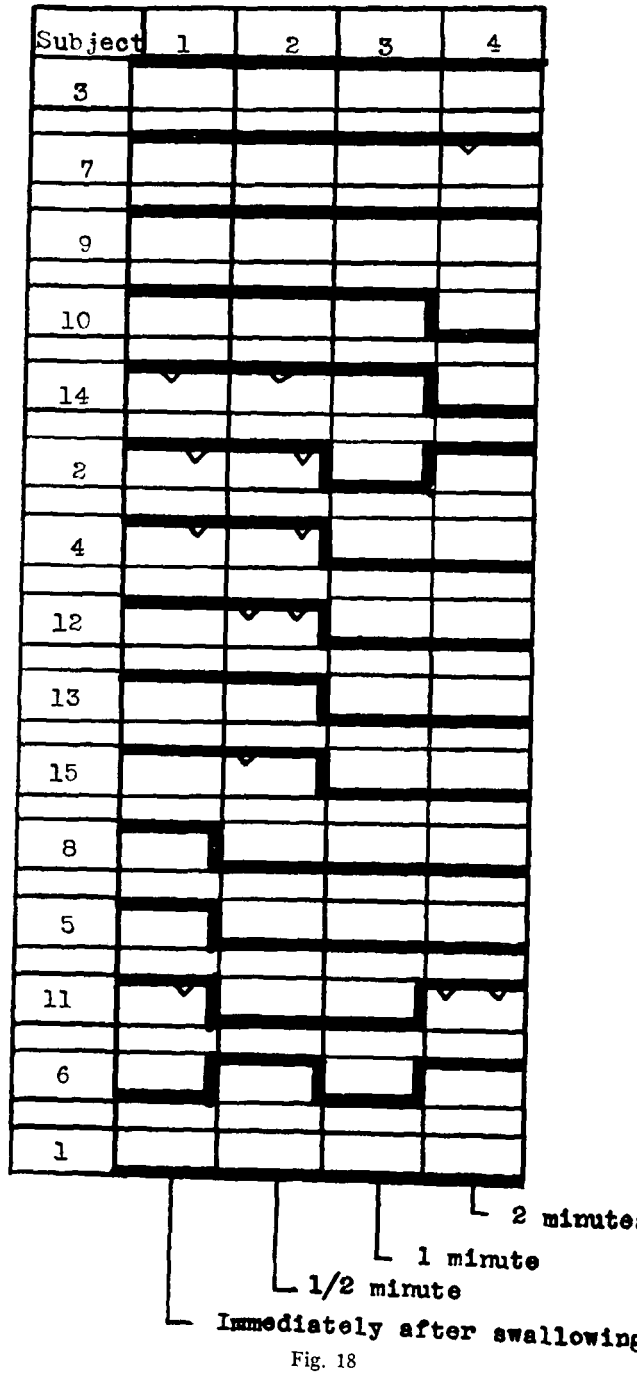


Fig. 18

all four of the roentgenograms in the second series. This condition occurred only in subjects Nos. 3, 7 and 9. The subject was given no positive reason for moving the tongue away from the palate if that was where he naturally would have put it. The desire to swallow within the two minute period, if it had any effect, would have been to bring the tongue in contact with the palate, not away from it. Furthermore, the subject had no reason to feel self-conscious about the position of his tongue, as it had not been called to his attention, therefore, there could have been no disposition to move it. There is nothing in the evidence, other than subjects Nos. 3, 7 and 9, to give any support to the belief that the normal position of the tongue is invariably against the palate, except for a short period immediately after swallowing. At this time, the tongue should be in contact with the palate and this contention was supported by the fact that in thirty-nine of the forty-seven roentgenograms made immediately after swallowing the tongue was in that position. (In the eight cases when the tongue was not against the palate immediately after swallowing in all probability it had been removed before it was possible to make the roentgenogram.) It is quite possible the belief that the normal position of the tongue, when not in function, is in contact with the palate is based on observations made immediately after swallowing.

In subjects Nos. 5, 8, and 11, the tongue had dropped away from the palate before thirty seconds after swallowing and in subjects 2, 4, 12, 13 and 15, the tongue had dropped away from the palate between thirty and sixty seconds after swallowing. The evidence of these eight subjects, and also of subjects 10 and 14, in whom the tongue dropped away from the palate between one minute and two minutes, *suggests that the tongue should be against the palate immediately after swallowing but that, in many persons, it shortly drops away from the palate.*

It will be recalled, from the review of the literature, that the only positive evidence for a normal position of the tongue in contact with the palate, with a vacuum space existing between the posterior portion of the palate and the tongue, was furnished by Cryer[16] from frozen cadaver specimens. The probability that the tongue position under these conditions does not represent the normal is strengthened by the fact that other features in his diagrams from these cadavers do not agree with the roentgenograms of the living subjects.

Cryer's diagram, Fig. 3, shows the soft palate and posterior border of the tongue to be in close proximity with the postpharyngeal wall. Cryer states, "Fig. 301 (Fig. 3) is from a sagittal section of a frozen skull, showing the various structures of the brain. It also gives a true idea of the

lateral portion of the nasal cavity, the hard and soft palates, the pharynx, the mouth, the tongue and the epiglottis, and their relations to each other. The incisor teeth are in good occlusion. The mouth is nearly filled by the tongue, leaving but little space under the arch of the palate. The tongue also extends well back into the oropharynx, coming in contact with the soft palate, which is carried backward against the pharyngeal wall."

"In the normal living subject, when the mouth is closed, the soft palate, the posterior border of the tongue and the epiglottis are all in close proximity to the postpharyngeal wall."

The roentgenograms of the living subjects show that they are not in close proximity and there is a fairly large space for breathing (see Figs. 8, 9 or 10).

The evidence brought out in this investigation apparently indicates that there is no fixed position of the tongue. The variation in the tongue positions in these subjects, when the tongue was away from the palate, suggests that the tongue is mobile and there is no fixed position that the tongue should assume when the individual is not speaking or swallowing.

There is very little, if any, evidence to support the belief that a vacuum space exists between the tongue and posterior portion of the hard palate, as first described by Donders in 1875. Of the twenty-six roentgenograms in the first series, in which the tongue was in contact with the palate, only four indicated the presence of a space between the tongue and posterior portion of the hard palate. In the second series, of thirty-five roentgenograms made at different time intervals, when the tongue was against the palate, only ten indicated the presence of a space between the tongue and hard palate. These spaces are not as large as those described in literature. In one of these, the space was in the anterior and in two, the space was at the center of the hard palate rather than at the posterior.

The space is indicated in Fig. 18 by a "V." It did not occur in any of the roentgenograms of subjects Nos. 3, 7 and 9, whose tongues were against the palate throughout the second series, except for a small area in the anterior in the fourth roentgenogram of subject No. 7. The space did occur in at least one of the roentgenograms of subjects Nos. 2, 3, 11, 12 and 15; and in these subjects the tongue was dropped away from the palate in the immediate subsequent roentgenograms. Subject No. 14 was the only one in which a space occurred which was not immediately followed by a dropping of the tongue; however, the tongue did drop in the next roentgenogram. This evidence suggests that the space, rather than being indicative of a vacuum space, is evidence that the tongue is beginning to drop away from the palate and that this area was where the first break between the tongue and palate occurred.

Since the space occurs in only a few of the cases in which the tongue was in contact with the palate, and since the mouth, in the other cases, did not open, it is apparent that there must be another more important factor that keeps the mouth closed and the jaws together. This factor is possibly muscle tonus.

The negtive pressure that is assumed to exist in the oral cavity of a normal breather, is said to be an important factor in the development of the maxilla. However, the evidence brought out in this investigation suggests that it may only be active for a period shortly after swallowing. As soon as the tongue drops away from the palate, as it did in most of the subjects shortly after swallowing, the negative pressure can no longer exist, as air can enter the oral cavity from the pharynx when the posterior seal is broken. If the negative pressure only exists periodically, after each swallowing act, then it cannot be as important as it has been believed to be.

Conclusions

1. The results of this study do not agree with the general belief that the tongue, when at rest, is invariably against the palate.

2. In 83% of the roentgenograms made immediately after swallowing the tongue was against the hard palate and the soft palate was against the posterior portion of the tongue.

3. Apparently the tongue should normally be against the palate immediately after swallowing, however, it shortly drops away from the palate and a negative pressure could then not exist.

4. The results of this study do not agree with the general belief that a vacuum space exists between the tongue and posterior portion of the hard palate, as in all but a few of the roentgenograms in which the tongue was against the palate there was no evidence of space.

5. The results of this investigation suggest that a vacuum or negative pressure within the mouth is not so important a factor in the maintenance of the mandible in its rest position as has been assumed.

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