Oral Habits -- Studies in Form, Function, and Therapy

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To place things in proper perspective, it seems wise to point out that nervous habits in children are many and varied. One of the few inventories of habits among grade school youngsters was reported by Olson.[1] Nervous habits were listed as follows: finger and nail picking, scratching, eye rubbing, blinking, nose picking, ear pulling, hair twisting, and then the broad category labeled "oral habits." The oral habits were defined as thumbsucking, fingersucking, nail biting, tongue sucking and tongue thrusting. The subdivision of oral habits was found to be most prevalent of all the habits of youngsters, over half the youngsters observed had such habits.

According to Olson, the most common habit within the oral group was thumb and fingersucking. Nail biting was second in frequency, lip biting third, lip and tongue sucking fourth, and lowest on the list, ranking fifth, was tongue thrusting. More recent studies[2,3] indicate a much higher incidence of tongue thrusting. In fact, several investigators have reported that over half the youngsters in grade school levels exhibit tongue thrust. These more recent reports place tongue thrusting on top of the list as the most common oral habit in young children.

Since it is frequently considered to be the most common of oral habits, discussion should begin by attempting to define just what is meant by "tongue thrusting", especially, in light of the fact that tongue thrusting during swallow has lately been considered to be an abnormal or perverted pattern of swallowing leading to orofacial muscle imbalance and problems in occlusion. The assertion is made that abnormal function of the tongue and lips has an unfavorable effect upon the form of the interposing dental alveolar complex.

Definitions and Variable Patterns

The descriptions of abnormal tongue and lip function have been presented in terms of deviations from normal. Thus, current descriptions of abnormality have been influenced by the prevailing concept of normal patterns of swallowing. Apparently many dental and speech specialists have accepted the following description of normal deglutition which states: 1) during swallowing, the muscles of facial expression are not used; 2) the muscles of mastication bring the teeth and jaws together and hold them together during the entire act of deglutition; 3) the tongue mass remains within the confines of the dental arches during swallowing. On the basis of these statements abnormality would be described in terms of lip, jaw and tongue activity. Abnormality in swallowing would be indicated: 1) by lip (circumoral) contraction; 2) by failure of the buccal segments or the molars to contact, in other words, the teeth remain apart; and, 3) by tongue protrusion between the incisor and/or the buccal teeth during the act of de-

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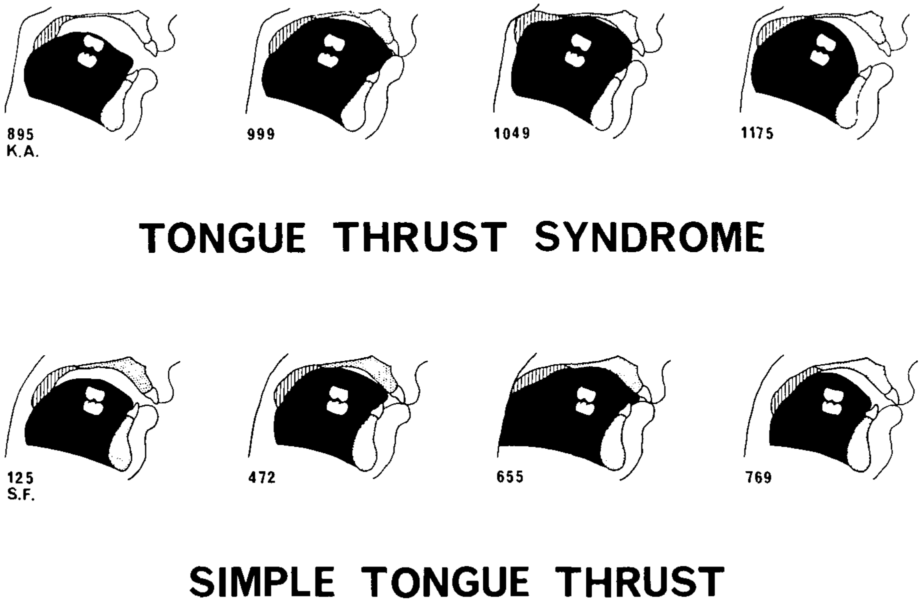

Fig. 1 Tracings of cineradiographs of two individuals depicting features of prevailing concepts of abnormal patterns of swallowing. Tongue Thrust Syndrome: Tongue-tip protrusion, circumoral contraction, no molar contact. Simple Tongue Thrust: Tongue-tip protrusion.

glutition (Fig. 1). These, in essence, are the three aspects that have been evaluated and defined in differentiating normal from abnormal swallowing. The fact, not so apparent, is that much confusion has arisen relative to the normal pattern of swallowing as it relates to tongue, lip and jaw activity. Normal swallowing patterns have not been adequately defined or simply have not received enough clinical attention in the past to be able to differentiate the normal from the abnormal.

Clinically, it has been demonstrated that "so-called" abnormal muscle patterns could be present in patients with normal occlusion. Although most of the clinical reports have described abnormal swallowing which is associated with malocclusion, there are a few descriptions of tongue and lip activity associated with normal occlusion. For example, Rogers[4] studied 290 randomly selected elementary school children ranging in age from 5 to 12 years. In his study occlusion, as well as swallow activity, was noted. In youngsters with normal occlusion he found one out of every five to have abnormal swallow activity. Thus, abnormal lip and tongue patterns were found to exist when occlusion was normal. In these children the so-called abnormal muscle patterns, of themselves, did not seem to have an adverse effect upon occlusion. Quite clearly it is evident that abnormal swallow is not always associated with malocclusion.

One begins to question whether the criteria for abnormality in swallowing are faulty. Several studies have been conducted which permit observations relative to normal patterns of deglutition. Cineradiography has been applied to study swallowing activity and considerable attention should be given to some of the salient results of these studies. Essentially, the advantage of the technique as applied to swallow discussion lies in the fact that tongue, lip and jaw movements can be identified without lip retraction and defined within the reference of time.

In 1955 an excellent report on swallowing was published by Ardran and Kemp.[5] Material consisted of cineradiographic examinations of 250 adults under thirty years of age. None of the persons examined had any gross facial or associated dental abnormalities or known abnormalities of speech or swallowing. After analysis of films, the following description of swallowing was written. "In the erect position, a small, fluid bolus rests in a depression upon the upper surface of the forepart of the tongue. When swallow begins, the tip of the tongue is thrust *forward* against the upper incisor teeth and the posterior surface of the gums. The tongue is then pressed upward against the hard palate. When swallow begins, the teeth may be in *apposition* or *slightly parted.* In many of the films the teeth were not tightly in apposition but the combined action of teeth, cheek and tongue was enough to stop barium from being squirted into the cheek cavity during swallow. The tongue was spread and went between the teeth in certain acts of swallow." In summarizing observations Ardran and Kemp stated the general pattern of movement is constant, but there are many variations in individual behavior. These findings show that tongue thrust against incisors and incomplete contact of molars can be characteristic of normal swallowing activity.

In another study completed in 1964 at Eastman Dental Center, cineradiographic observations were analyzed for twenty-eight adolescents with normal occlusion. Cleall,[6] who reported this work, stated that the tongue tip moved upward and forward from rest to make contact with either the lingual surface of the upper incisors or the palatal mucosa just behind the incisors during the initial stage of swallowing. He states that, whereas in most cases the tongue tip remained behind the incisors, eleven per cent of the subjects with normal occlusion protruded the tongue tip beyond the incisors. This finding suggests, again, that the protrusive movement of the tongue tip during swallow may not necessarily be abnormal. Further analysis of the data relative to molar contact showed forty per cent of the subjects with normal occlusion made no molar contact during any phase of swallowing.

In another study Lopez[7] reported eight of ten adults with normal occlusion did not exhibit molar contact during the entire act of swallowing (Fig. 2). These findings indicate that tooth contact during deglutition is an improper basis for differentiating normal and abnormal activity. Furthermore, in the latter study ten per cent of the cases with normal occlusion exhibited tongue-tip protrusion during swallowing.

Whereas cineradiography has been employed to study jaw and tongue activity during swallowing in normal patients, orofacial muscle activity has been investigated by photographic and clinical techniques at the Eastman Dental Center. Rosenblum[8] studied orofacial muscle activity during deglutition in twenty subjects with normal occlusion. A standardized and orientated motion picture technique was used. Analysis of films relative to the duration and magnitude of the muscular activity showed perioral activity occurred in subjects with normal dentitions more than fifty per cent of the time (Fig. 3). From this cinephotographic evidence, activity of the perioral musculature during deglutition would not appear to be a reliable and valid indication of abnormality in de-

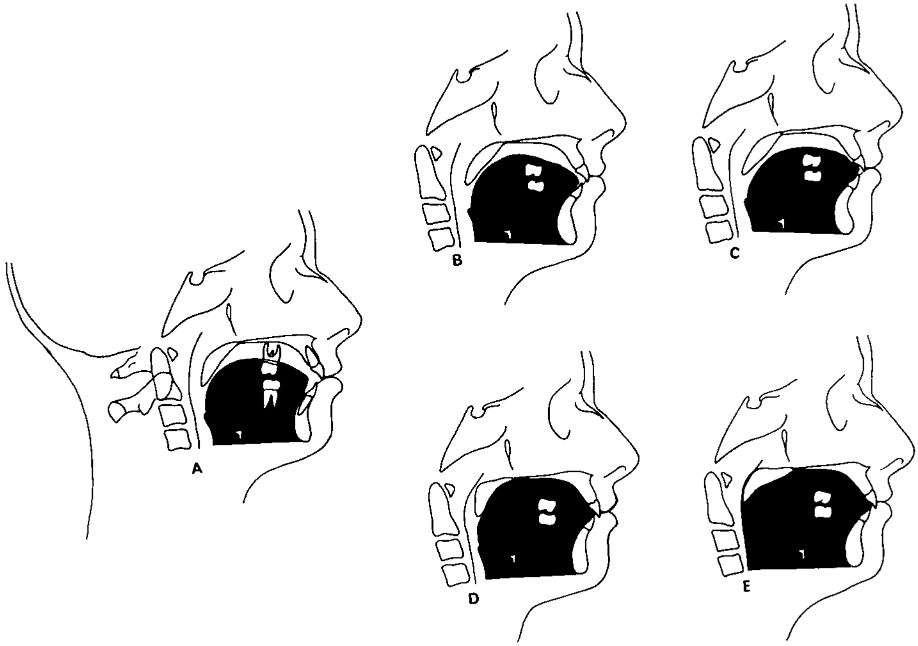

Fig. 2. Tracings of cineradiographs taken on an individual with a normal occlusion during swallowing. Molar contact is not evident. Slight tongue protrusive activity is noted in D. A to E represent different stages during the swallowing act.

glutition. If perioral activity is considered an indication of abnormality, then this abnormal muscle function was found to be associated with normal occlusion.

In the subjects with normal occlusion, assistive orofacial muscle activity during swallow occurs; molar contact varies, even tongue thrusting is sometimes observed. Much of what has been described as an abnormal pattern of deglutition could really be an acceptable variable with a normal pattern of deglutition. Not everybody looks alike, not everybody functions alike, nor does everybody swallow alike. The latter phrase has been substantiated by the study of people with normal occlusion who were observed to be functioning in different ways during the process of swallowing. In a goodly number of individuals with normal occlusion some of the manifestations of so-called abnormal swallowing patterns were observed. Many variables were noted in normal patterns of deglutition. Molars were found to be apart or together; tongue protrusion was observed as well as no protrusive activity; the same was found to be true of circumoral muscle activity. Assumed deviation in function was noted when form was normal. It might also be stated that in studies involving other cases with abnormal form, namely malocclusions, relatively normal function was noted (Fig. 4). In reality, part of the controversy today may be related to a faulty definition of what constitutes abnormal activity during swallowing.

Explanations: Why the Variable Patterns?

In many youngsters the tip of the tongue can be observed to protrude between the incisors during the swallowing procedure. Is it something to be concerned about? Should an at-

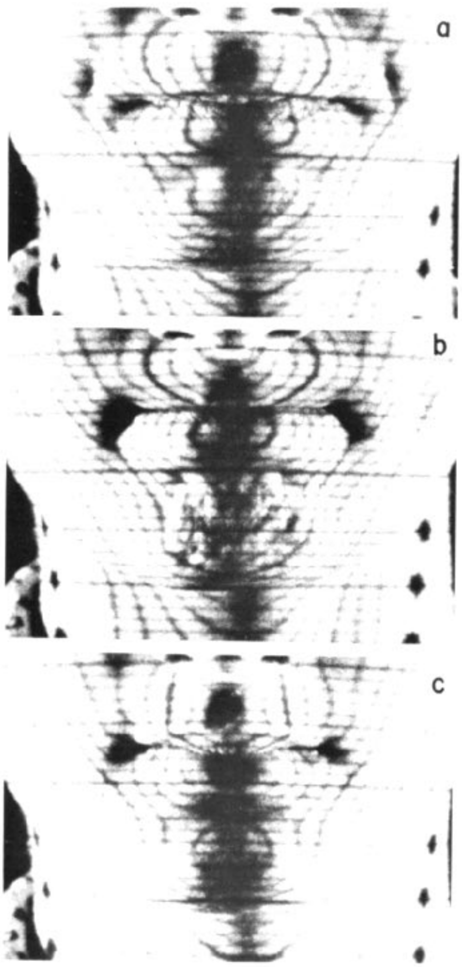

Fig. 3. Selected physioprints taken from the cinephotos of an individual with a normal occlusion. During the act of swallowing some circumoral muscle activity is evident: a. peak of lip compression, b. peak of mentalis activity, c. conclusion of swallow.

tempt be made at correction or not? Finally, when is it a problem and when not? In an effort to explain the phenomenon of tongue-tip protrusion during swallowing, several different, but related factors will have to be taken into consideration, i.e., oral-pharyngeal development and maturation as well as oral habits and environmental influences. As may become evident, variables of age, environment and oral habits such as thumbsucking, mouthbreathing, etc. can have an influence upon the occurrence and relative incidence of "tongue thrusting."

Initially, the influence of growth and development on the prevalence of tongue protrusive activity should be taken into consideration. In considering growth as a factor, one concept must be kept in mind at *all* times. Different parts of the human body grow at different rates and at different times. During over-all body growth there is an expression of disproportionate growth. During the early months of fetal life the human head may proportionately measure one third to one half of total body length; at the time of birth the head takes up approximately one quarter of total body length. With progression of time into maturity, the head finally takes up a smaller proportion, approximating one-eighth of total body length.[9] This does not mean the head has not been growing; it simply means it has been growing disproportionately to other parts of the

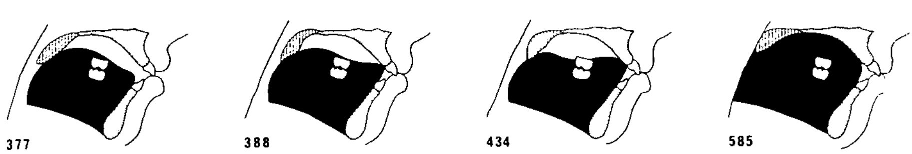

Fig. 4. Selected frames traced from the cineradiographs of an individual with an open-bite malocclusion taken during swallow. None of the features of abnormal swallowing can be observed.

Fig. 5. Midsagittal section of a fetal head. The tongue occupies a large area of the oropharyngeal region with protrusive tongue-tip posture noted.

human body; different parts of the human head also grow at different rates and different times. One has only to follow the progressive development of the tongue, jaws and dentition to understand the significance of this observation relative to the function of swallowing.

It has been stated that prior to birth there are three structures within the human head that are well-advanced in development in comparison with other structures of the head. They are the brain, the eyeball and the tongue; interestingly, all are soft-tissue structures. This observation is readily corroborated by studies done on fetal heads.[10]

In sections of the fetal head the noteworthy observations have been that the fetus is retrognathic, with the chin in a considerably retruded position and that the tongue occupies a goodly portion of the oral cavity and the pharyngeal cavity (Fig. 5). In the fetus, the tongue-tip protrudes beyond the confines of the dentoalveolar process and frequently contacts the lower lip. The fetal tongue frequently assumes a posture that simulates swallowing action but, more significant to the present discussion, the tongue is disproportionately large relative to the oral cavity. It occupies a disproportionately large part of the oral-pharyngeal cavities. This disproportion in tongue size is not only evident prior to birth, but also at the time of birth.

Ortiz and Brodie[11] have shown that at birth the tongue will occupy an excessive portion of the oral cavity. Much as was observed in the fetus, the newborn will give evidence of a tongue that occupies most of the oral cavity and protrudes beyond the alveolar gum pads. Ortiz and Brodie have described this relationship as normal during infancy. One gains the impression that normal infants will posture the tongue in a forward position and, as has been described by Ardran and Kemp,[12] will thrust the tongue during swallowing. This posture and action, supposedly abnormal, have been described as fairly typical at the time of birth and shortly after. It is important to note that the protruded position of the tongue-tip relative to the dentoalveolar complex will change as a function of time and the associated changes in the oral-pharyngeal environment which occur with growth and development. This generalization is based upon cross-sectional data. Apparently, there is no well-defined longitudinal reference of normal tongue growth and swallowing activity as it relates to orofacial structures.

With progression of time and growth, teeth will erupt into a muscular environment which can have an influence upon the developing occlusion, but which in turn can have an influence in containing and supporting the contiguous muscular structures. At the time of eruption of the deciduous dentition, a comparatively and disproportionately large tongue still exists. At this stage of dental development, unless abnormality in the facial skeleton exists, crowding of the deciduous teeth is rarely evident. One of the reasons may be that a comparatively large tongue within the oral cavity will maintain deciduous teeth in nice arch alignment. Many times spacing between the anterior deciduous teeth will be evident. Later on, crowding may be encountered as is emphasized by a rather common expression of parents contemplating orthodontic treatment for their children. "His teeth were so beautifully aligned when he had baby teeth. Now, I am told he must have teeth extracted because of the crowding." This does not negate the added dimension of permanent teeth, but does indicate the favorable influence of a comparatively large tongue on the deciduous dental arch alignment. Needless to say, protrusive tongue activity can be strongly evident at these early age levels.

When the deciduous anterior teeth are lost and before eruption of the permanent anterior teeth, protrusive tongue activity becomes very apparent. Initially, there is a natural opening in the anterior region of the dentition dictated by mother nature. Any time a tooth has been lost there is a natural area for the tip of the tongue to explore. It may be assumed that with the loss of anterior deciduous teeth and with the resultant anterior opening in the dental arch, some protrusive tongue activity would be observed.

To verify or refute this assumption[13] cineradiographs were obtained on a group of youngsters before and after the eruption of permanent incisors. In many instances prior to the eruption of the permanent incisors, the tongue-tip was observed to protrude beyond the anterior dentoalveolar region during swallowing. In these cases, subsequent to the eruption of the permanent incisors effecting a natural closure of the anterior space, tongue protrusion was no longer evident (Fig. 6). Thus, when tongue thrust is noted, it may disappear after the eruption of the permanent incisors. However, even at

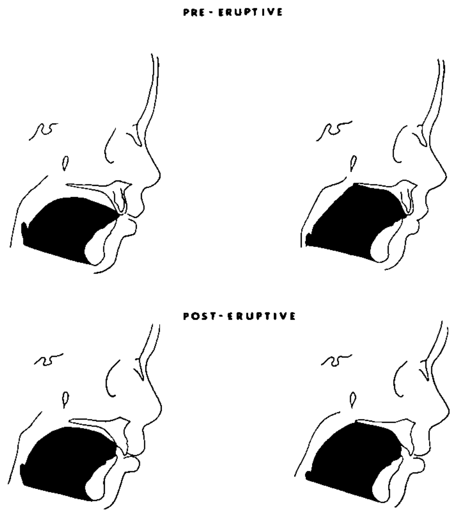

Fig. 6. Tracings of comparable frames of cineradiographs taken on the same individual before and after eruption of the incisor teeth. During swallowing, tongue-tip protrusion is evident before eruption of incisor teeth, but not after eruption of these teeth.

this stage of development there are some youngsters who still appear to have tongues disproportionately large relative to their contiguous environment. As a result, tongue protrusion may be associated during swallowing. This is still not a time to be concerned with protrusive activity. In most instances there will be a change in the disproportion with continued maxillary and mandibular jaw growth and with anticipated tongue growth. Eventually and usually jaw growth will be adequate to maintain the tongue within the confines of these structures. To a degree this can explain the spontaneous closure of open bites incident to time and growth as is sometimes observed at later age levels (Figs. 7 and 8). It has also been observed that during the later stages of development the dentoalveolar processes fall back and upright relative to their skeletal foundations. These observations suggest that, coincident with continued jaw growth, the influence of the tongue

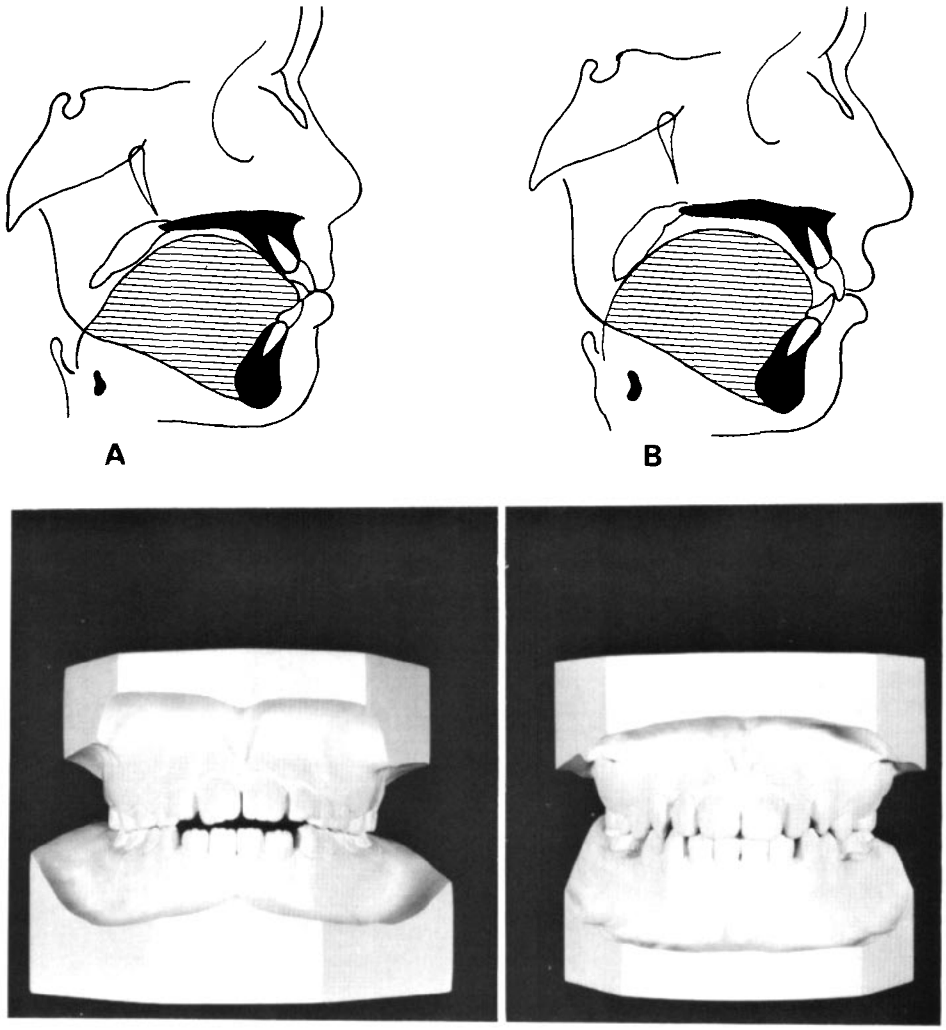

Fig. 7. Cephalometric tracings and dental casts of the same individual taken with a three year interval between records. Self correction of the open bite is evident.

diminishes while the influence of the lips increases.

A major contribution to understanding the influence of age and growth as it relates to swallowing has been made by Fletcher, Casteel, and Bradley.[14] To estimate the incidence of tongue thrusting, 1,615 school children, aged six to eighteen, were examined. The criterion of abnormal swallow was based upon presence of all of the three swallowing symptoms: 1) no palpable contraction of the masseter muscles during swallow; 2) extreme difficulty in swallowing when the labial seal was broken; and 3) protrusion of the tongue beyond the edges of the incisor teeth. Analysis of the data, cross-sectional in nature, showed a proportional incidence of tongue-thrust swallow that decreased with age. Over half of the youngsters, six and seven years of age, thrust their tongues. Less than twenty-five percent of the 16 to 18 year old

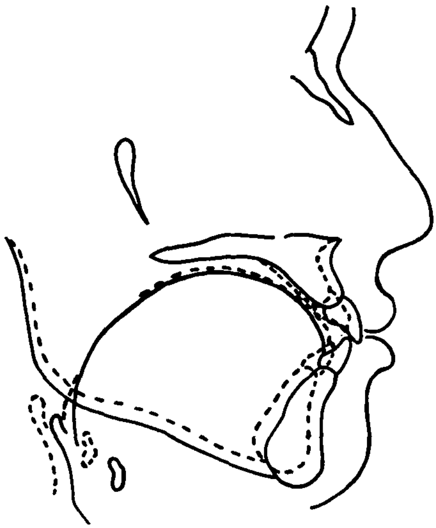

Fig. 8. Cephalometric tracings of the individual depicted in Figure 7 have been superimposed along the palatal plane registering on the posterior nasal spine. Sufficient jaw growth to accommodate the tongue is noted.

age group showed such behavior. The relative incidence of tongue thrust alone was proportionately lower in older age groups than in the younger. This finding supports the premise that with growth the tongue eventually can be contained within the dental arches. Growth, in itself, may provide a partial explanation for the reduced incidence of tongue thrust during the later age levels.

Other Oral Habits

Another factor explaining the phenomenon of tongue thrust should be discussed. Here it would be desirable to regress to the time of the transitional dentition as a stage of development, characterized by prevalence of oral habits, i.e., thumb or finger sucking. The term "thumb sucking" refers to placing the thumb or fingers into the mouth many times every day and night, exerting definite sucking pressure. It has been stated that thumbsucking could have an influence on the incidence of tongue thrusting. It is logical to assume that thumbsucking could create an anterior opening between the dental arches. With an opening created, there may be a natural tendency for the tongue-tip to protrude into the open area during deglutition. We might further conjecture that this is not a malocclusion related to protrusive tongue activity, but rather to the thumbsucking activity. The tongue protrusion might simply be an adaptation to the anterior opening.

To evaluate this possibility an anatomic and functional study on thumbsuckers was undertaken at the Eastman Dental Center.[15,16] A comprehensive study was conducted on thirty-four youngsters with strong thumbsucking habits. They ranged in age from approximately seven years to sixteen years with an average of ten. Records consisting of dental casts, cephalometric films, cineradiographs of swallowing and of the thumbsucking activity were obtained. An effort was made to: define the sucking patterns in youngsters, define the occlusal characteristics associated with thumbsucking, gain additional information concerning the manner of swallow in thumbsucking children, and finally, to evaluate possible changes in occlusion and swallowing activity after the thumbsucking pattern has been broken by the placement of an appliance.

Primarily, the x-ray motion pictures were used to study tongue activity during deglutition in youngsters with a thumbsucking habit. During swallowing, as observed on the cineradiographs, the majority of the thumbsuckers showed tongue thrusting or protrusive tongue activity. In eighty per cent of the cases (27 out of the 34) tongue-tip protrusion over the lower incisors during swallowing was observed (Fig. 9). Protrusive tongue activity was found to predominate in youngsters with a thumbsucking habit.

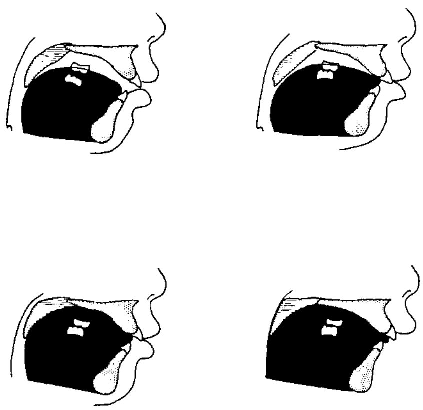

Fig. 9. Selected cineradiographic frames taken during the act of swallowing on an individual with a thumbsucking habit. Tongue-tip protrusion is noted during the later stages where the lower lip has been left out for illustrative purposes.

Furthermore, when data obtained on the thumbsucking group were compared with normative data, the thumbsucking youngsters exhibited a greater tendency to an open bite in the anterior region. One must be mindful, however, that this finding might be representative of a "loaded sample" since all of the cases in the thumbsucking group had malocclusion. There were slightly more cases with Class II molar malocclusion (54%) on one or both sides, than cases with Class I malocclusion (46%). When the anterior region was examined, specifically the anterior-posterior relationship of the cuspids, a Class II cuspid relationship was found on one or both sides in sixty-two per cent of the cases. A Class I cuspid relationship was found in the remainder. Thus, more deviation could be noted in the more anterior region of the dental arch.

The dental casts were measured and compared with data presented by Moorrees in *Dentition of the Growing Child.*[31] Highly significant was the fact that maxillary arch length, as measured anterior to the first molars, was found to be elongated in the thumbsucking group when compared with the normative data. Surprisingly, mandibular arch length was also significantly longer in the thumbsucking group. Additionally, although intermolar width was not significantly different, intercuspid width seemed greater in both jaws in the thumbsucking group.

Interestingly within the thumbsucking group, when the Class II and Class I subjects were subdivided and compared with each other, there were no differences in maxillary arch length, overjet or overbite. This would indicate that these features were influenced by the thumb. The over-all impression is that the influence is somewhat restricted to the anterior region of the mouth from the cuspids forward.

In the cephalometric appraisal the thumbsucking subjects were grouped according to age and compared with the Mota and the Downs cephalometric standards (Fig. 10). In both comparisons the results were similar. There were no appreciable differences in the relationship of the jaws to the cranium and to each other, when the thumbsuckers were compared with normal subjects. However, differences were noted in dental malrelations and seemed to be specific to the anterior region of the dental arch. The upper incisors were positioned forward, relative to the AP plane, and more proclined in the thumbsucking group. Thus, the upper incisors were not only positioned anteriorly but their axial inclination also indicated greater procumbency. In the thumbsucking group the lower incisors were also found to be more proclined when compared with the mandibular plane and in conjunction with the upper incisors. This resulted in a highly significant difference in the interincisal angle with increased procumbency in the thumbsucking group.

THUMBSUCKERS

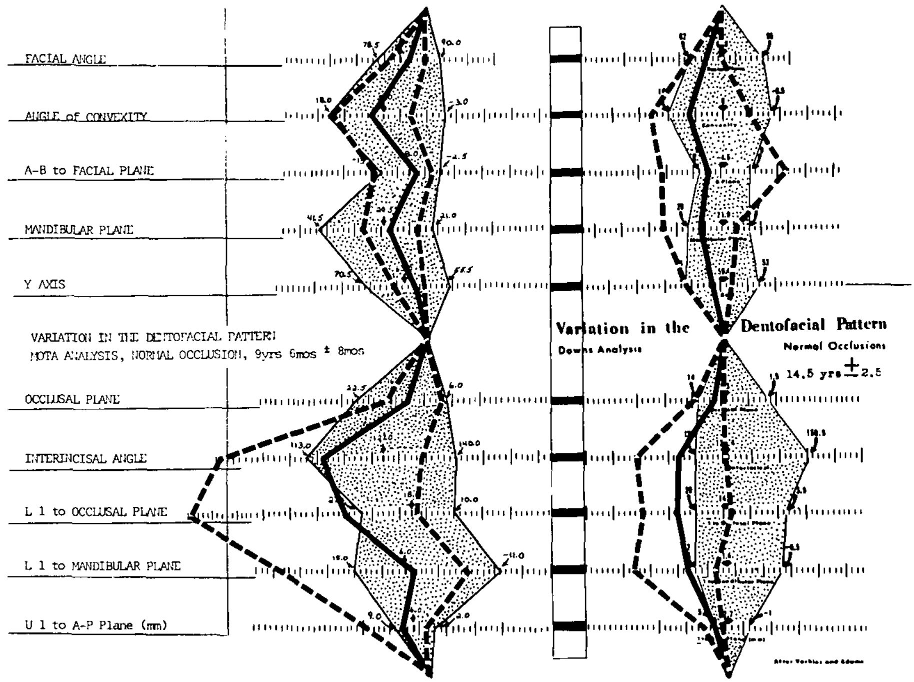

Fig. 10. Wiggles to illustrate variations in the dentofacial patterns of the thumbsucking sample in comparison with normal groups (Mota analysis, left, Downs analysis, right). The means are depicted as solid lines; broken lines represent ranges of variation.

All of the observations indicate that thumbsucking could affect dental relationships, although not necessarily having an effect on the type of occlusion such as Class I or Class II. This is further substantiated by the fact that a goodly number of Class I cases were found to have a cuspid forward on one side or the other with the forward positioning of the upper incisor teeth. Thus thumbsucking, as a habit, could be considered to be a causative factor in a tendency toward an anterior open bite and a procumbency in the position and axial inclination of the upper incisors.

The cineradiographs were studied to evaluate whether variation in patterns of thumbsucking and thumb position could selectively have a specific effect on the occlusion and on the position and inclination of the upper and lower incisors. Variation in thumb position during thumbsucking was found to fall into four major categories of decreasing prevalence. In the first and largest group, including half of the subjects (17 of 34), the thumb was observed to enter into the mouth considerably beyond the first joint or knuckle (Fig. 11). The thumb occupied a large portion of the vault of the hard palate pressing against the palatal mucosa and alveolar tissue. The lower incisor pressed into the thumb or contacted it somewhere beyond the first joint. In the second group, including eight of the thumbsuckers (24%), the thumb did not go completely into the vault area of the hard palate; however, it usually

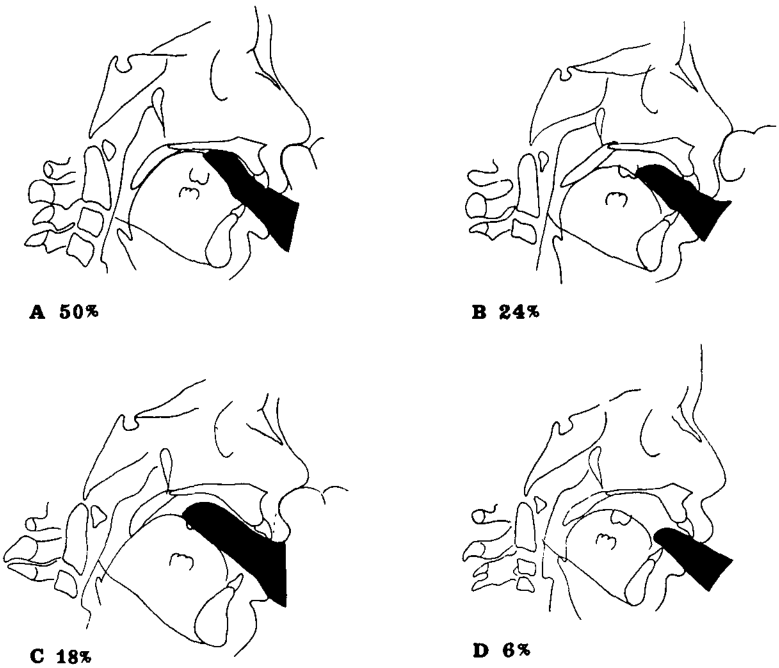

Fig. 11. Tracings of cineradiographs taken on four different individuals during the act of thumbsucking. Each represents a variable pattern (percentages) in thumb posture.

entered into the mouth, up to, and around the first joint or just anterior to it. Thus, in approximately seventy-five per cent of the subjects, contact between the lower incisors and the thumb was noted. In the third group the thumb passed fully into the oral cavity and approximated the vault of the hard palate as in Group A. (Fig. 11). However, this group varied from the other thumbsuckers in that the *lower incisor did not touch or contact the thumb* at any time during the thumbsucking procedure. Finally, in two subjects (6%) the thumb did not progress appreciably into the mouth. The lower incisor made contact at the approximate level of the thumb nail.

With these variables in thumb position there seemed to be two general variations in tongue posture during the thumbsucking procedure. In the majority (82%) the tongue was found to be under and fully contacting the thumb, with the tongue-tip approximating and pressing against the lingual aspect of the lower incisors (Fig. 12). In only four cases the tongue was postured back into the posterior region of the mouth where the tip contacted or closely approached the end of the thumb and remained in that general area. These observations indicate that tongue position is closely related to thumb position during thumbsucking. It is interesting to speculate that the proclination of the lower incisors noted in the thumbsuckers could result from the posture of the tongue-tip as well as the thumb. The tongue was usually found to be pressing against the lower incisors. It has always been assumed that the thumb exerted a posterior force on the lower incisors; in actuality the tongue could be exerting a forward pressure on the lower incisors.

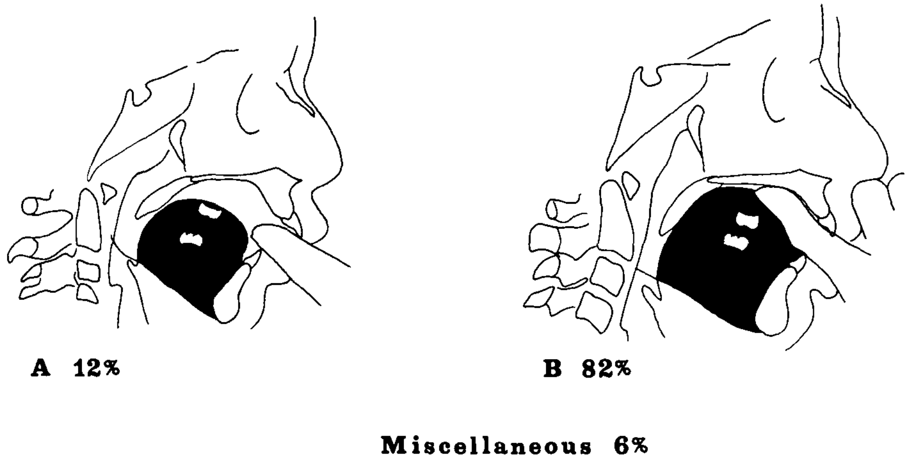

Fig. 12. Tracings of the cineradiographs of two individuals to illustrate the variations noted (percentages) in tongue posture during the act of thumbsucking.

In certain instances, however, thumb action could conceivably be exerting a lingually directed influence on the lower incisors. These would logically be cases with considerable mandibular and lower lip movement. On the cineradiographs mandibular movement was evaluated by the degree of movement of the lower incisor relative to the thumb. Measurements indicated that thirteen subjects exhibited no appreciable mandibular movement during thumbsucking; eight showed minimal movement; the remainder (38%) exhibited marked movement ranging from three to nine millimeters during thumbsucking (Fig. 13). Cases exhibiting mandibular movement or the lack of it did not seem to be specific for any type of occlusion. Mandibular movement was identified in both Class I and Class II types of occlusion. However, as previously conjectured, subjects with marked mandibular movements seemed to show a greater tendency toward more upright lower incisors. Children with minimal or no movement of the mandible during thumbsucking showed a greater tendency toward proclination and anterior positioning of the upper and lower incisors.

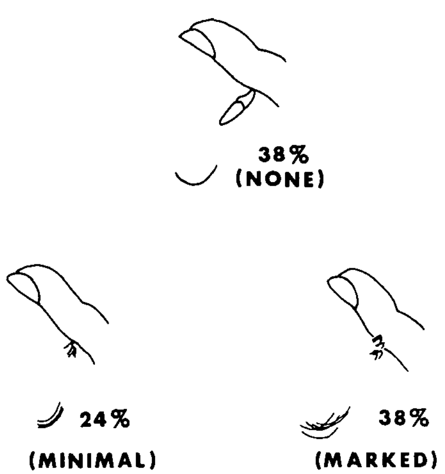

Fig. 13. Tracings of cineradiographic frames of three different thumbsucking individuals to illustrate variations in mandibular movements (percentages of total sample) during the activity of the thumbsucking habit. The incisal tip and the gnathion regions indicate the extent of activity.

In addition to cineradiographic analysis, conventional motion pictures were secured for eighteen cases to evaluate perioral and buccal muscle activity. Of these, eleven showed considerable activity, while seven were passive showing minimal or no discernible movement. Active buccal and perioral musculature cases were identified, as might be expected, with marked mandibular movement cases, while passive muscular activity cases were found primarily in the cases with little or no movement. The children with active perioral muscle activity showed a trend toward a more upright lower incisor in axial inclination and in position when compared with the cases having passive perioral muscle activity. The subjects with passive muscular activity showed a trend toward proclination of the upper incisor. No tendency in either the axial inclination or position of the upper incisor was noted within the active musculature subjects. This may indicate that the activity of the perioral musculature may have some effect on the lower incisor, but does not seem to counteract the influence of the thumb on the upper incisor.

The effect of thumbsucking seems to be localized to the anterior aspect of the dentition with a tendency toward openness of the bite. This creates an opening for the manifestation of protrusive tongue activity during swallowing. If the protrusive tongue activity is the result rather than the cause of the anterior malocclusion, which must be relegated to the thumbsucking habit, then we would anticipate correction of the anterior malocclusion if the thumbsucking habit were eliminated. This has been observed to happen after the placement of appliances to eliminate the habit and when the habit has been discontinued by the youngster on a voluntary, nonappliance basis. When the habit has been discontinued in the preadolescent child, changes in occlusion can occur with or without conjunctive mechanotherapy (Fig. 14). The elimination of thumbsucking also eliminates the mechanism for maintaining an anterior open-bite malocclusion. Normal physiologic changes permit bite closure and a correction of the anterior malocclusion provided that the open bite is not skeletally determined. Most frequently, protrusive tongue activity is modified when an associated change in the anterior dental environment occurs (Fig. 15). Relative to the anterior dental malocclusion, there are strong indications that the thumb is the primary causative factor and not protrusive tongue activity. In response to the age old question as to which came first, "the chicken or the egg," current observations indicate that the thumbsucking came first and then protrusive tongue activity.

Protruding Tongue Posture and/or Forceful Tongue Function

To further explain tongue-thrusting activity, it seems advisable to reconsider developmental periods of normal as well as abnormal form and function. The development and influence of lymphatic tissue upon tongue posture and activity must be discussed as well as the influence of abnormal neurological development upon tongue activity.

In the late deciduous dentition period it is not unusual to observe a youngster suffering with enlarged tonsils and/or adenoids. Large tonsillar masses in the oropharynx posterior to the root of the tongue can have an effect on the postural relationship of soft tissue structures. The tongue may be postured forward keeping the root of the tongue and the tonsillar tissue away from the posterior pharyngeal wall to maintain an open port posteriorly for respiratory purposes. The tongue is maintained in a forward position to facilitate adequate respiration. The tonsils, in necessitating an anterior tongue posture, can be instrumental in causing an anterior open bite. The open bite results primarily from a physiological respiratory need and secondarily from deviate tongue posture and activity.

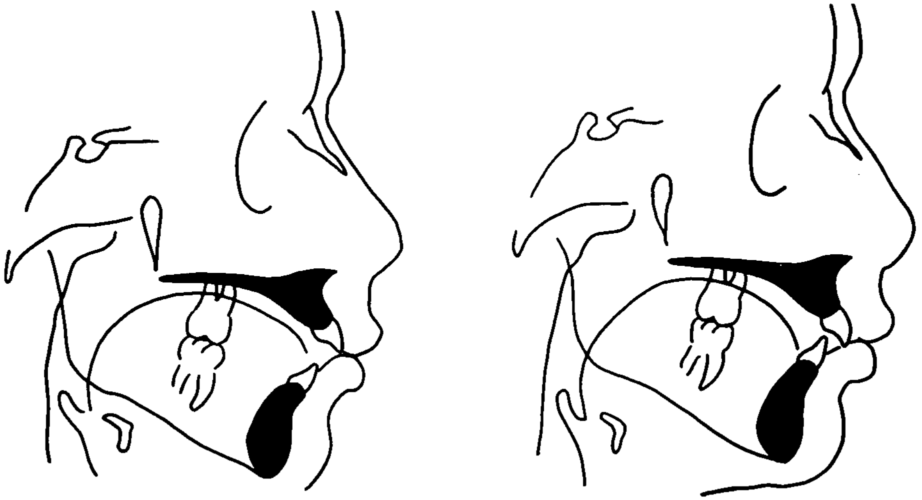

Fig. 14. Tracings of the cephalometric headplates of the same individual, before (left) and after (right) the placement of an intraoral appliance to eliminate a thumbsucking habit. Closure of the anterior open bite is noted, incident to the elimination of the habit.

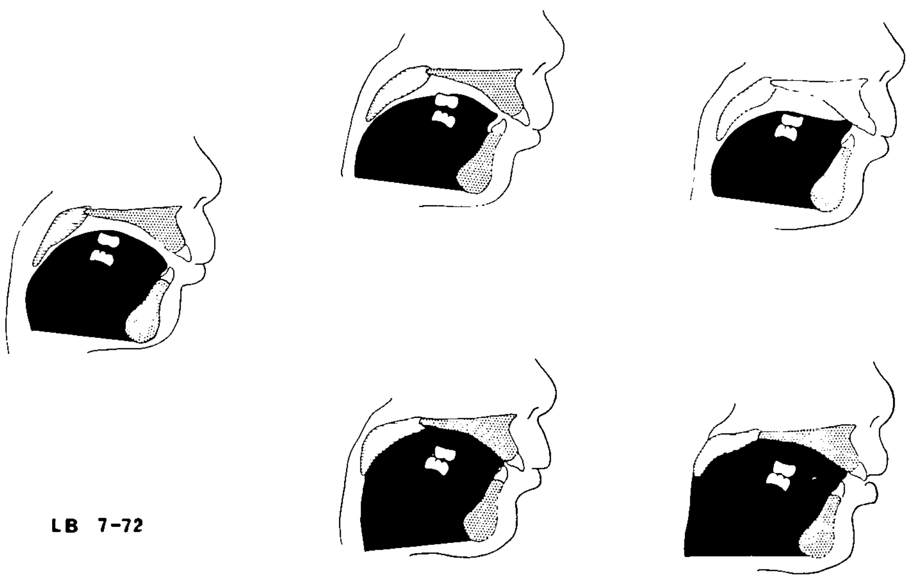

Fig. 15. Tracings of selected frames of cineradiographs attained during the act of swallowing on the same individual depicted in Figure 9. After elimination of the habit, despite maxillary protrusion, a change in tongue-tip activity is noted.

Similar circumstances may be observed where there is a blockage of the normal respiratory passage, incident to excessive development of adenoid tissue in the nasopharyngeal area. If air cannot pass through this area, mouth breathing becomes a necessity requiring numerous changes in the postural relationships of the structures involved.[17] The lips, in repose, will part; the tongue will move downward and forward away from the soft palate with an accompanying depression in the posture of the mandible. Of particular importance, the tip of the tongue may be forward in a protrusive posture, which functionally may be expressed as protrusive tongue activity.

It is true that, with growth, lymphatic tissue will reduce in mass and atrophy, but the desired transformation may occur too late to prevent the development of an orthodontic problem. In these instances protrusive tongue activity and an anterior open bite are observed as the result of excessive lymphatic tissue. This concept may be well illustrated by longitudinal cephalometric studies of patients with anterior open bite, protrusive tongue activity and excessive lymphatic tissue. After surgical removal of enlarged tonsillar and/or adenoid masses, a change in tongue posture and occlusion is observed (Fig. 16). If an open bite exists because of forward posturing of the tongue, it can close with the retroposturing of the tongue. At times, an anterior open bite can be corrected by the judicious removal of tonsillar tissue.

Much of the preceding discussion was relegated to considerations of the proportional size and posture of the tongue and its influence upon occlusion. Recognition of some problems related to central nervous system control of the tongue now seems in order. The area of impaired neurologic control of the tongue is somewhat poorly understood and is discussed infrequently in orthodontic literature. Inadequate control of tongue movements and its effect upon occlusion is clinically demonstrated in patients suffering from cerebral palsy. Poor coordination of tongue, lip, and mandibular movements are observed. Protrusive and erratic tongue movements are frequently associated with marked deformities of the dental arches. An open-bite malocclusion is commonly apparent.

Manifestations of neurologic impairment are easily recognized in patients with severe cerebral palsy; however, neurologic impairment of lesser extent may not be identified by orthodontists. Minimal central nervous system impairment may be expressed by reduced control of muscular movements within the oral and pharyngeal cavities. Although previously unrecognized and undiagnosed, minimal neurologic damage can adversely affect tongue activity and may preclude any positive change in the surrounding environment attempted by the orthodontist. Because of this fact it seems wise to review clinical indications of minimal damage which may be helpful to the orthodontist.

Blomquist[18] studied the precision and speed of specific tongue movements in a group of normal children to establish a functional reference for comparative purposes. Diadochokinetic rates of tongue movements were established by requesting subjects to rapidly repeat certain syllables. For example, the syllable "ta, ta, ta, etc." was used to evaluate tongue-tip activity, while the repetition of the syllable, "ka, ka, ka, etc." was used to determine normative values for the mobility of the back of the tongue. Subjects exhibiting difficulty in movements and notable reduction in the rate of tongue movements provide some indication of varying degrees of central nervous sys-

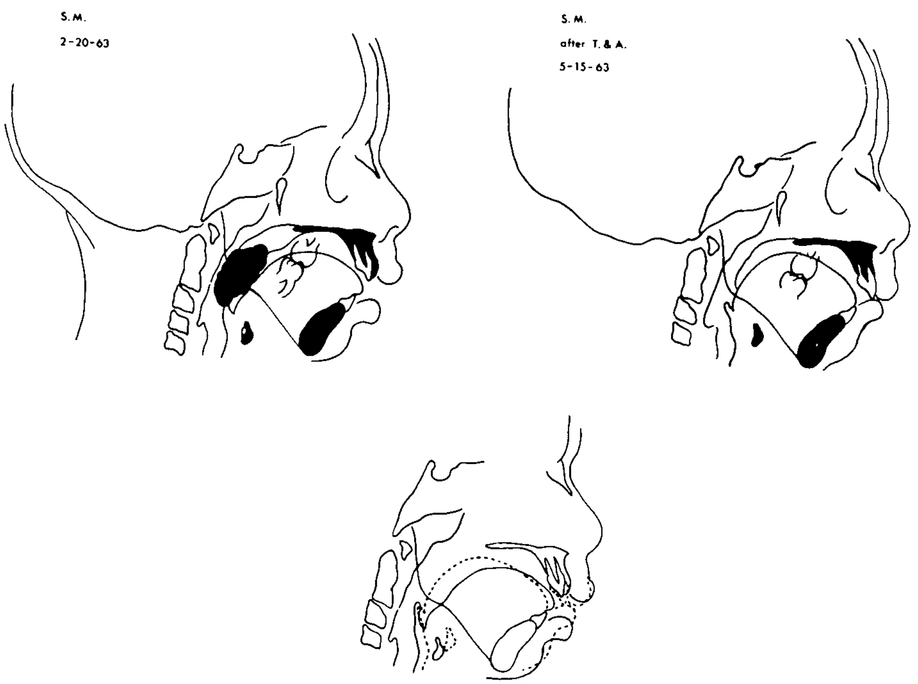

Fig. 16 Tracings of two cephalometric headplates of the same individual, before and after removal of tonsils and adenoid tissue. Below is a composite to illustrate retropositioning of the tongue within the oral cavity and the initiation of rapid eruption of anterior teeth (dotted lines).

tem impairment. As an example, a youngster with "pseudobulbar palsy" may exhibit sluggish tongue movements as well as difficulty in movements in all directions. Tests such as these are useful in identifying patients with minimal neurological impairment, which may adversely affect tongue function and the surrounding dento-skeletal environment.

Many youngsters with minimal neurological damage can be recognized by characteristic posturing of the lips and tongue. Frequently, the lips are not approximated during rest. There appears to be difficulty in maintaining proper mandibular posture and in protruding and retracting lips. Erratic tongue movements with or without adequate clearance of saliva can be observed. Diadochokinetic movements of the tongue can be produced but at a slower rate with less precision. Compositely, these clinical observations suggest some degree of neurological involvement. When there are associated orthodontic problems, as an open bite, the causative mechanism is primarily attributed to the impaired central nervous control of tongue and related structures. Since tongue function and posture are centrally controlled, attempts to fully correct the resulting orthodontic problem promise considerable frustration and probable failure.

This observation is documented in Figure 17 which presents records taken prior to and after years of continued treatment. This youngster not only was diagnosed to have some central nervous system impairment, but also a lingual tonsil which forced the tongue to posture forward. The open bite could not be corrected. Forward posturing of the

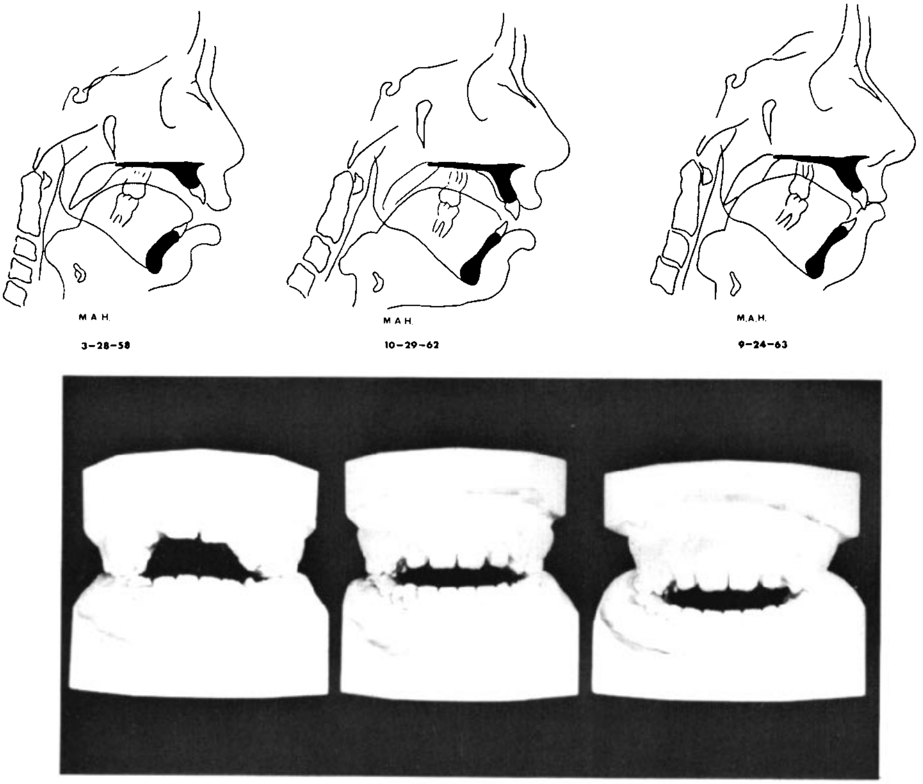

Fig. 17. Cephalometric headplates and corresponding dental casts of the same individual, finally diagnosed to have some central nervous system impairment. Closure of the anterior open bite was not possible despite long periods of orthodontic treatment lasting over five years.

tongue served to add insult to injury resulting in an unalterable surrounding environment for the tongue.

The point to be emphasized here is that protrusive tongue activity may be a manifestation of faulty neurological control and not an abnormal swallowing habit.

Adaptation to the Oral Environment

Tongue-tip protrusion during swallowing can be seen and described. In seeking explanations for its presence, could it be an adaptation to the surrounding oral environment? Is it possible that oral-facial muscle function which has been described as abnormal, may actually be an adaptation to an existent orthodontic problem? Are the muscular structures adapting to an abnormal dentoskeletal environment, rather than creating that abnormal environment?

The incidence of tongue-thrust swallowing has been reported to be higher in patients with malocclusion than in children without malocclusion. Early studies relating patterns of orofacial muscle activity to occlusion resulted in data which supported a close relationship between Class II, Division 1 malocclusion and tongue thrust.[19] Most recent studies are in basic agreement in that tongue thrust is most commonly associated with protrusive incisors.

However, recent information does not support the contention that tongue thrust of itself causes the protrusive incisor relationships, nor does it support the contention that tongue thrust is associated with the Class II, Division 1 malocclusion exclusively. Walther[20] reported on muscle behavior for 375 patients attending an orthodontic clinic. His data showed tongue thrust was about as common in Class I malocclusion as it was in Class II, Division 1. Tongue thrust was also found in seventeen per cent of the patients with Class III malocclusion. These findings are not as unusual as might appear at first, when one considers that tongue thrust has been reported to be present when occlusion is normal.

Several years ago, studies at Eastman Dental Center were undertaken to evaluate characteristics of swallowing behavior in different types of oral environments and to study the effects of myofunctional therapy as well as orthodontic treatment on patterns of orofacial muscle activity.[21] High speed cineradiographs, taken during the swallowing process and recorded at the rate of 240 frames per second, were obtained for ten subjects with normal occlusions and for thirty subjects with malocclusions. The latter group included patients with maxillary protrusion, patients with maxillary retrusion (true maxillary skeletal deficiencies), and patients with open-bite malocclusions. Children with normal occlusions established base-line material for the pattern of normal deglutition within the oropharyngeal areas.

The cineradiographic films revealed several similarities as well as differences. As a baseline reference, in the normal occlusion group the tip of the tongue at rest was observed to be positioned lingual to the lower incisors. During the initial stages of swallowing the tip moved toward the lingual of the upper incisors to achieve first tongue-tip contact. During the entire swallowing procedure the tongue usually functioned within the confines of the oral cavity, although tongue-tip protrusion was observed in a few of the normal subjects. In only a small percentage of the subjects was molar contact visible during the act of deglutition.

The fundamental aspects of the process of swallowing were basically the same in the different individuals with differing dentoskeletal environments. Just prior to the initiation of swallowing, the tongue-tip was found to be positioned lingually to the lower incisors in all the malocclusion cases. During the early stages of swallowing, regardless of the configuration of the oral environment, all the malocclusion subjects moved the tip of the tongue toward the lingual aspect of the maxillary incisors and its contiguous alveolar tissue. Once the dorsum of the tongue reached the more posterior regions of the oral cavity, the swallowing process was similar and strikingly consistent in all of the subjects regardless of whether a normal occlusion or a malrelationship was present.

When variations in swallowing were observed in patients with differing types of dentoskeletal configurations, they were seen in the anterior region of the oral cavity. The varying patterns of tongue movement seemed to functionally adapt to the variations in the configuration of the anterior malocclusion (Fig. 18). In the maxillary protrusion subjects the tongue-tip protruded over the lower incisors in an attempt to contact the lingual surfaces of the upper incisors during the initial stages of deglutition. In many, the lower lip was observed to function lingually, rather than labially, to the upper incisors and tongue-tip-lip contact was observed often.

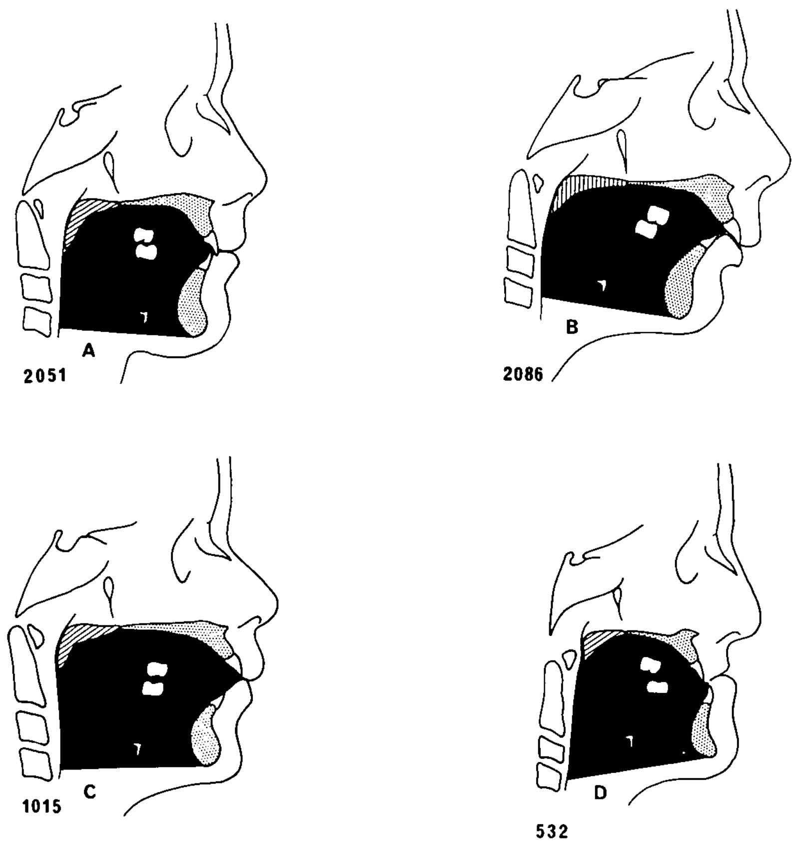

Fig. 18. Tracings of cineradiographic frames of four different individuals taken during the act of swallowing. Adaptation of tongue-tip activity to the anterior dental environment is noted: A, normal occlusion, B, maxillary protrusion, C, open bite, D, maxillary deficiency or retrusion.

In the maxillary deficiency cases also, the tongue attempted to achieve first tongue-tip contact by approximating the lingual aspect of the maxillary incisors. Variation was subsequently noted in that the tip passed under the incisal edges of the upper incisors to touch the lower incisors in these cases.

In the open-bite malocclusions the tongue-tip first approached the lingual of the upper incisors during the initial stages of deglutition and then progressed between the incisors contacting lip structure during the swallowing process.

In summary, appreciable differences in tongue-tip function during swallowing were identified with differences in the contiguous dentoskeletal form. The interpretation is drawn that the tongue was functionally adapting to the specific anterior oral environment to achieve a seal during swallowing. From all indications the functional movements of the orofacial musculature structures were adapting to the variables of the form of the adjacent oral environment. The basic pattern of function, once the tongue-tip adapted to its contiguous environment, was the same in all of the subjects studied. Thus, another explanation for the presence of protrusive tongue activity could be a functional adaptation to its environment.

Mechanical or Myofunctional Therapy for the Re-education of Swallowing

Methods of correcting tongue-thrust swallow have been carefully described, step by step and lesson by lesson, in the literature. Although swallow correction appears to be a recommended procedure by some investigators, there has been very little evidence presented to indicate that a so-called "abnormal" pattern of swallow can be changed to constitute a more favorable involuntary swallowing pattern. Furthermore, it might be pointed out that there is little evidence to suggest that a change in a swallowing pattern, of itself, will have a favorable effect upon occlusal relationships. In other words, there has been a great deal of discussion of why it is necessary to change the pattern of swallowing and even more discussion of how the training should be accomplished. What is lacking is evidence that the training procedures are effective.

Two studies were undertaken to see whether the process of swallowing could be appreciably altered in pattern and maintained permanently. In the first a mechanical approach was used to study a group of twenty subjects with open-bite malocclusion in the permanent dentition and with protrusive tongue activity. Clinical examinations and high speed cineradiographs during swallowing were obtained before and after treatment. Tongue cribs which confined the tongue to function lingually to the crib were placed and maintained for six months. Follow-up cineradiographs were made immediately upon the removal of the appliances and three months after their removal.

Analysis of the films showed that the tongue was forced to function behind the crib during the time it was in place; however, immediately after its removal some tongue-tip protrusion during swallowing was evident. After six months of mechanical restriction, the tongue did not retain functional positions within the confines of the oral cavity during swallowing. Within three months after appliance removal, a complete return of protrusive tongue-tip activity was evident.

The second investigation was undertaken to determine if patterns of muscle activity in the oral-facial region could be modified through myofunctional therapy as recommended by Straub.[3] Successive first steps in training to correct the swallowing pattern are generally described as: acquainting the patient with the abnormal swallow pattern; teaching the correct pattern; and finally, reinforcing the correct pattern.[21] Five children with various combinations of the characteristic features of abnormal orofacial muscular activity received an intensive therapy program designed to alter patterns of activity during swallowing. Before therapy, clinical appraisals of swallowing, cephalometric radiographs, dental study models, and high speed cineradiographs of swallowing were obtained for each child. Within ten days after completing three months of intensive myotherapy, provided by a speech pathologist experienced in swallow correction, new records were obtained.

Comparative analysis of the before and after therapy dental models and cephalometric x-rays revealed no significant changes. Form was not appreciably altered by the myofunctional therapy. Clinical re-evaluation revealed that subjects exhibiting tongue protrusion prior to therapy continued to do so. Subjects with excessive activity in the muscles of facial expression also continued to exhibit this activity after training. These findings were supported by the cineradiographic analysis. When tongue-tip protrusion and abnormal lip activity were observed prior to therapy, the same basic observations were made after therapy with only a slight change in the timing of sequence noted.

Prior to the re-education program, tongue protrusion was clearly evident during the initial or oral phase of swallowing. After training, the protrusive activity became more evident during the later or pharyngeal phase of swallow. On the basis of these findings it seems that myofunctional therapy modified tongue activity during the initiation of the swallow but did not change the basic protrusive pattern as expressed in swallow completion. Subsequent to the myofunctional therapy, tongue protrusion during deglutition was still evident. Since study of dental models and cephalometric films revealed the environment or form had remained relatively stable, it is reasonable that the basic pattern of deglutition did not change. Modifications in the oral phase of deglutition did not alter form.Although modifications of the conscious or oral phase of swallowing may be relatively simple to achieve, the value of such change relative to correction of malocclusion seems questionable. Furthermore, the prognosis for modification of tongue protrusion during the pharyngeal phase of deglutition without associated changes in occlusion is not excellent, to say the least.

Tongue Force and Frequency of Deglutition

Although tongue protrusion can be seen and explained, should it be considered as a direct causative mechanism in the development of a malocclusion and as a problem in correction of malocclusion? If a tongue protrusion cannot be corrected or trained "out", should it be considered a problem which precludes orthodontic treatment?

The orthodontist's interest in tongue and lip function falls basically within the reference of force exerted on the dentition and its effect upon tooth position. Research to quantitate muscular force exerted on the denture has been encouraged by the recognition that muscle activity can affect occlusion. Specifically, pressures on the denture have been studied as proportional values and related to the inclination of incisors and other characteristics of occlusion. Pertinent to the present discussion is the work of Winders[22] who compared pressures during swallowing in one group of subjects with excellent occlusion with another group of subjects with Class II, Division 1 malocclusion. According to Winders, lingual force against the protrusive incisors of patients with Class II, Division 1 was not different from lingual force against incisors which were in normal occlusion. He concluded, therefore, that the balance of forces commonly described in the literature is not a significant factor in determining position of teeth.

When Winders' sample of subjects with Class II, Division 1 and with normal occlusion was subdivided on the basis of "normal-abnormal" swallowing patterns, higher lingual pressure values were obtained from the abnormal swallowers. The higher lingual pressure values, however, were not restrictively related to the subjects with malocclusion. Winders concluded that so-called "abnormal swallows" can be present with any type of occlusion.

In another effort to quantitate force, Kydd[23] measured maximum forces exerted on the dentition by perioral and lingual musculature. Lip pressures for the lower and upper arches were considerably less, averaging about half the tongue pressure exerted against upper incisors. Tongue pressure against the upper anterior teeth was higher than against the mandibular anterior teeth.

Such tongue pressures were considerably greater than lip pressures. Winders concludes that the hypothesis that the force of the tongue from within the dental arch is normally compensated for by the action of the lips and cheek is not supported. By way of reservation, Kydd also expresses the possibility that the lips may assert a lighter pressure for a longer duration of time than does the tongue thus equalizing lingual and labial forces.

In a more recent study Kydd and others[24] showed that subjects with open bite and normal occlusion differed significantly relative to maximum pressure exerted by the tongue and upper lip during all types of swallow. Tongue pressures for the open-bite sample were twice as high as the pressures exerted in the normal occlusion group. The pressure exerted by the upper lip in the open-bite sample was much less than the upper lip pressure in the normal occlusion group. Comparatively then, the open-bite patients had greater tongue pressure and lesser lip pressure than were found in the normal occlusion group.

Significant differences in the duration of pressure were also apparent. The mean values indicated that subjects with open bite exerted both tongue and lip pressures of longer duration than were encountered in the normal group. Lip pressures in the open-bite sample were of lesser magnitude but of longer duration while tongue pressures were greater and of longer duration.

To consider whether or not pressures were of clinical significance, the authors projected differences in duration of pressure for the thrusters and nonthrusters over a twenty-four hour period. To do this, pressure values measured during deglutition were simply multiplied by the frequency of swallow. Kydd and Neff[25] found nonthrusters to swallow at a mean rate of sixty-one times per hour while the thrusters swallowed at a rate of thirty-seven times per hour. This difference, significant at the one per cent level, revealed tongue thrusters swallowed much less often than others; however, tongue force against the teeth in the abnormal swallowers with an open bite has been found to be about twice the force generated in subjects with normal occlusion. The duration of force during swallow was also much longer in the open-bite swallowers. In summation, past studies indicate tongue thrusters swallow significantly less often than normal swallowers; however, the total effective force is about equal in normal and abnormal swallowers. The tongue-thrust swallow occurs at a significantly slower rate exerting greater lingual force over a longer duration of the swallow. The total effect of the lingual force must be evaluated in terms of the frequency of deglutition.

In order to interpret the effects of muscle force upon tissue form, several facts are needed: 1) the degree of force exerted, 2) the duration of the force, and 3) how often that force is applied. Estimates of the frequency of swallow which have appeared in the literature range from 1200[2] to 2400 swallows per day.[26] Research published in 1965 by Lear, Flanagan, and Moorrees[27] reported a mean frequency of swallowing of 585 times per day with a range of 203 to 1008. These data show an appreciably lower incidence of swallowing than was suggested by earlier estimates. In earlier work by Lear and Moorrees,[28] labial, buccal, and lingual forces were measured by utilizing strain gauges. Data derived from thirty-three examinations of seven adolescent and young adults with normal occlusion showed that the average force exerted during deglutition is about 6.9 grams (palatal surfaces of the premolars) and that it occurs for over a two second interval during swallow.

Using this force gradient of 6.9 grams occurring over a two second period, and adding the data accumulated for frequency of deglutition, the authors have concluded that, "the total force impingement on the palatal surfaces of the dental arch over a twenty-four hour period may only be increased owing to swallowing by the equivalent of approximately one-tenth of a gram acting constantly."

The same authors have reported that there is a fairly continuous resting force of two to four grams laterally on the maxillary lingual surfaces in the premolar area. On the basis of these figures the authors state that the force contribution during deglutition, if converted to terms relating to continuous rather than spasmodic function, is only 1/40 - 1/20 as great as was made by the resting forces. In other words, the resting force of two to four grams is considerably greater than the conversion of the lingual forces during deglutition.

On the basis of these findings they conclude, "swallowing may make only a small addition to the aggregate of lateral force impingement palatally in individuals with normal tongue function and arch form." This finding is considered in addition to the work reported by Kydd and Neff indicating that the total energy in tongue thrusters incident to the dental arches may approximate that of subjects with no "so-called" anomalies of tongue function. The two studies are then summarized, ". . . regardless of the pattern of tongue activity during swallowing, the deglutitive act may play a minor role in whatever influence soft tissue function has upon hard tissue form."

To Treat or Not to Treat

Muscular force exerted during deglutition, of itself, may not be a significant determinant of tooth position. The pattern of tongue-tip activity during swallowing may not be altered on a total, subconscious basis via myofunctional therapy. Under these conditions, perhaps it would be useful to determine if the "desired" modifications in tongue function can be achieved by changing the surrounding environment. If tongue function does modify or adapt to the environment, why attempt to change the pattern of tongue activity? Why not change the surrounding environment? Can a modification in the functional patterns of oral and perioral soft tissues be achieved if the dental skeletal environment is improved?

In pursuing this question, follow-up records have been obtained from the five subjects previously exposed to myofunctional therapy. After this therapy, as reported, the basic patterns of swallowing activities remained the same. Orthodontic correction of the malocclusion was then initiated to attain a more acceptable dental environment. After orthodontic treatment cineradiographs were again made to determine what functional changes, if any, were evident in the patterns of tongue-tip and lip activity during swallowing.

Aberrant tongue-tip and/or aberrant lip activity were evident during swallowing both prior and subsequent to functional myotherapy. Subsequent to the orthodontic correction of these cases, aberrant soft-tissue function was reduced or eliminated (Fig. 19). With changes in the anterior dental relationships the associated patterns of swallowing became more acceptable in nature. The tongue was confined within the dental environment with no protrusion over the lower incisor evident in the cineradiographic data. The tip was observed to progress toward

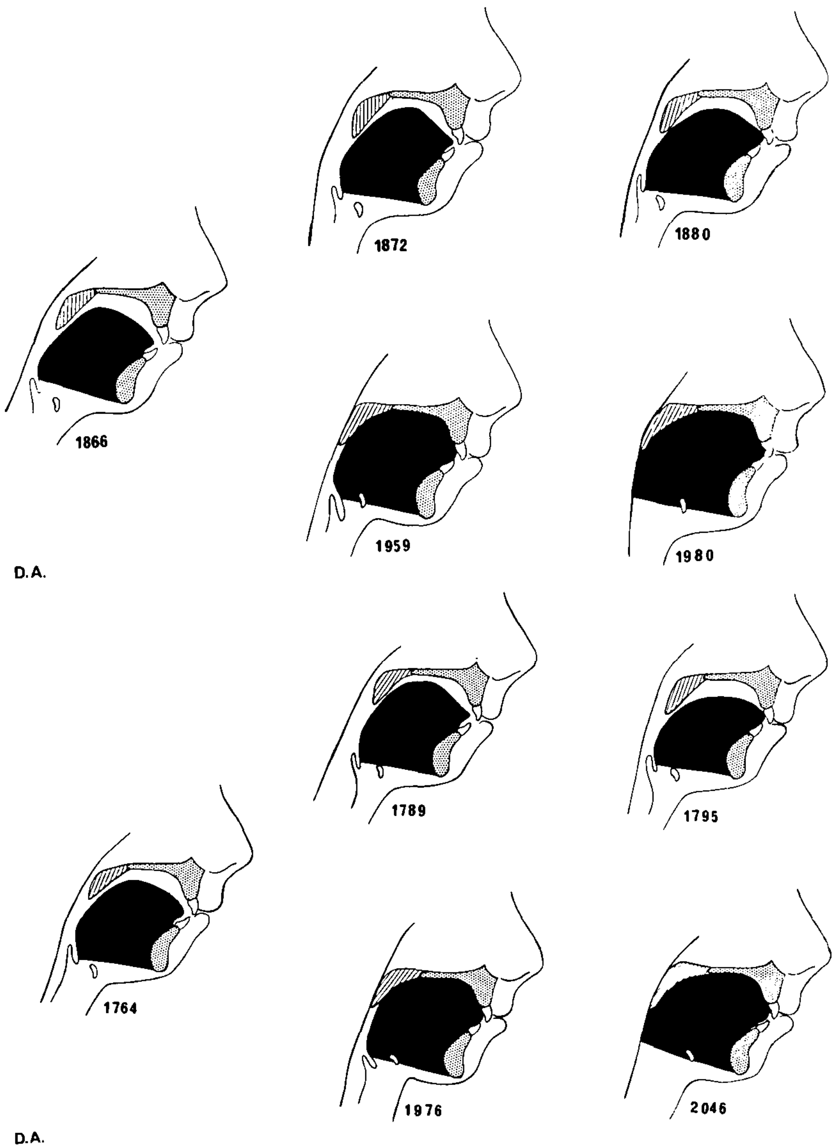

Fig. 19. Tracings of selected frames of cineradiographs attained during the swallowing act on the same individual at the time of retention (above) and after the removal of retention (below). This individual had functional myotherapy and tongue protrusive activity which could not be corrected. Refer to Figures 8 and 9, p. 184, in Angle Ortho., 40: 170-201, 1970. Subsequent to orthodontic correction, tongue protrusive activity is not evident.

the lingual aspect of the upper incisor as normally expected and the lower lip elevated to cover the lower aspect of the labial surface of the maxillary incisors establishing firm contact with the upper lip during the swallowing process.

Whereas myofunctional therapy did not appreciably modify the swallowing pattern or the malocclusion, proper correction of the malocclusion was identified with an associated change in the pattern of deglutition. In this study, limited to five subjects, the aberrant muscular patterns during swallow changed as the occlusion was changed.

On the basis of these data, the recommendation to initiate myofunctional therapy, if indicated, should be made after orthodontic treatment if and when the occlusion is satisfactorily adjusted and if adverse patterns in tongue and lip activity persist. The experience described above strongly indicates a spontaneous improvement in muscle patterns during deglutition coincident with orthodontic correction. On the basis of current information myofunctional therapy may well be unnecessary and inconsequential in the successful treatment and retention of most orthodontic patients.

One further question arises: without myofunctional therapy, if the environment of malocclusion is corrected, can a change in the pattern of swallowing be anticipated? To pursue this question many patients with Class II, Division 1 and open-bite malocclusions were studied before and after orthodontic treatment. Patients with these severe malocclusions were selected specifically because abnormal swallowing or protrusive tongue-tip activity are said to be commonly associated. Before treatment of the Class II, Division 1 malocclusions, the lower lip usually assumed an abnormal posture lingual to the maxillary incisors at some time during the process of deglutition. After orthodontic correction, subsequent to the retrusion of the maxillary incisors, the lower lip at rest was observed to be postured labial to the upper incisors. During deglutition the lower lip maintained functional postures anterior to the upper incisors and was not postured lingual to the maxillary incisors during functional sequences. In these instances lower lip function changed with the environment or with the reposition of the anterior teeth.

Cine examination showed that in some of the Class II, Division 1 cases before orthodontic treatment, the tongue-tip postured forward over the lower incisors, many times contacting the lower lip, during some stage of swallowing. This protrusive activity in one case of maxillary skeletal protrusion is illustrated in Figure 20-A. For this patient two maxillary premolars were extracted. No lower teeth were removed because the comparatively large tongue contraindicated an excessive reduction of the lingual cradle or the surrounding environment. The modification in the swallowing pattern subsequent to orthodontic correction of the environment is illustrated in Figure 20-B. During deglutition tongue-tip activity was confined within the oral cavity. As in many similar Class II cases, the tongue elevated to contact the lingual surfaces of the maxillary incisors during the initial stage of swallowing and, subsequently, did not protrude between the incisors. Thus, a good muscular response to the changed environment resulted.

Similar findings were found in dental open-bite cases which were orthodontically corrected. Subjects with dental rather than skeletal open bites were specifically selected for study. Patients with severe soft-tissue abnormalities such as excessively large tongues or hyperactive tongues correlated with

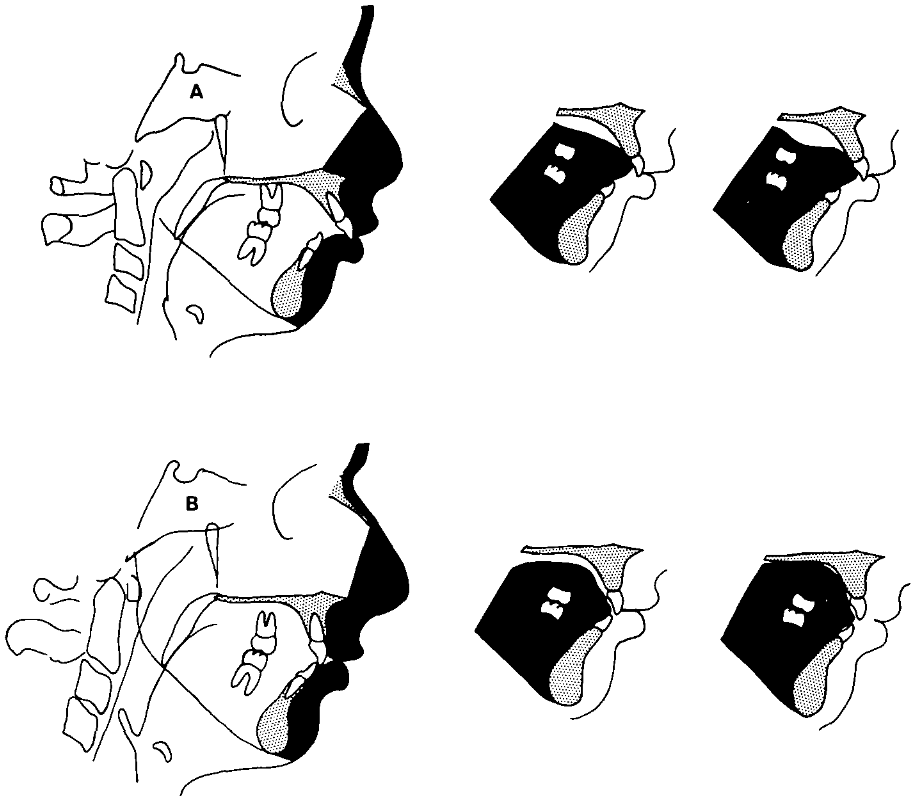

Fig. 20. Cephalometric tracings and cineradiographic frame tracings taken during swallowing on the same individual before and after orthodontic treatment. Two maxillary premolars were extracted as part of treatment in this case.

neurologic impairment were also excluded. Before treatment tongue protrusion into the open area between the anterior teeth was evident at some time during the swallowing procedure. Many times excessive lip activity occurred concomitantly so that tongue-lip contact occurred during the more forceful stages of swallowing. Subsequent to orthodontic correction of the anterior dental open bite, tongue protrusion was no longer observed cineradiographically or clinically. The tongue remained confined within the dental arches demonstrating again that a change in function can be anticipated in many cases subsequent to a change in the environment provided, of course, that there are no severe and/or neurologic complications to contend with (Fig. 21).

In cases which involve the surgical repositioning of the jaws, experience indicates similar conclusions regarding form and function relationships. If the environment has been favorably and judiciously altered, muscular patterns of function will also modify harmoniously. Tongue movements during deglutition adapt to new and more acceptable skeletal relationships, as is well exemplified in Figure 22. In this case of maxillary deficiency, the maxilla was surgically repositioned anteriorly to achieve an acceptable relationship with the cranium and the mandible. Adaptation in tongue activity was observed on cineradiographs taken before and

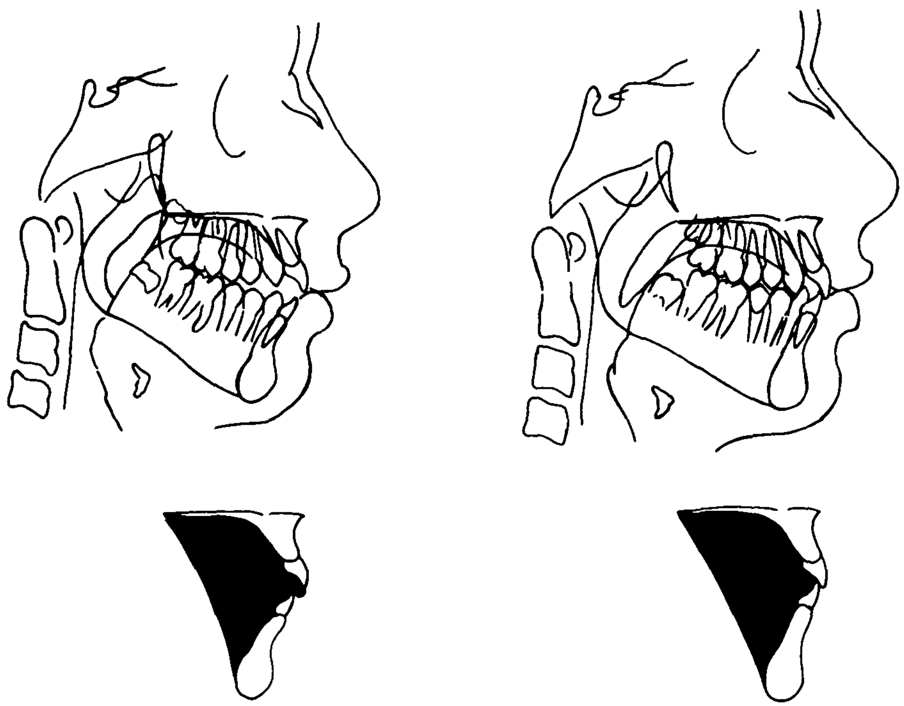

Fig. 21. Tracings of cephalometric headplates of the same individual taken before and after the correction of an anterior open bite (above). Tracings of a selected cineradiographic frame (below) indicate a change in tongue protrusive activity incident to orthodontic correction.

after surgery, and after a postoperative interval of a year and a half. In all examinations, before and after surgery, the tip of the tongue was observed to be postured lingually to the lower incisors prior to the initiation of the swallowing. However, adaptation or a modification in pattern was noted as the tongue moved to achieve initial tongue-tip contact during swallowing. Before surgery the tongue retracted considerably achieving initial contact somewhere lingual to the maxillary incisors. After surgery the tongue-tip did not retract, but rather moved upward and forward to contact the cingulum area of the maxillary incisors.

Adaptation was also clearly indicated during the later stages of deglutition. Prior to surgery, during the later stages of deglutition the tongue-tip moved forward and protruded under the maxillary incisors to achieve tongue-lower incisor and/or lip contact. After surgery the tip did not protrude but remained lingual to the maxillary incisors returning to a posture behind the mandibular incisors upon the completion of the swallow (Fig. 23); the "so-called" abnormal function did not persist after the dental-skeletal environment was modified. The tongue, during deglutition, adapted to the forward position of the repositioned maxilla and functioned in a pattern described as "normal."

Similar adaptation also was noted in a few cases with prognathic mandibles which were surgically retropositioned to attain more normal relationships. Prior to mandibular resection, tongue protrusion during deglutition

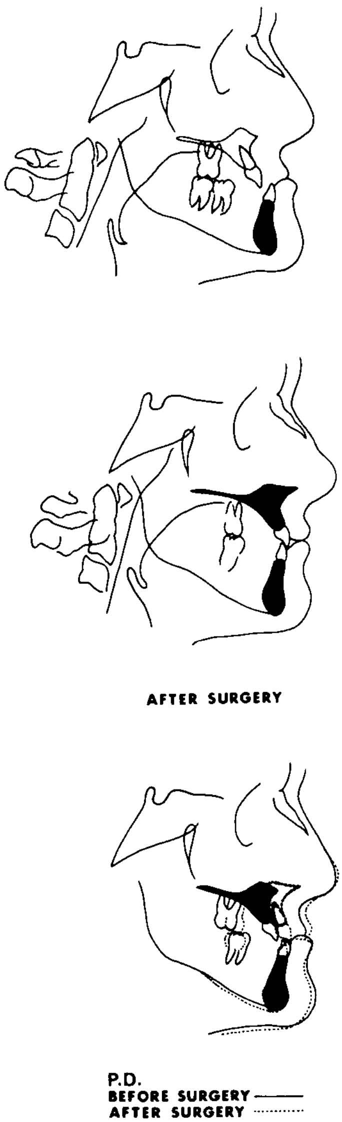

Fig. 22 Tracings, superimposed on S-N, of the same individual before and after surgical correction for maxillary deficiency. The composite below indicates the changes achieved in skeletal relationships.

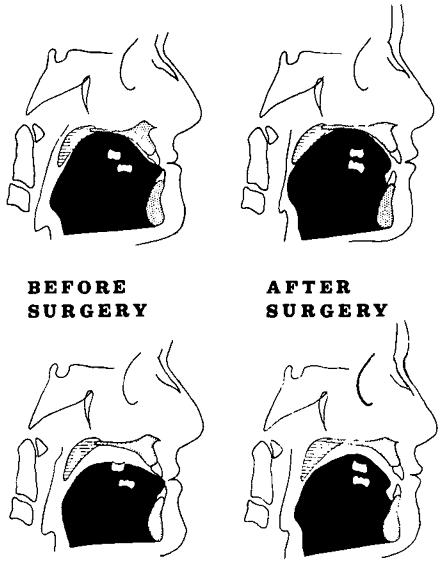

Fig. 23. Tracings of comparable, selected cineradiographic frames taken during the act of swallowing on the individual depicted in Figure 22. Adaptation of tongue-tip activity to the new environment, incident to the surgical correction, is noted.

was clearly evident. After repositioning of the mandible, the tongue-tip did not protrude between the incisors but remained within the confines of the new environment. Once again, these observations indicate that patterns of muscle function during deglutition adapt to alterations in form designed to establish correct relationships.

Unfavorable Candidates for Orthodontic Treatment

If there is nothing seriously abnormal in the skeletal form of the craniofacial structures, and if there is nothing seriously abnormal in the anatomy (form) and function of the related muscular structures, then a change in the form of the dental environment should be associated with adaptive changes in oropharyngeal function. Problems can arise, however, in certain cases which perhaps should be considered unfavorable candidates for orthodontic treatment. Several factors which seem to contraindicate orthodontic treatment and successful adaptation include abnormal skeletal relationships, neurologic impairment in the control of orofacial muscle function and abnormal tongue size.

Skeletal relationships may be extremely poor and beyond the limitations of correction which can be achieved by conventional orthodontic procedures. In some cases surgical consultation and treatment may be recommended with or without orthodontic assistance. In many patients with marked skeletal problems it is orthodontically impossible to alter the environment sufficiently so that a favorable modification in muscle function can be achieved.

If the tongue is too large to be confined within the surrounding oral cavity, the undesirable lingual posture and movement may result in an open bite deformity and defective speech, as illustrated in the following discussion. The patient with a severe open bite was referred for orthodontic and surgical consultation after many years of unsuccessful speech therapy. In group consultation with the orthodontist and plastic surgeon, the speech therapist expressed the opinion that there was little or no improvement in speech because of the structural deformity which also was identified as the primary factor responsible for high school drop-out and severe problems in psychosocial adjustment. After thorough examination the orthodontist stated treatment could not be initiated because the exceptionally large tongue presented anatomic and physiologic features considered insurmountable from an orthodontic viewpoint. The subject, with severe lisp, showed tongue protrusion during swallowing and during speech. At rest, the tongue overlay the lower incisors by a considerable dimension. The observed disproportion in tongue size was confirmed by cineradiographic, cephalometric and other clinical examinations.

After extensive discussion the consensus was that nothing significant could be done to improve facial appearance, emotional adjustment or speech unless a surgical procedure was undertaken to reduce tongue size. Although this seemed somewhat radical, no alternative plan could be projected. Consequently, a T-shaped wedge of tongue tissue with the crossbar located at the tip was excised. This surgery, considered conservative in nature, failed to remove sufficient mass. Although the mass had been reduced somewhat, the tongue remained excessively large for the confines of the oral cavity. In sum, the results of surgery were disappointing since slight improvement in occlusion, appearance and speech were noted. Despite failure, much can be learned from this case.

Two and a half years after lingual resection, new radiographic and dental records were obtained. Detailed analysis of data revealed changes in occlusion, subsequent to the surgical procedure and incident to continued jaw growth. The cephalometric tracings revealed considerable growth over the two and one half year interval. The tracings also revealed retrusion, uprighting and further eruption of the maxillary and mandibular incisor teeth (Fig. 24). These changes were in the line of desired correction and were considered to result from the tongue reduction. It must be remembered, however, that tongue size remained excessively large necessitating a posture and functional relationship that remained undesirable from a functional and cosmetic aspect (Fig. 25). The associated open mandibular posture permitted continued eruption of the maxillary and mandibular molars which, to a degree, explained the per-

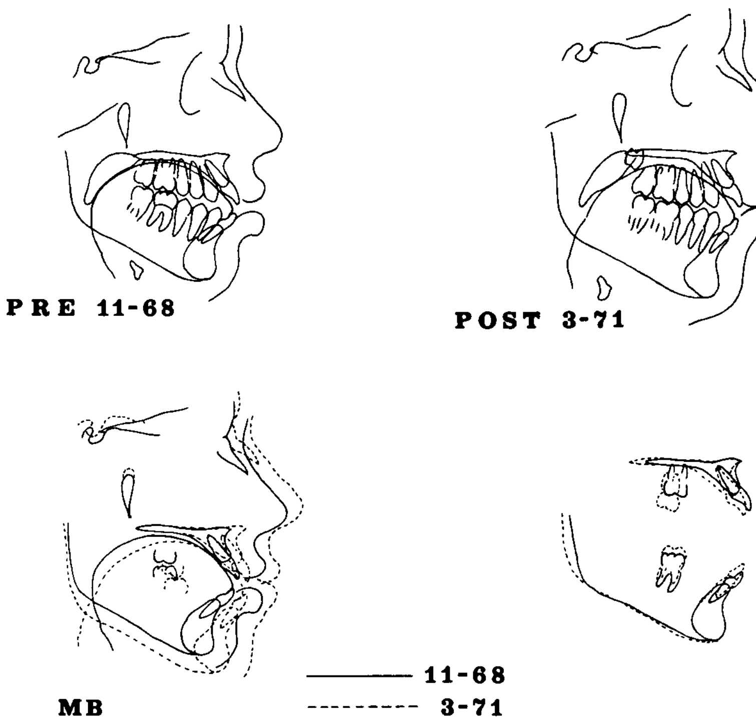

Fig. 24. Tracings of cephalometric headplates and superimposed composites to indicate changes incident to growth and reduction in tongue size. Lower left, superimpositioning on the palate with PNS registered. Lower right, superimpositioning on the palate with ANS registered and on the mandibular symphysis. Growth of the jaws, uprighting of anterior teeth, and eruption of posterior as well as anterior teeth are noted.

sistence of an open-bite malocclusion. With reduction in tongue mass, some improvements in anterior dental relationships, a narrowing of arch width, and a reduction of diastema spaces were observed. To document these observations, one-to-one photographs of the occlusal surfaces of the dental casts were studied, traced and superimposed. By registering on the first molars, the reduction in the width of the cuspids and bicuspids, the retrusion of the maxillary and mandibular incisors, and a considerable reduction in diastemas anterior to the bicuspids were confirmed (Fig. 26).

At this time additional surgical reduction of the tongue would seem indicated since sufficient jaw growth could not be anticipated to permit correction of the malocclusion. Provided adequate lingual tissue had been removed while generous growth potential remained, this case could have turned out infinitely better from an orthodontic viewpoint. The point emphasized is that excessive tongue dimension can preclude orthodontic correction. Without sufficient growth to accommodate lingual mass, it may be impossible to correct disproportionate lingual size via orthodontic or myotherapeutic procedures.

As previously mentioned, orthodontically treated open-bite malocclusions generally show adaptation in tongue function during swallowing. Whereas tongue protrusion was frequently evi-

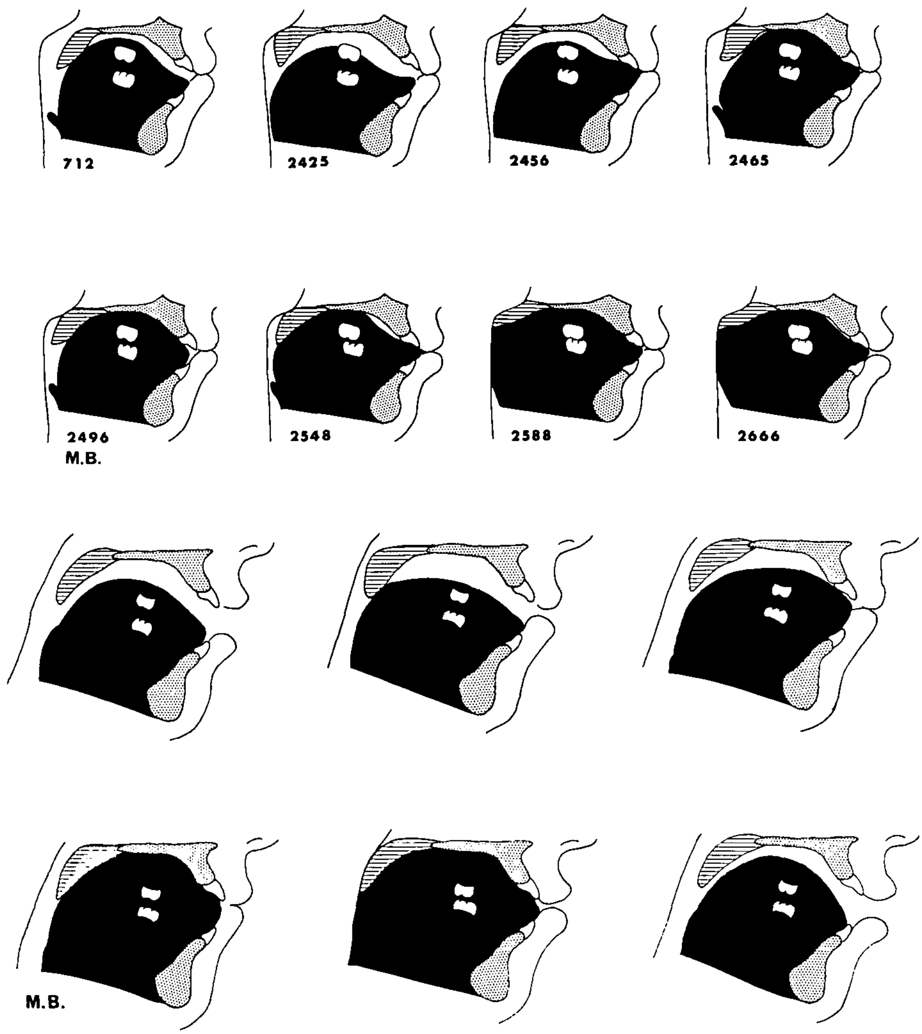

Fig. 25. Tracings of cineradiographic frames taken during swallowing on the individual depicted in Fig. 24, before (above) and after (below) surgical reduction of the tongue.

dent with the presence of an open bite, tongue protrusion was no longer evident following orthodontic correction. These patients, however, were favorable for orthodontic correction. Unfortunately, some open-bite deformities cannot be corrected orthodontically with stable results. These patients with open bites usually have severe skeletal problems. The malocclusion then is caused by skeletal malrelationships.

The effect of skeletal malrelationships on tongue function is well exemplified by discussion of an adult patient who developed an open bite after surgery. The patient appeared seeking surgical and orthodontic correction of a skeletal dysplasia which involved excessive mandibular prognathism, slight maxillary retrusion and some degree of vertical overclosure (Fig. 27). Cineradiographic analysis of deglutition

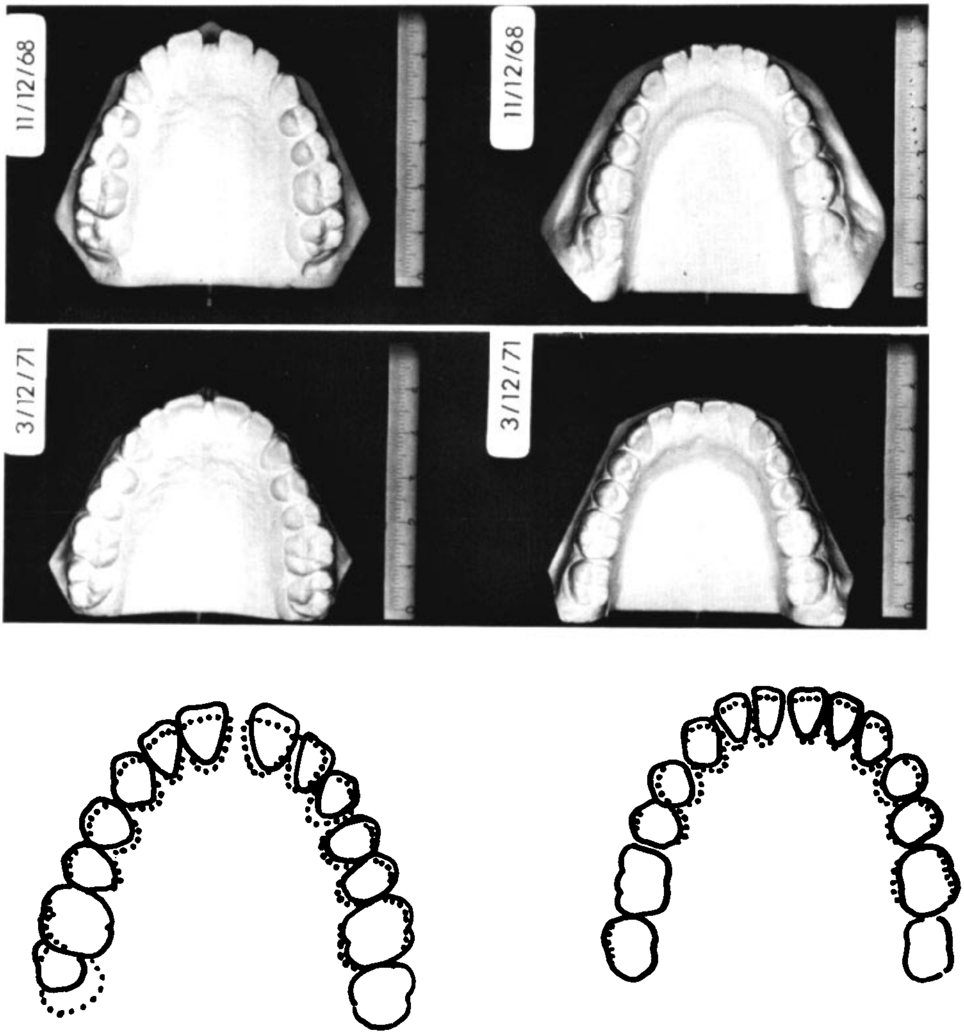

Fig. 26. Occlusal views of the dental casts (above) and superimposed tracings of photographs, taken to scale, of the dental casts (below) of the individual depicted in Figure 24. Reduction in the width of the arch and in the diastemas between teeth are noted when comparing the before casts (solid line) with the casts attained after surgical reduction of the tongue (broken line).

revealed many features previously described for maxillary deficiency cases. The tongue moved under the maxillary incisal edges gaining close approximation with the lips to achieve an anterior oral seal.

To correct the mandibular prognathism, surgery was recommended and a sagittal split procedure[29] was undertaken with elastic therapy used for occlusal fixation. Unfortunately, proper healing did not occur. Bilaterally, union of the mandibular fragments was not achieved and, as a result, a change in the positional relationship of bony parts was observed. This change may be related to the pull of the various masticatory muscles. The bony area of the

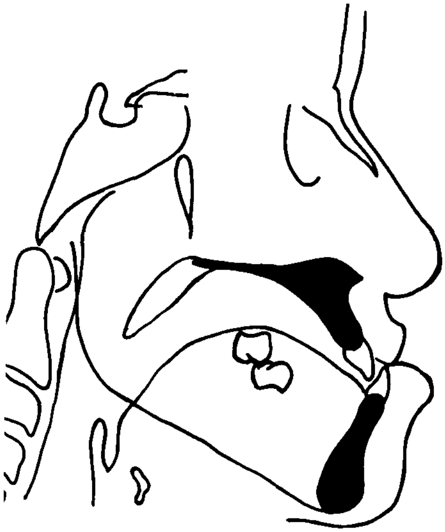

Fig. 27. Tracings of the cephalometric headplates of an individual before the orthodontic-surgical correction of mandibular prognathism.

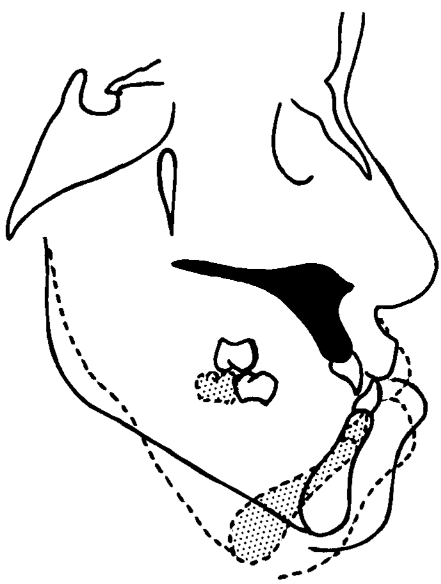

Fig. 28. Superimposed tracings (on S-N) of the cephalometric radiographs taken on the individual depicted in Figure 27 before and after the unsuccessful correction of the mandibular prognathism. Changes in the postural relationships of the parts of the mandible, as described in the text, are noted.

gonial angle moved upward and forward, while the mandibular symphysis went downward and backward with the center of rotation around the area of the molar teeth (Fig. 28). The composite result of these changes in the relationships of the bony parts was a configuration of the mandible closely resembling the mandibular form previously described in skeletal open bites. With this mandibular pattern an open-bite malocclusion was evident despite coincidental extrusion of the maxillary and mandibular incisors. At rest, the tongue was postured closer to the hard palate and slightly closer to the posterior pharyngeal wall.

Postoperative cineradiographs revealed protrusive tongue activity into the open-bite area with the tip progressing between the incisor teeth despite their extrusion (Fig. 29). With the surgically created form of a skeletal open bite, protrusive tongue activity appeared as the adaptive pattern to be modified (new environment) and will probably persist as long as the open-bite deformity remains.

The pattern of deglutition described above is frequently observed in skeletal open-bite cases. In patients with this malocclusion skeletal relationships usually are beyond the limits of orthodontic correction. As a result, conventional orthodontic treatment, per se, should not be considered. Unfortunately, a significant number of these subjects have skeletal malrelationships of sufficient magnitude to justify a recommendation for surgical correction.

Protrusive tongue activity during deglutition is a characteristic pattern of deglutition in open bites which can be treated orthodontically as well as in those who cannot be treated orthodontically. In both instances the presence of such activity does not seem to justify the institution of myofunctional therapy prior to orthodontic or surgical/

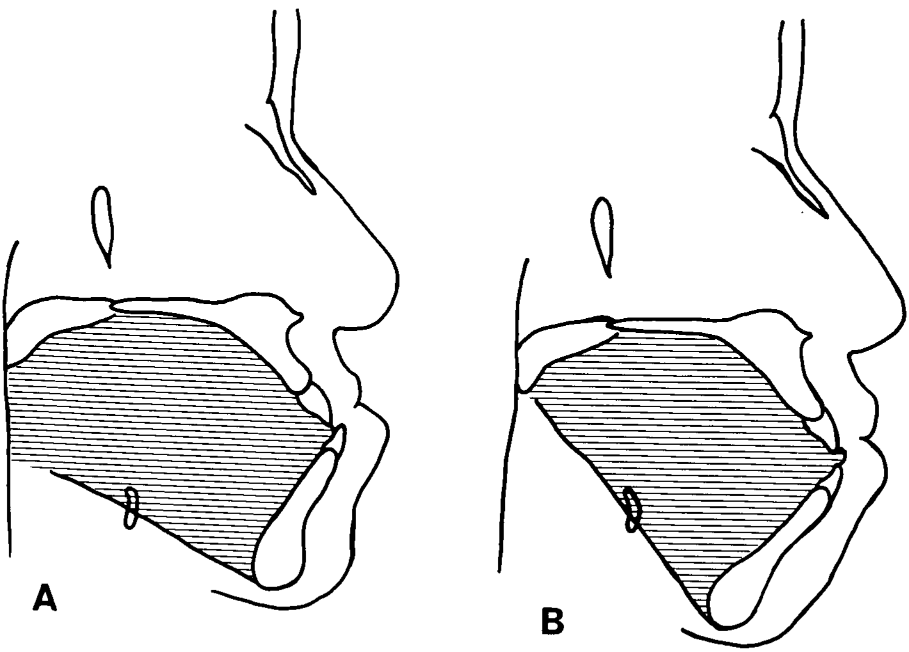

Fig. 29. Tracings of comparable, selected cineradiographic frames taken on the individual depicted in Figures 27 and 28, before and after the surgical procedure. With the change in skeletal relationships into a skeletal open-bite configuration, tongue protrusion during swallowing is evident.

orthodontic correction. Tongue-tip protrusion is considered an adaptation to the oral configuration. If the case can be orthodontically treated, the tongue will usually adapt to the properly corrected occlusal relationship. If the problem is due to a severe skeletal malrelationship, then it cannot be anticipated that myofunctional therapy will permit spontaneous correction of the open bite. Skeletal open-bite cases, furthermore, should also be beyond the limits of functional myotherapy simply because further incisor eruption cannot logically be anticipated. It has been demonstrated that the incisors are already supererupted in skeletal open bites. Functional adaptation during swallowing after surgical correction of skeletal malrelationships may be anticipated provided that the surrounding environment has not become too confining for the existing tongue dimensions.

Summary

An attempt has been made to review, integrate and interpret research and clinical studies of deglutition as they relate to occlusion and to the treatment of malocclusion. The effect of growth and development, thumbsucking, myofunctional therapy, mechanical restraints and surgical treatment have been considered as related to correction of malocclusion and to modification of orofacial muscle activity during deglutition. Although objective data remain sparse in some areas, especially in regard to the effect of myofunctional therapy upon occlusion, the bulk of evidence indicates the specific pattern of muscular activity associated with deglutition is dictated principally by form. When form is modified by orthodontic and/or surgical procedures within the anatomical and physiological limitations of the

patient and within the reference of anticipated changes incident to growth and development, stable adjustments in occlusion and favorable adaptations in orofacial muscle activity may be anticipated.

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