The "three M's": Muscles, malformation, and malocclusion

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IT WOULD be hard to convince the neophyte that fashions flourish in orthodontics even as they do in interior decorating and clothes design. A quick glance at the programs of the various sectional components of the American Association of Orthodontists and a summary perusal of the literature of the past 10 years would, indeed, indicate that there is a time-linked subject orientation. Ten years ago editors were surfeited with papers on cephalometrics. The majority of theses being written by graduate students were cephalometrically oriented and, as one observer has put it, "the numbers racket was in high gear." Most appliance articles 10 years ago were on the Angle edgewise appliance if they dealt with mechanotherapy. The tenor of most of these articles was that the problems were really quite simple if you had the proper mechanism and observed the commandments emanating from above. For one group of disciples, the most important commandments were the following:

1. Never take out teeth; to do so means compromise, and failure is only a matter of degree.
2. You have been given an appliance that is capable of any movement you choose. Use it properly and you shall not fail. Remember, you are one of the "chosen people," following in His footsteps.
3. The only true research is that being done by those who have inherited His mantle; there is no other God but He.
4. Do not degrade thyself by commingling with disbelievers. You have been given the divine message.
5. Obey and do not question.
6. If you put the teeth in their proper relationship to each other, normal function will result and stimulate the development of supporting bone.
7. Ignore the soft tissues; they will move out of your way.

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8. Don't worry about the amount of force you use. Teeth will move one way or the other.
9. Read extensively in comparative anatomy, anthropology, and art, for an erudite display of such knowledge will assist you in times of travail.
10. Retain the orthodontic results indefinitely. This will allow function to take over and stabilize the results.

If these commandments did not instill the fear of the deity in the eager young orthodontist, he was somewhat perplexed when he ran into another set of precepts, also emanating from an oracle on high. These commandments—from a slightly different cult, of course—were as follows:

1. Thou shalt not expand.
2. Honor thy patient and practice and strive for perfection and a pleasing profile.
3. Remember that the master has said that the lower incisors must be 90 degrees to the mandibular plane, or 65 degrees to the Frankfort horizontal. Do not deviate!
4. Do not hesitate to extract first premolars. Only in this way can you achieve the objectives required by our master.
5. Band as many teeth as possible; to do less indicates sloth, indecisions and lack of comprehension of the only road to orthodontic salvation.
6. Ignore muscles, particularly those of the tongue, as you strive for the magic mathematical formula.
7. Ignore morphogenetic pattern and growth gradients. Occlusion is the be-all and the end-all of our existence.
8. Ignore root resorption, but do not show the roentgenograms to your confrères because they might interpret this as a sign of weakness.
9. Take your "finished" records as soon as you remove appliances. If you have not achieved the objectives as outlined by the master, the case is not to be considered "finished."
10. Retain the case indefinitely. Never discuss failures with nonbelievers, for you may sow the seeds of ugly suspicion and mistrust.

It is obvious from looking at both sets of the "sacred ten" that the adherent to either set of commandments had to have "religion." Conflicting as some of the admonitions seem, however, there were some common denominators. In both cases, it was assumed that the appliances would automatically produce the desired result if used properly. In both cases, one just did not think about failure or the accomplishment of less than ideal results. In both cases, to use something different meant to compromise, and compromise was a therapeutic disgrace. Followers of both sets of rules paid lip service to functional forces but ignored the role of muscles.

In this wonderful world of fashion, muscles were bound to have their day. The patient's failure to wear his retainer could not be blamed for all the relapses. Even the most zealous operator could see that his perfect manipulations at times produced very imperfect results. Third molars provided a good alibi, as did that nebulous entity known as "growth and development," but there still must be something else.

There was a rude awakening as clinicians suddenly saw that the patient had a tongue. From the pulpit came the sonorous declaration that "90 per cent of all patients are reverse swallowers!" Disciples gulped a bit when they heard this. Such a statement was, indeed, hard to swallow. Had not the master said to ignore the tongue? At least, he had said this in effect when he said that for every degree over 25 degrees for the Frankfort-mandibular plane angle, the lower incisors should be tipped 1 degree lingually past the magic 90 degree norm. In the spirit of the immortal Tennyson poem, "Theirs not to make reply, theirs not to reason why, theirs but to do and die." So now there was at least the perfect scapegoat—the tongue!

The fine work of Gwynne-Evans,[26] Ballard,[7] Hovell,[30, 31] and Tulley,[49] studying the role of the musculature, was "discovered" and the numerous graphs and curves associated with the cephalometric contribution to the literature gave way to the curves and contours of the orofacial soft-tissue environment. Speech therapists became tongue tamers. They soon found that lion taming was more successful.[9] Improper nursing, poor design of artificial nipples, retention of infantile mechanisms, and nonnutritive sucking were blamed for orthodontic relapses. These tenuous connections are in much the same category as those used by armchair psychologists who often attribute every adult neurosis to imagined childhood frustrations. Many a physiologist has raised an eyebrow as budding "muscle-bound" orthodontists delve in fanciful flights of teleology to explain their failures.

This facetious critique is exaggerated, but we cannot deny the basic fact that, from a complete disregard of muscle activity and habit patterns, we have jumped to a belief that muscle plays a dominant role, affecting our manipulations whether we like it or not. One almost senses a feeling of hopelessness or pessimism in sharp contrast to the great optimism of the early 1950's when orthodontists could move teeth as they desired. Perhaps this reflects a belated recognition by our orthodontic engineers that the results produced by the most precise techniques and the most efficient armamentaria will not stand the test of time when there is a conflict between the morphologic pattern attained and the physiologic structure of the stomatognathic system. Fortunately, the fundamental phenomenon of homeostasis, or the organism's ability to adapt to change, does give the orthodontist some leeway, reducing the air of gloom and pessimism that pervades the lair of the muscle men today.

The orthodontic vernacular has been greatly expanded recently with the inclusion of such terms as *reverse swallowing, hereditary incompetence, endogenous pattern, visceral swallow, somatic pattern, retained infantile swallow, simple tongue-thrust, complex tongue-thrust, transitional swallowers,* etc. Where do muscles and malocclusion stand with respect to this mass of verdant verbiage? Are the answers to be found in current myometric and electromyographic research and basic muscle physiology? Is it not possible that there are many facets to this problem?

The remainder of this study attempts to balance orthodontic therapy and the musculature philosophically, just as the orthodontist must balance them physically with his own appliance manipulations. The discussion deals with the role of muscles in the etiology and correction of the various categories of malocclusion. Some simple methods of controlling abnormal perioral muscle function are illustrated.

CLASS I MALOCCLUSION

Muscle function is usually normal in cases of Class I malocclusion. The teeth are in a state of balance with environmental forces (Fig. 1). While actual measurements of tongue and lip forces show that they are not equal in any one area during a particular function, a state of equilibrium has been reached if we consider morphogenetic pattern, tooth size, available basal bone, character of contiguous tissue, postural forces, and the various functional forces. Weinstein and associates[50] indicate that there is probably more than one position of equilibrium, all factors considered.

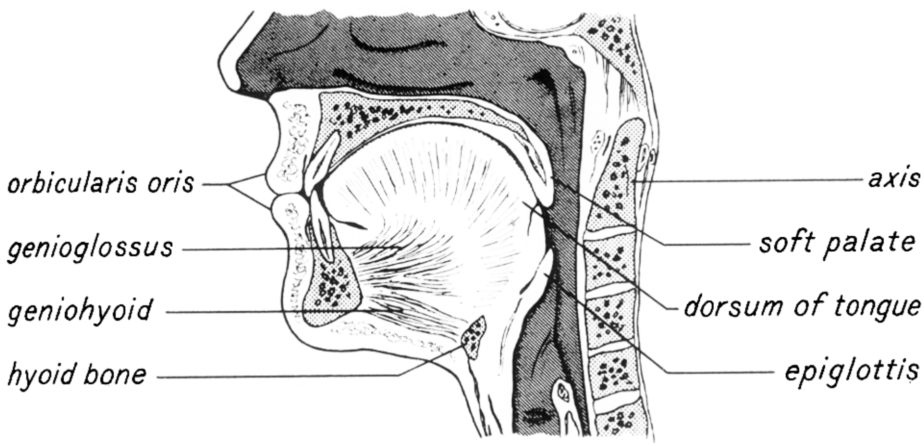

Fig. 1. Normal structural relationship. Note proximity of tongue and palate; gentle, unstrained lip contact; normal overbite and overjet. (After Lischer, B. E., in Graber, T. M.: Orthodontics, Principles and Practice, Philadelphia, 1961, W. B. Saunders Company.)

Mastication is the primary consideration for us, as dentists, when we think of the teeth, jaws, and motivating musculature. This is only part of the picture. Posture, deglutition, respiration, and speech make use of the same structures, and these functions are no less important.[22] The head is balanced precariously on a bony column and is held erect by the chain of postvertebral, prevertebral, masticatory, facial, suprahyoid, and infrahyoid muscles[23] (Fig. 2).

As we know, the primary position, or the point of initiation of the manifold functions of the stomatognathic system, is the postural resting position.[12] This position has been determined by the morphogenetic pattern and by the complex functional demands that are constantly made on it from birth to senescence. The orthodontist finds that as the point of return, as well as the point of initiation for the functions of mastication, deglutition, respiration, and speech, this

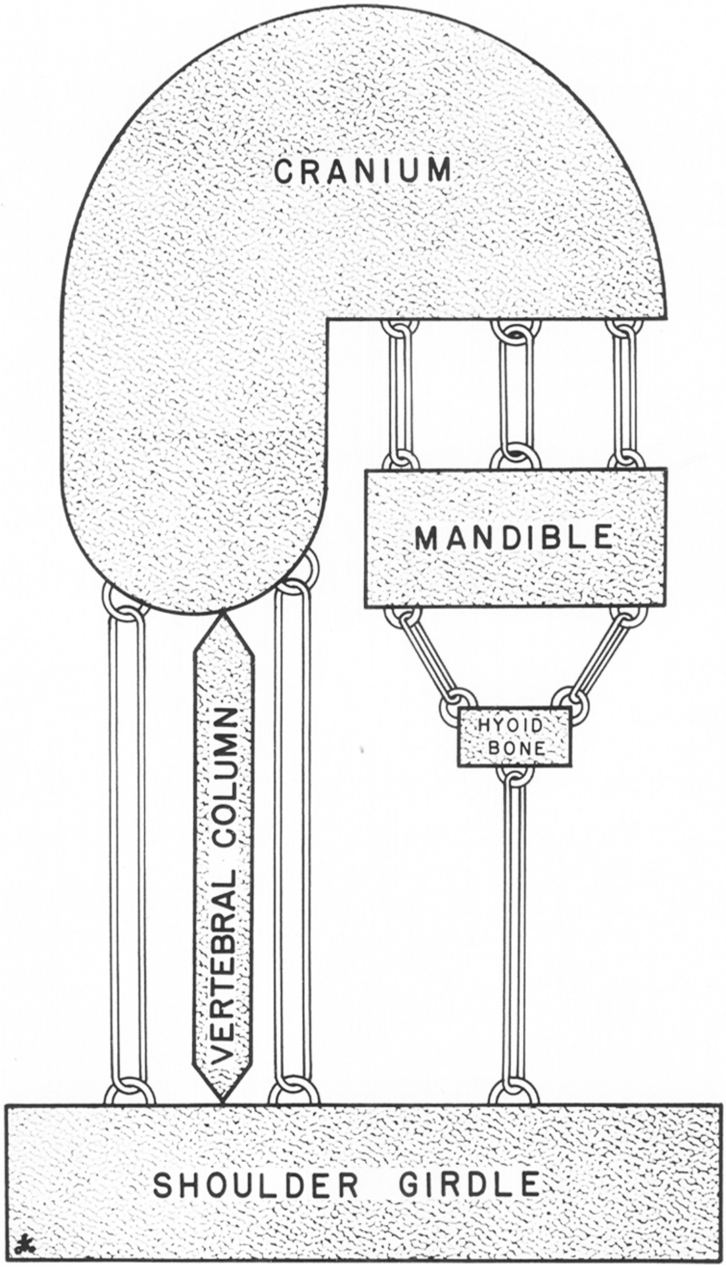

Fig. 2. Vertical dimension, diagrammed to demonstrate role of muscles in maintaining the balance of the head on the vertebral column. Post- and prevertebral muscles and masticatory, facial, and hyoid group muscles all contribute to the establishment of the relatively constant postural resting position. It is from here that the dynamic functions of respiration, deglutition, mastication, and speech begin. (After Brodie, A. G., in Graber, T. M.: Orthodontics, Principles and Practice, Philadelphia, 1961, W. B. Saunders Company.)

relationship is constant (Fig. 3). As Posselt[39] has shown, stretch-reflex control can be traced to the mesencephalon and the pons (Fig. 4).

However, in our eagerness to establish a "base of operation," we must not forget that even postural resting position is amenable to alteration. There may

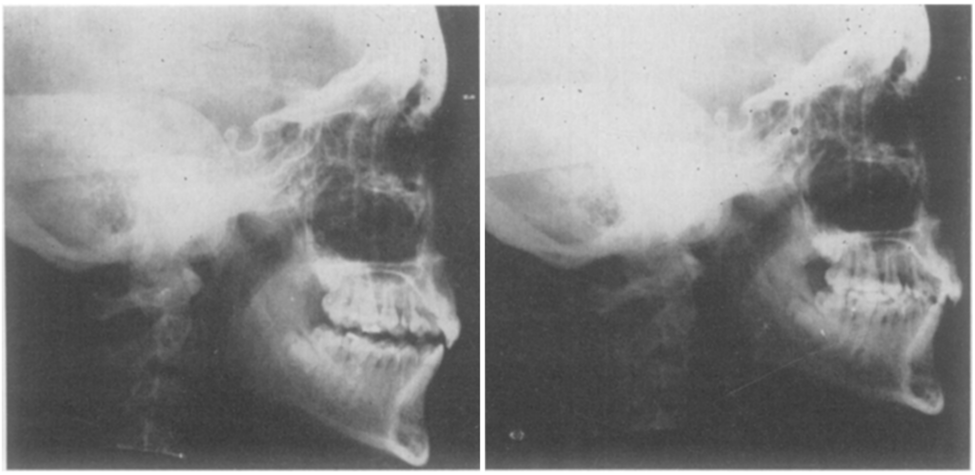

Fig. 3. Lateral cephalograms showing postural resting and habitual occlusion positions. Patient has a Class II, Division 2 malocclusion. Mandible moves upward and forward to point of initial contact and is then forced upward and backward until posterior-segment occlusion is established.

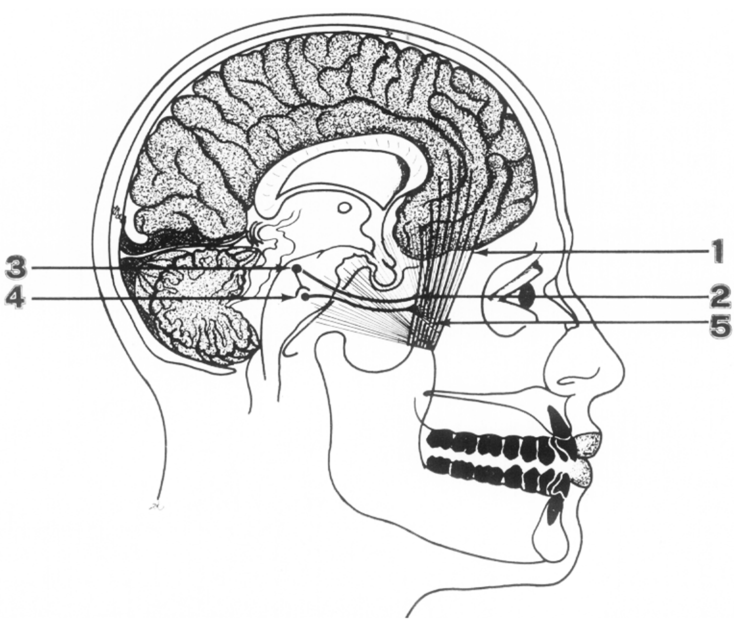

Fig. 4. Postural reflex of temporalis muscle. Drawing is mainly of anterior fibers (*1*), including stretch receptors (*2*), the sensory nucleus in the mesencephalon (*3*), the motor nucleus in the pons (*4*), terminating in the muscle fiber end plates (*5*). (From Posselt, Ulf: Physiology of Occlusion and Rehabilitation, Philadelphia 1962, F. A. Davis Company.)

be a measurable change from morning to night. Nervous tension, premature contacts, temporomandibular joint disturbances, and homeostasis may all produce variation, and these possibilities should be checked whenever a postural rest registration is made.[23] Usually such variations as are produced are minor and do not mitigate any more against the concept of postural resting position than does inherent variability in other areas of the body. Constant peripheral recruitment of muscle fibers and tonus maintains the head in the position of best advantage, from which the active functions may be initiated with minimum effort.[36] Thus, postural resting position is hardly a system at rest in the truest sense. When we measure the total forces acting on the dental arches, a significant amount must be credited to these subclinical, relatively minimal and yet potent

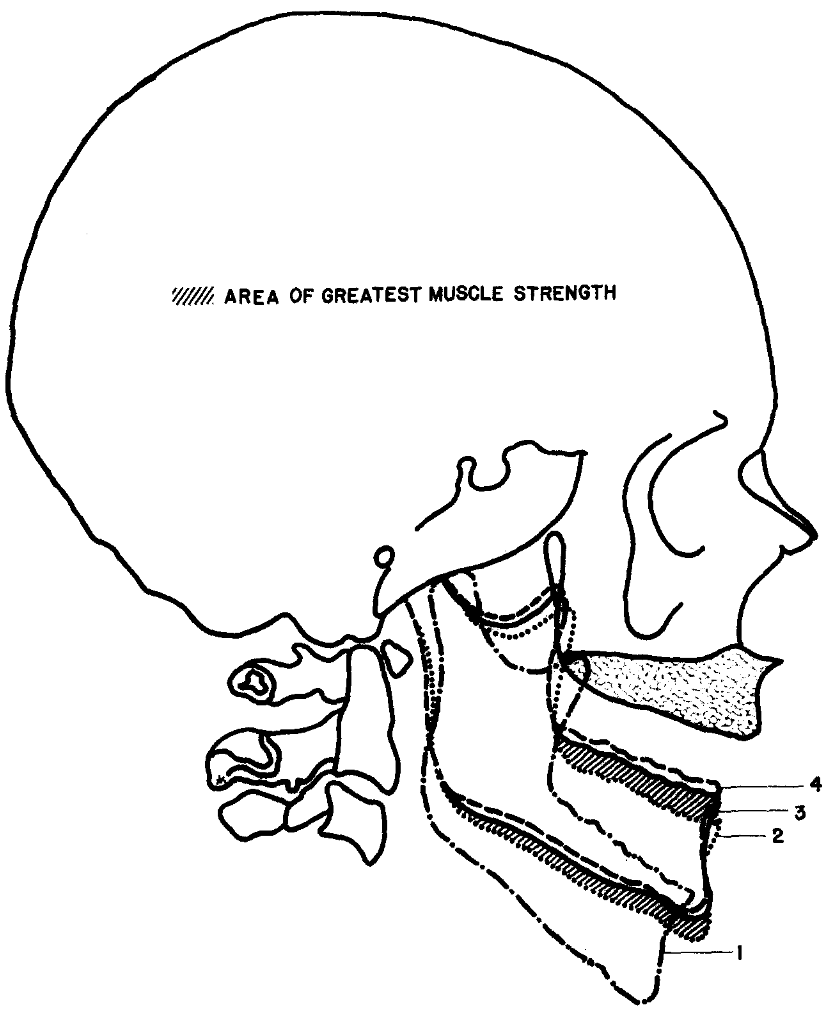

Fig. 5. Lateral cephalometric tracings of mandible in open-mouth (*1*) and postural resting (*2*) positions, occlusion (*3*), and overclosure (*4*). Positional influence of mandible on strength of muscle contraction is shown by the fact that between *2* and *3* the greatest force is created. Magnitude falls off rapidly between *3* and *4*.

increments. These forces are from one fourth to one tenth those recommended as minimum for tooth movement, according to Weinstein.[50]

Over any period of time, kinesthetic neuromuscular impulses, in the form of proprioception, maintain a constant maxillomandibular position, with the teeth separated by a V-shaped space[8] (Fig. 4). This interocclusal clearance is wider anteriorly than in the posterior region. The prudent orthodontist has learned to build his orthodontic objectives around this muscularly determined position, even as the prosthodontist has learned that he cannot ignore resting-position limitations unless he wants to see the alveolar process melt away as Nature re-establishes an occlusal position in harmony with postural rest. Thus, muscle physiology teaches us that there are two vertical dimensions—(1) occlusal vertical dimension (OVD) as determined by the teeth when related in habitual occlusion and (2) postural vertical dimension (PVD) as determined by the draping and motivating musculature. Lack of harmony of treated malocclusions with postural resting vertical dimension means deterioration of post-treatment morphology.[15] Even from the point of view of functional efficiency, it is obvious that the correct establishment of OVD is essential.[49] The area of greatest muscle strength is in the 4 mm. range from postural resting position to occlusion (Fig. 5). The strength of muscle contraction falls off rapidly if the patient is permitted to overclose. As we have seen in our studies of cleft palate children with markedly deficient occlusal vertical dimension, even with significant adaptive changes, and with increased anterior temporalis and anterior masseter fiber activity and greater suprahyoid and infrahyoid activity, the magnitude of closing forces is greatly reduced.[22]

One would think that while we have not been sufficiently aware of the vertical dimension, we at least have been concerned about the other two components that make up the horizontal vector—the lateral and anteroposterior muscle forces. This is partly true. Case, Grieve, and Tweed strongly attacked the expansion philosophy in orthodontic therapy.[23] With effective appliances and a precise technique, Tweed and his followers exerted a profound influence on American orthodontic thought. Acutely aware of the failures resulting from moving crowded teeth outward and off basal bone, they bent all their efforts toward maintaining existing arch form and size through the medium of tooth sacrifice and space closure. Expansion as a rationale in Class I therapy has been severely curtailed. There are those, however, who feel that the primarily mechanical orientation of Tweed's philosophy has largely ignored the enveloping soft-tissue and muscle forces. With the major consideration being basal bone and available space, Tweed literally built his cases around the mandibular incisor and a 90 degree inclination to the mandibular plane (Fig. 6). If the mandibular plane was steeper than the arbitrary 25 degrees chosen as "normal," Tweed advised his disciples to tip the mandibular incisors lingually past the so-called norm, or 90 degree inclination, 1 degree for each degree over the 25 degree mandibular plane inclination. Thus, if a patient has a Frankfort-mandibular plane angle of 35 degrees, the lower incisor must be "set" at 80 degrees to compensate for the steepness and to provide the necessary profile improvement. In their zeal to prevent expansion, Tweed and his followers thus ignored an

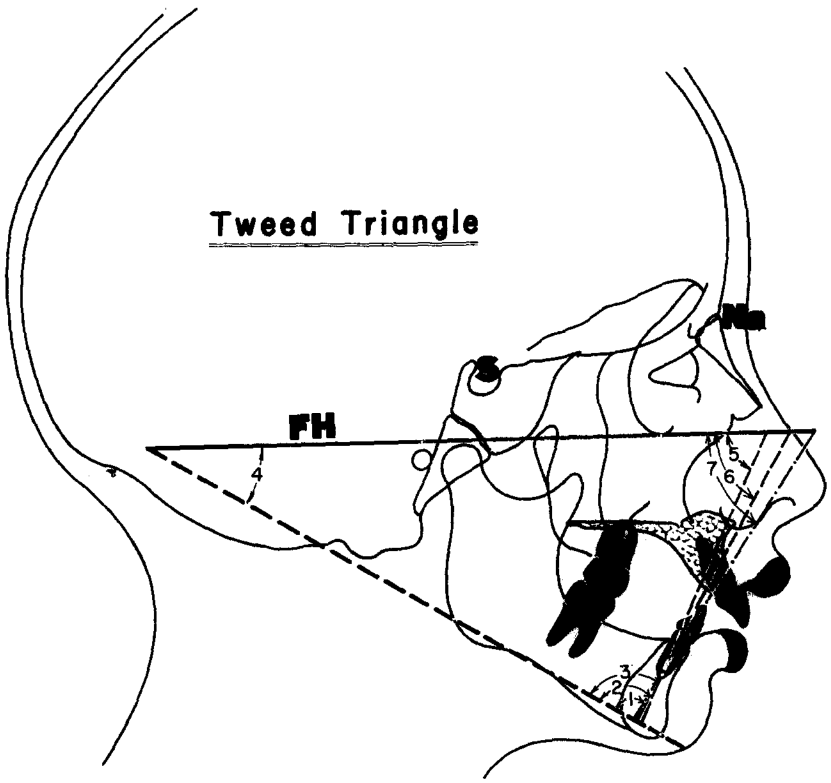

Fig. 6. Cephalometric analysis by Charles Tweed. The larger the angle at *4* (the greater the Frankfort-mandibular plane angle), the smaller the angles formed at *1, 2* and *3* must be to compensate for the gonial obtuseness. The treatment objective is a 65 degree angle formed by the long axis of the mandibular incisors and the Frankfort horizontal plane at *5, 6,* and *7*. Mandibular incisors must be moved lingually to compensate for steep mandibular plane. The maxilla (shaded area) is ignored in this analysis, regardless of category of malocclusion.

equally important muscle force and mass—the tongue. The 90 degree incisor inclination by itself was a fiction, nonexistent as a ''norm'' in Nature; it was a convenient clinical creation that was obtainable by appliance manipulation but empiric and mathematical and unphysiologic. As Winders and others have shown, the functional forces of the tongue can be three to four times as great in some areas as the opposing lip and cheek muscles and can hardly be ignored (Fig. 7).

To *expansion* must be added *contraction* in Class I malocclusion, or in any category of malocclusion in which the teeth are tipped to arbitrary inclinations that ignore the contiguous functioning muscle masses. For the extractionist there is ample posttreatment evidence in the form of spaces in the extraction site, deepened overbite, crowding mandibular incisors, soft-tissue proliferation and all-too-frequent root resorption, and temporomandibular joint disturbances.[15] These sequelae are of no less concern than the untoward effects of injudicious expansion. With expansion, we are at least moving the teeth in the direction in which normal growth and development may take them as the stomatognathic system develops its fullest potential through growth. Routine empiric tooth sacrifice at times gives the opposite impression of a general shrinking process.

Those who favor differential light-force techniques spend a great deal of time discussing the optimum force for moving a tooth, but many of them have been no less guilty than proponents of the edgewise techniques in ignoring the balancing effect of contiguous muscle and the role of growth and development. Teeth are often tipped to bizarre inclinations during one stage of treatment. Excessive lingual tipping of incisors frequently remains to encroach on the tongue space.

The three-dimensional nature of muscle forces as they act on the dentition is thus apparent. In the vertical plane the postural considerations are dominant, and yet the orthodontist must also be concerned with the functions of respiration, deglutition, mastication, and speech—all of which use the same structures.

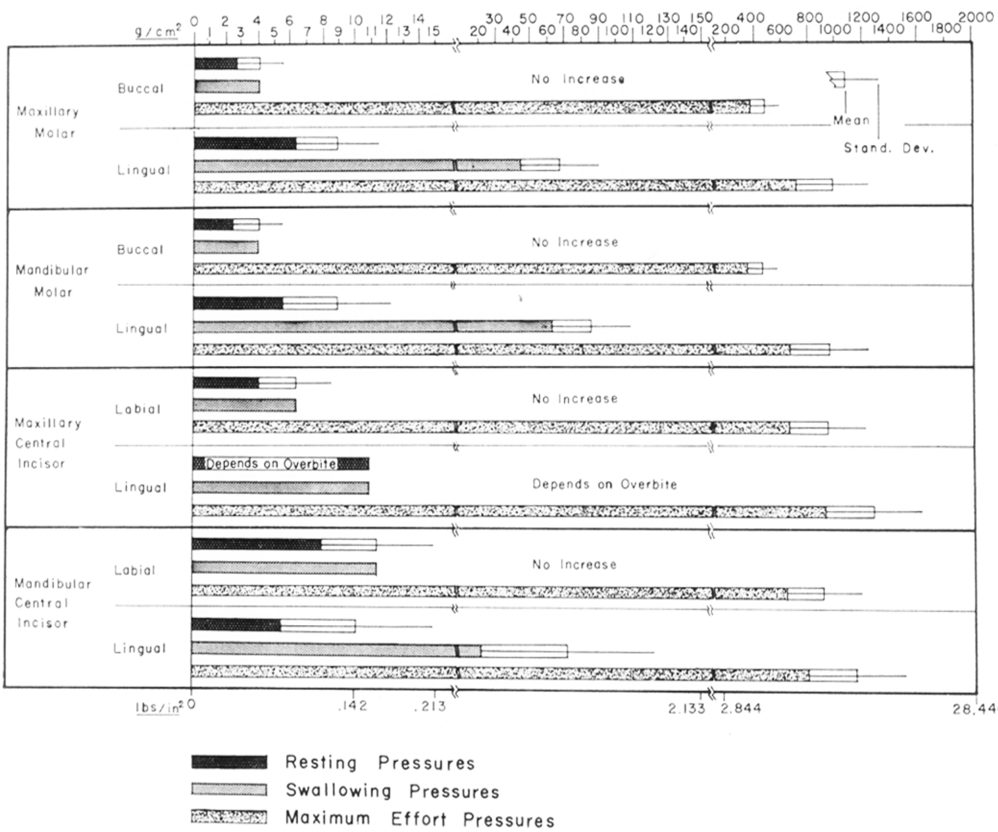

Fig. 7. Magnitude of lip, cheek, and tongue pressures in molar and incisor areas, as measured by Winders with strain gauges and transducers. Pressures were obtained on subjects with excellent dentition. Resting, swallowing, and maximal-effort pressures are graphed for buccal labial and lingual components. Lingual pressures are significantly greater during postural rest and deglutition but little more during maximal effort. Resting pressure appears greater only on the labial aspect of the mandibular incisors. (Adapted from Winders, R. V.: Angle Orthodontist **32:** 38-43, 1962.)

We have been more cognizant of the horizontal forces and no longer accept expansion as routine rationale in Class I treatment, but contraction can be equally bad and will fail just as surely in the posttreatment adjustment.

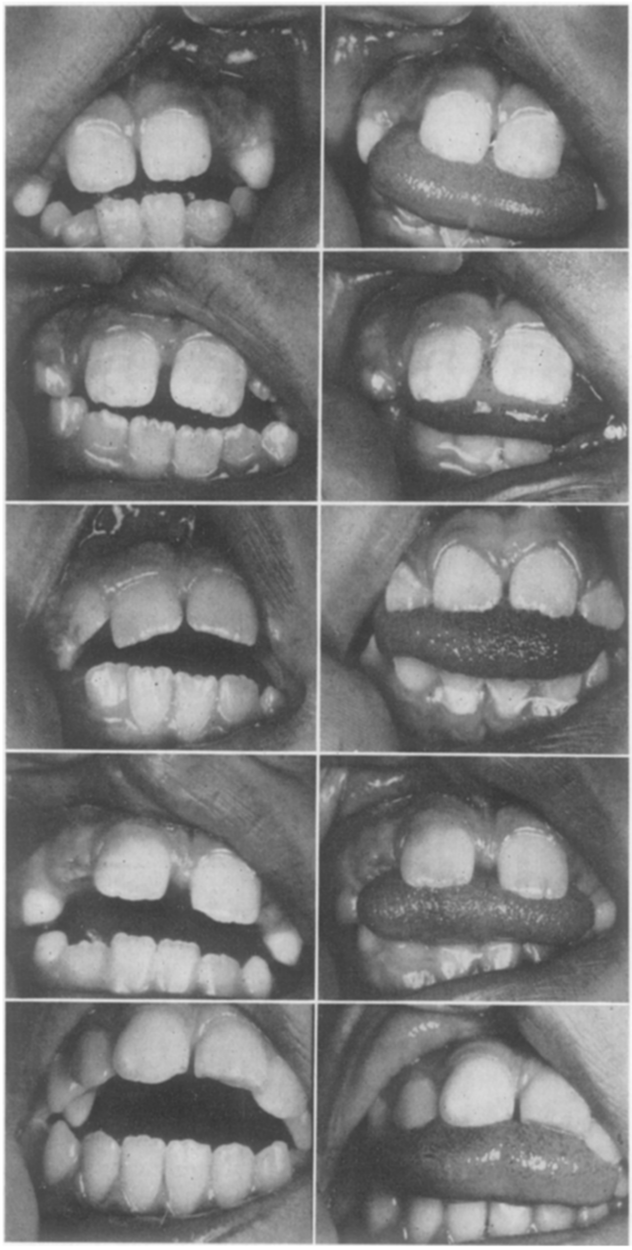

Fig. 8. Anterior open-bite associated with a retained infantile swallowing habit and manifest tongue-thrusting. The peripheral portions of the tongue do not overlie the posterior occlusal surfaces during rest. Thus, postural resting position and habitual occlusion are the same, with no demonstrable interocclusal clearance.

It has been pointed out that muscle activity is normal in Class I malocclusions in general, that Nature has given us the mold, and that we must work within this frame of reference. In other words, we start with normal muscle activity and we must maintain it. Some important exceptions, however, are seen in the various types of open-bite (Fig. 8).

The greatest share of Class I open-bite problems may be attributed to thumb- and finger-sucking, a retained visceral or infantile swallowing habit, or a combination of both.[4, 17, 32, 51] This type of malocclusion provides an excellent example of applied muscle physiology. The infant begins life with a well-developed tongue-thrusting mechanism (Fig. 9). This nursing instinct is one of the best developed of all infantile movements and is quite a contrast to the akimbo and apparently meaningless activities of the extremities.[10] It is an efficient mechanism, too, as the tongue darts forward innumerable times to obtain milk from the mother's breast or from a reasonable facsimile thereof.[4]

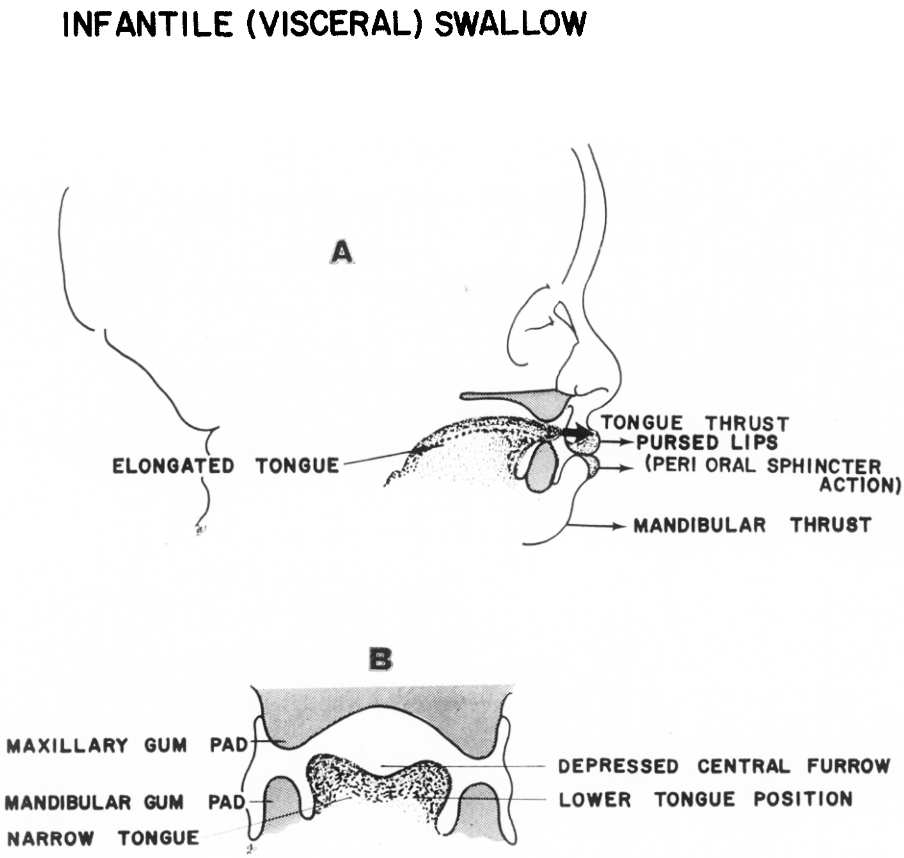

Fig. 9. Infantile swallowing mechanism. Plungerlike action is associated with nursing. Cheek pads flow between posterior gum pads during nursing, unopposed by peripheral portions of tongue. Associated with the tongue-thrust is the anterior positioning of the mandible. The condyle may be felt gliding rhythmically forward and backward in the nursing act. Note concave midline contour of dorsum of tongue.

There are no teeth to get in the way, and the dominant posture of the tongue is one in which the center is depressed, the peripheral portions are raised, and the mass is elongated, ready for plungerlike action. The instinct is so powerful that the infant usually engages in the suckling act even when there is no nipple present. There is very little in the way of an articular eminence, so the mandible moves forward readily to assist in the nursing act. Lips purse and move rhythmically in unison.[14]

At about 5 to 6 months of age, as the incisors begin to erupt, certain proprioceptive impulses come into play and the peripheral portion of the

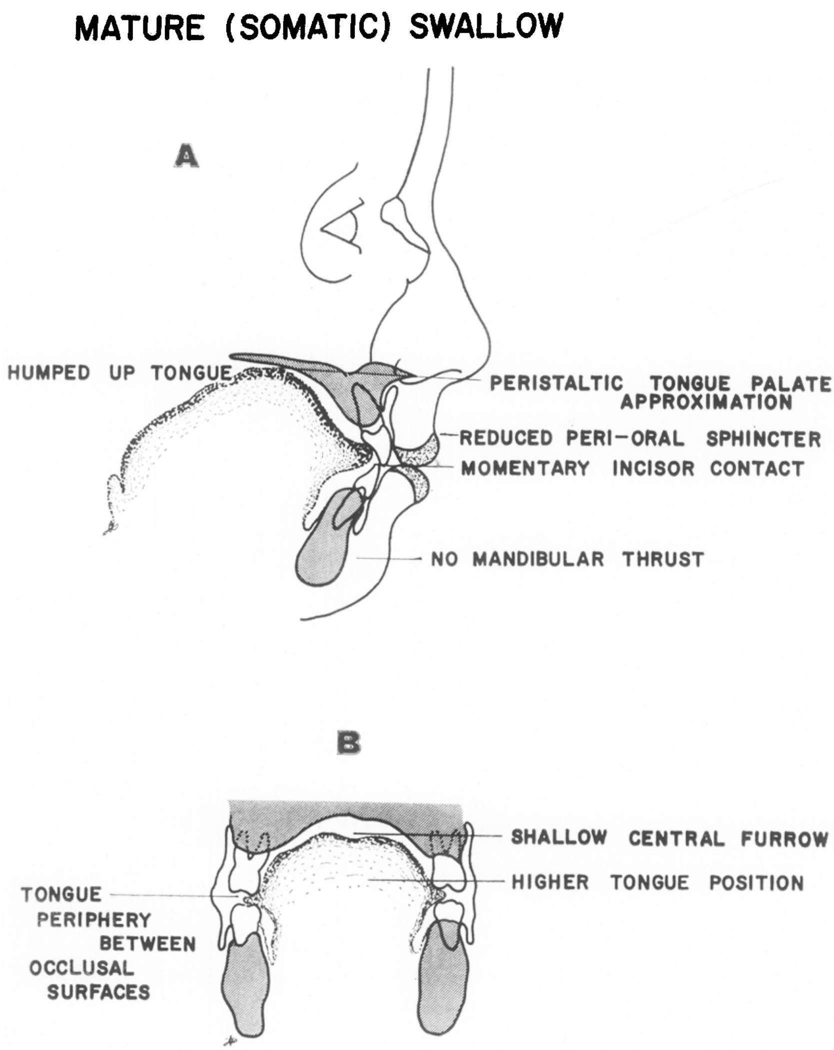

Fig. 10. Somatic swallowing mechanism. The dorsum is less concave and approximates the palate during deglutition. The tip of the tongue is contained behind the incisors; peripheral portions flow between opposing posterior segments. Anterior mandibular thrust has disappeared.

tongue starts to spread laterally. This change in tongue function is a gradual one, and it is called the transitional stage.[37] As the incisors erupt more fully, the peripheral portions of the tongue occupy the space between the remaining edentulous areas of the upper and lower gum pads, and the more mature somatic swallow is the result (Fig. 10). The lips close, and the incisors come together momentarily as the tip of the tongue lies behind the incisors during the swallowing act. Actually, all postural muscles are brought into play during this activity, as electromyographic studies have shown.[3, 8, 14, 15, 18, 25, 31, 33, 40, 49] As the deciduous canines and molars erupt, the peripheral portions of the tongue still overlie the occlusal surfaces during rest, as the mandible is maintained at postural resting position. Thus, the tongue assists in maintaining the interocclusal space or clearance.

With any physiologic phenomenon there is a wide range of variations that can be called "normal." An average infant would show a dominant and exclusive thrusting visceral swallow for the first 6 months of life, a transitional thrusting and lateral spread of the tongue during the next year, and a dominant somatic type of swallow, with the tongue contained within the dentition, thereafter.

It is considered normal for children to engage in nonnutritive sucking during infancy.[48] The most common form is thumb- or finger-sucking (Fig. 11). Since the mouth is the initial avenue of communication with the outside world, and since the orofacial musculature is relatively well developed, this nonnutritive sucking apparently gives the infant a feeling of warmth, a glow, a sense of satisfaction or euphoria that is closely linked to the infantile or visceral swallowing mechanism. As other avenues of communication with the outside world develop, as other muscle systems mature, and as visual and auditory stimuli become meaningful, the euphoria induced by the oral activity assumes less importance. In the average child, the nonnutritive sucking habits spontaneously disappear sometime between the sixth and eighteenth months of life. In some children these habits may be normal for at least another year or so. That the thrusting action of the tongue is a primary instinct is shown by a study of the child with athetoid cerebral palsy who returns to primitive developmental activities and exhibits the monotonous thrusting of the tongue through most of his waking hours.

There is a considerable body of opinion linking the nonnutritive sucking habits with inadequate nursing and with poor nipple substitutes and artificial nursing techniques. I have reached this conclusion after a study of more than 600 children with thumb- and finger-sucking problems in the last 17 years.[22] Whatever the reason for the persistence of the finger-sucking habit (slow physiologic maturation, inadequate or improper nursing methods, nipple designs which enhance the infantile thrusting and do not allow the development of more mature somatic swallow during the transitional stage, or possibly a hereditary Class II, Division 1 type of malocclusion which seems to demand more nonnutritive sucking because of the child's inability to thrust the mandible forward sufficiently), the infant begins with a finger habit of sufficient intensity, frequency, and duration to deform the maxillary anterior segment, forcing the

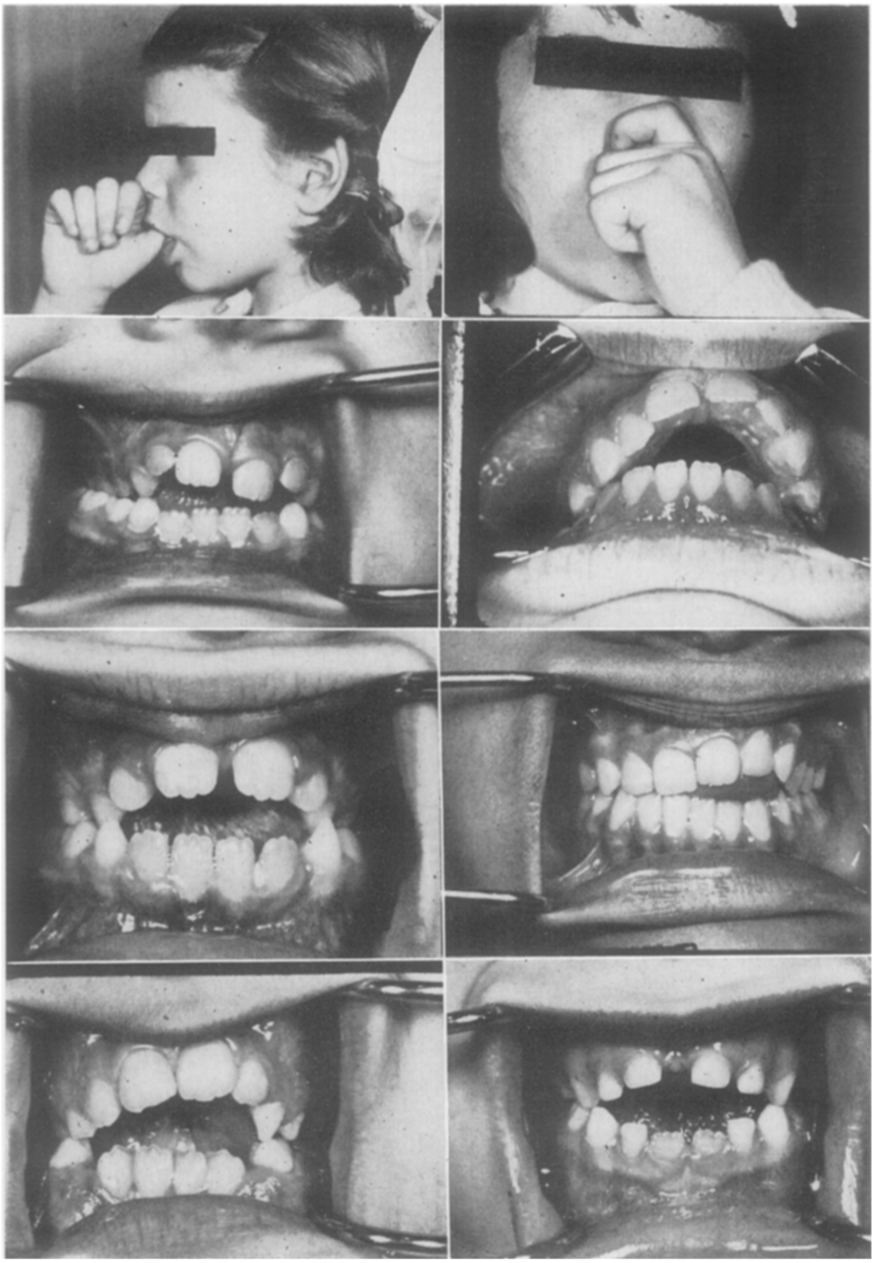

Fig. 11. Malocclusions associated with finger-sucking. Bilateral narrowing of maxillary arch may be attributed to tongue-thrusting, lower resting tongue posture, and excessive buccal pressures that are a part of the infantile swallowing mechanism. Unilateral cross-bites are the result of a "convenience swing" of the mandible to one side, with tooth guidance from point of initial contact to habitual occlusion.

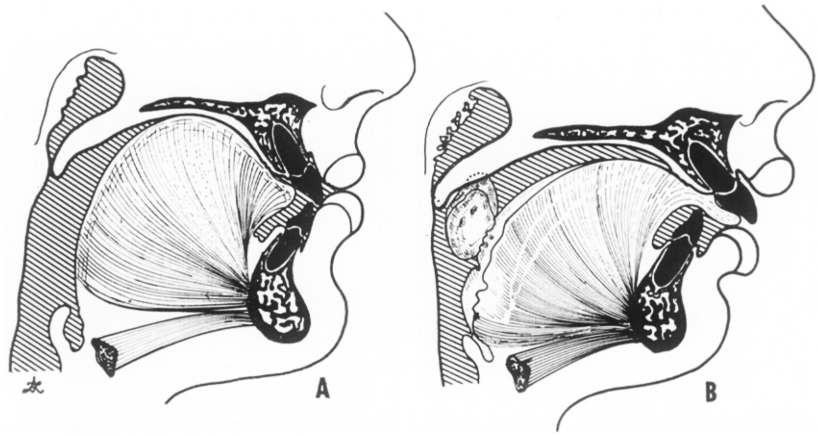

Fig. 12. Hypertrophic tonsils and adenoids may cause an anterior adaptive displacement of the tongue, enhancing the thrusting mechanism and interfering with the normal maturational cycle of deglutition. (After Moyers, R. E., in Graber, T. M.: Orthodontics, Principles and Practice, Philadelphia, 1961, W. B. Saunders Company.)

teeth labially and allowing the tongue to move further in this direction. Instead of graduating from the infantile visceral thrusting pattern in the transitional stage to the more mature somatic swallow, the tongue continues to thrust forward (Figs. 8 and 9). A large part of this activity may be a compensatory condition or an adaptive and adjustive mechanism. This is a classic example of the fundamental phenomenon of homeostasis. To close off the oral cavity for normal deglutition, either a lip seal or a tongue seal is needed to create the negative atmospheric pressure associated with the swallowing phenomenon.[14]

If the finger displaces the maxillary incisors labially, the lip seal becomes more difficult and the tongue thrusts forward between the maxillary incisors to "close off" the oral cavity. Such activity accentuates the open-bite tendency, preventing the incisors from erupting adequately, and the incisors are usually forced further labially. Since, as Winders[52, 53] has shown, the tongue force during function is actually greater than the opposing lip force (Fig. 7), this response is easy to understand. We swallow a total of 1,200 to 1,600 times every 24 hours, so it is no wonder that the compensatory tongue-thrust habit enhances the malocclusion as the lips become more hypotonic and no longer contact each other during rest. Mouth breathing is aggravated and becomes a dominant pattern. Tonsils and adenoids, which are normally larger at this stage, may also be a factor, as Moyers[36, 37] has shown (Fig. 12).

If the maxillary incisors are brought far enough labially, the lower lip enters the picture (Fig. 13). Lips no longer contain the denture, so to speak, as the tongue thrusts forward during the innumerable swallowing cycles in the course of the day.[44] With each swallow, the lower lip cushions to the lingual of the maxillary incisors and joins the tongue in Nature's adaptive or adjustive attempt to create the oral seal during swallowing.[2, 7, 13, 42] Mentalis muscle activity greatly increases, and a puckering of the chin can be seen with each swallow as both the lower lip and the tongue thrust upward and forward into the excessive overjet and open-bite configuration (Figs. 14 and 15).

With constant tongue-thrust, the tongue drops lower in the mouth and no longer approximates the palate most of the time.[47] The tongue naturally elongates in shape as it thrusts forward, decreasing its balancing effect on the buccal segments. Equally important, the lateral peripheral portions no longer overlie

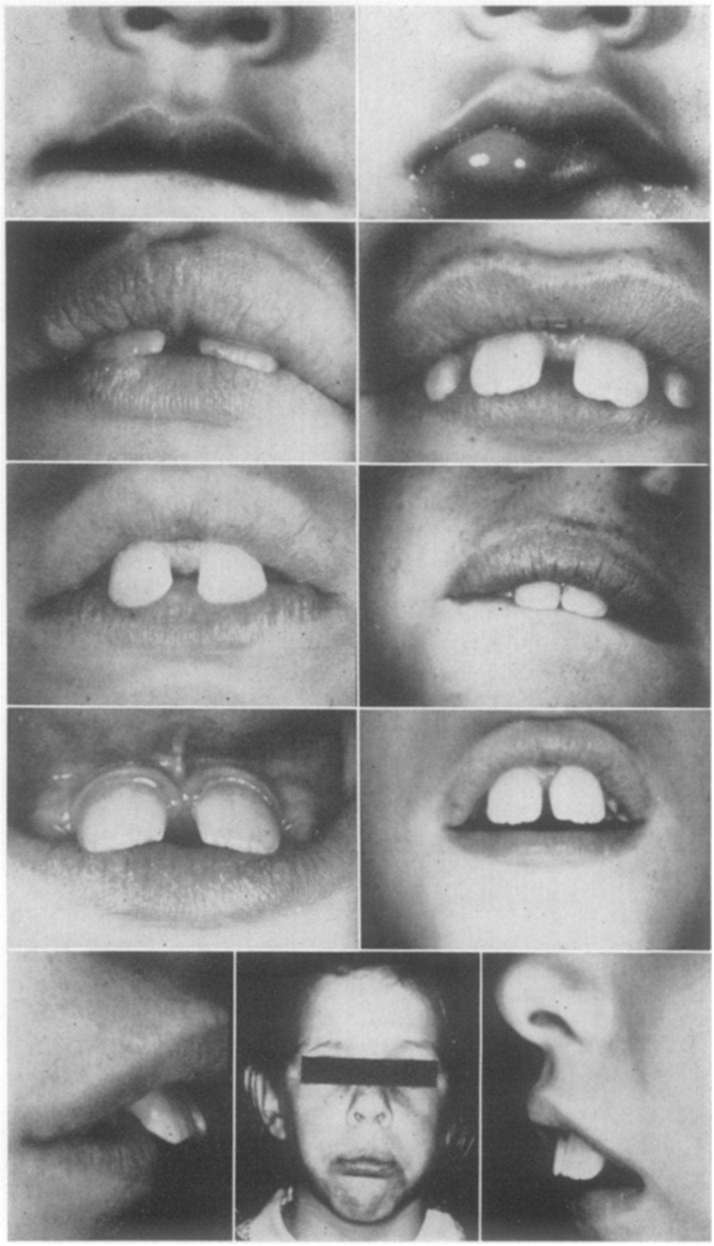

Fig. 13. Lip-sucking, the cushioning of the lower lip to the lingual aspect of the maxillary incisors during both rest and active function, and hyperactive mentalis muscle activity (lower center) enhance malocclusion and prevent normal deglutition. (From Mayne, Warren, in Graber, T. M.: Orthodontics, Principles and Practice, Philadelphia, 1961, W. B. Saunders Company.)

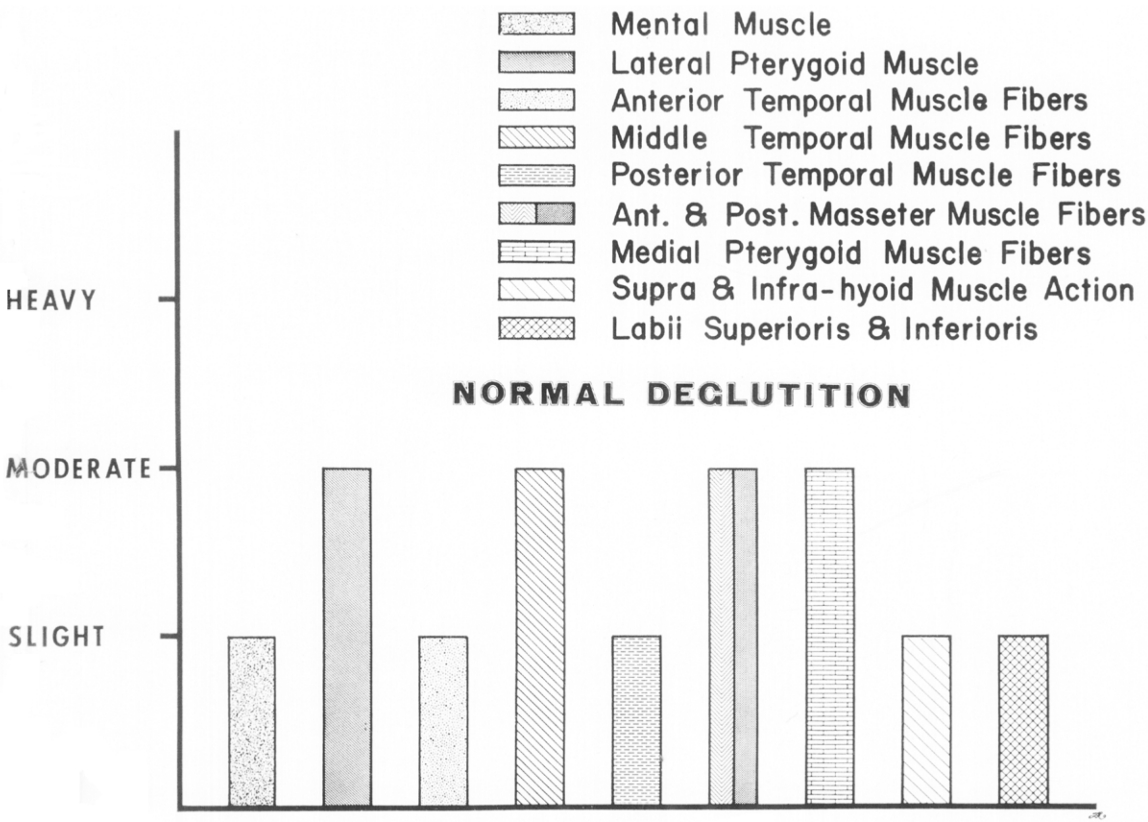

Fig. 14. Bar graph illustrating comparative muscle pressures during the normal swallowing act. Only lateral and medial pterygoid, middle temporalis, and anterior and posterior masseter fibers show moderate activity. The remainder demonstrate slight activity.

the occlusal surfaces of the posterior teeth during postural resting position. Morphologic and functional changes go hand in hand, each augmenting the other. With changes in the tongue, cheek, and lip muscle functions, the net effect is a significant narrowing of the maxillary arch and overeruption of the posterior teeth. Occlusal vertical dimension and postural vertical dimension (OVD and PVD) become one and the same as the interocclusal space is eliminated. A cross-bite condition is frequently created by the bilateral narrowing of the maxillary arch, and the convenience swing or mandibular displacement results in a deflection to one side or the other from the point of initial contact (Fig. 11). The open-bite is accentuated by this "vicious circle" activity. Unless normal activity can be restored and a mature somatic swallowing habit achieved, the malocclusion may well be perpetuated and aggravated until Nature has established a condition of balance with hereditary pattern, basal bone limits, tooth size, contiguous tissue, the functions of mastication, respiration, speech, and posture as well as deglutition, and other as yet unequated factors.[50]

As we have drawn this picture of a developing malocclusion, it is easy to say that the finger-sucking habit caused the malocclusion. This, of course, is

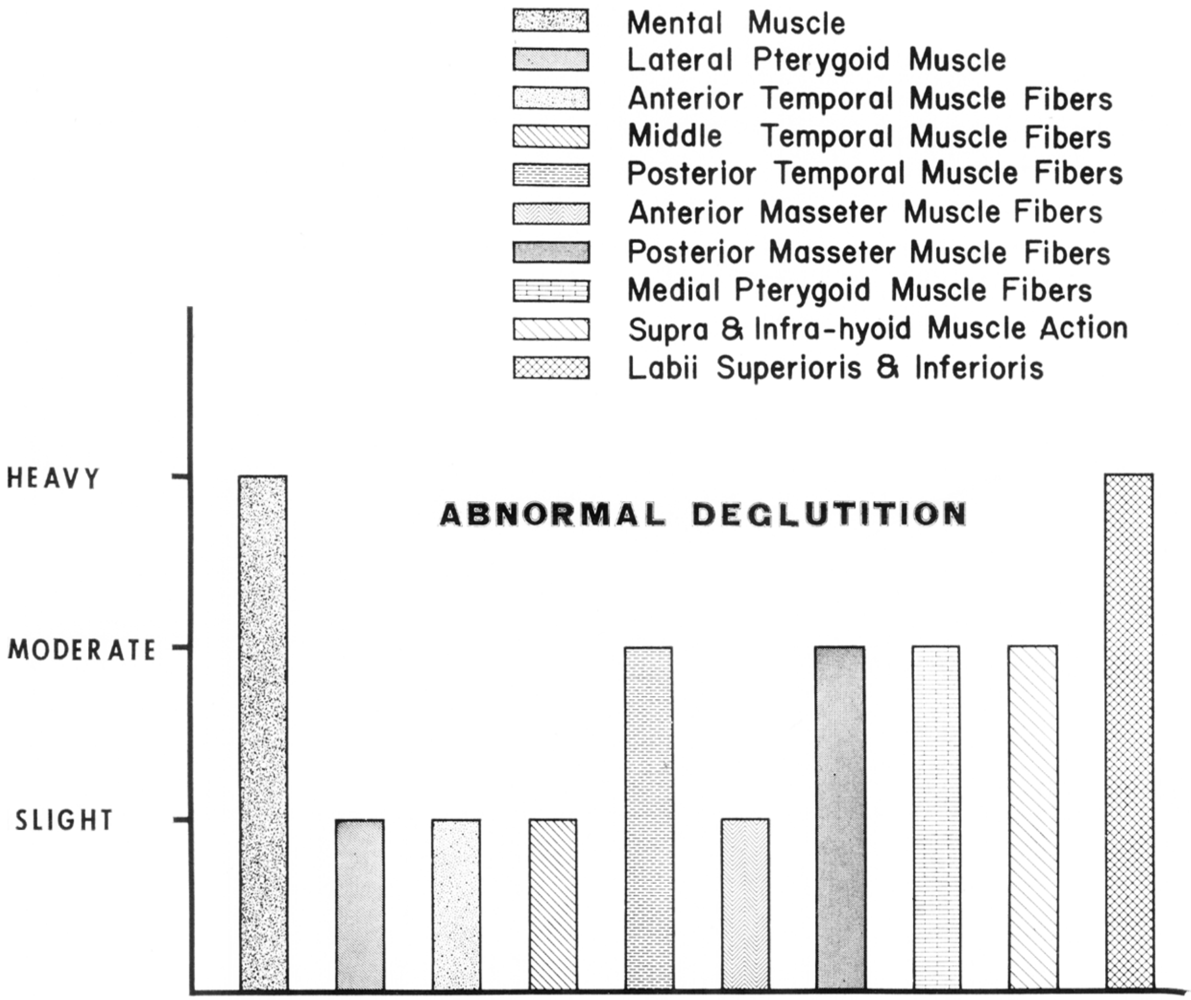

Fig. 15. Bar graph illustrating comparative muscle pressures associated with abnormal swallowing. Note heavy mentalis and lip activity, dominance of posterior temporalis and masseter fibers, and increased hyoid muscle action. (See Fig. 14.)

incorrect. It *is* entirely correct to say that the finger habit was the first assault on the integrity of the dentition and that the adaptive and compensatory activities of the tongue and lip teamed up to provide a much more significant deforming mechanism. Without the original deforming activity by the finger, however, the subsequent lip and tongue action might never have occurred. For this reason, it is considered a good interceptive orthodontic procedure to place an appliance which eliminates the finger habit before the arch is deformed sufficiently to require homeostatic muscle action during deglutition (Fig. 16).

The optimal time for appliance placement is between the ages of 3½ and 4½ years, preferably during the spring or summer when the child's health is at its peak and the sucking desires can be sublimated in outdoor play and social activity. The appliance serves several purposes. First, it renders the finger

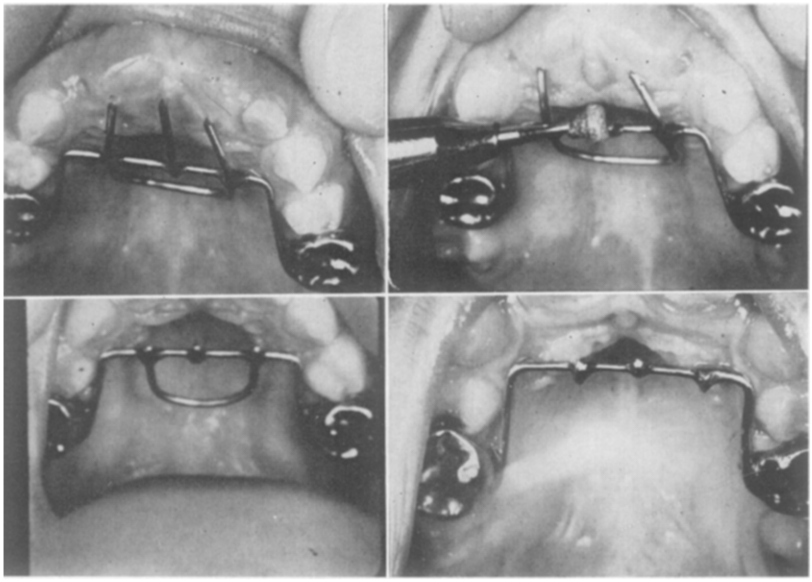

Fig. 16. Interceptive finger-habit appliance. Spurs are bent toward palate; posterior loop extends upward and backward at 45 degree angle. Main palatal bar crosses palate at level of gingival margin. Appliance is removed gradually over a period of 4 to 6 months—spurs first, loop next, and finally remaining bar and crowns.

habit meaningless by breaking the suction. The child may, of course, place his finger in his mouth but he gets no real satisfaction from it. Thus, the finger sucking becomes analogous to coffee without caffeine or cigarettes without nicotine. Great care is exercised to inform both the child and the parents that the appliance is *not* a restrictive measure, that it is used not to prevent anything but merely to straighten the teeth, improve the appearance and provide a healthy "chewing machine." Second, by virtue of its construction, the appliance prevents finger pressure from displacing the maxillary incisors further labially, from creating more damage, and from causing a greater likelihood of abnormal tongue and lip function. Third, the appliance forces the tongue backward, changing its shape during postural resting position from an elongated mass to a wider, more nearly normal tongue. As a result, the tongue tends to exert more pressure on the maxillary buccal segments and the narrowing of the maxillary arch by the abnormal swallowing habit is reversed; the peripheral portions again overlie the occlusal surfaces of the posterior teeth, preventing the overeruption of these teeth. If the patients are normal, healthy children, no unfavorable sequelae are observed except for a temporary sibilant speech defect which disappears while the appliance is being worn or immediately after it is removed.[28]

In more than 600 cases treated in this manner during the past 17 years, not a single case of habit transference has been observed. Psychological aberrations do not occur, psychoanalysts' predictions to the contrary notwithstanding. The appliance is worn for 3 to 6 months and is gradually reduced, the spurs and loop being removed first and finally the bar (Fig. 16).

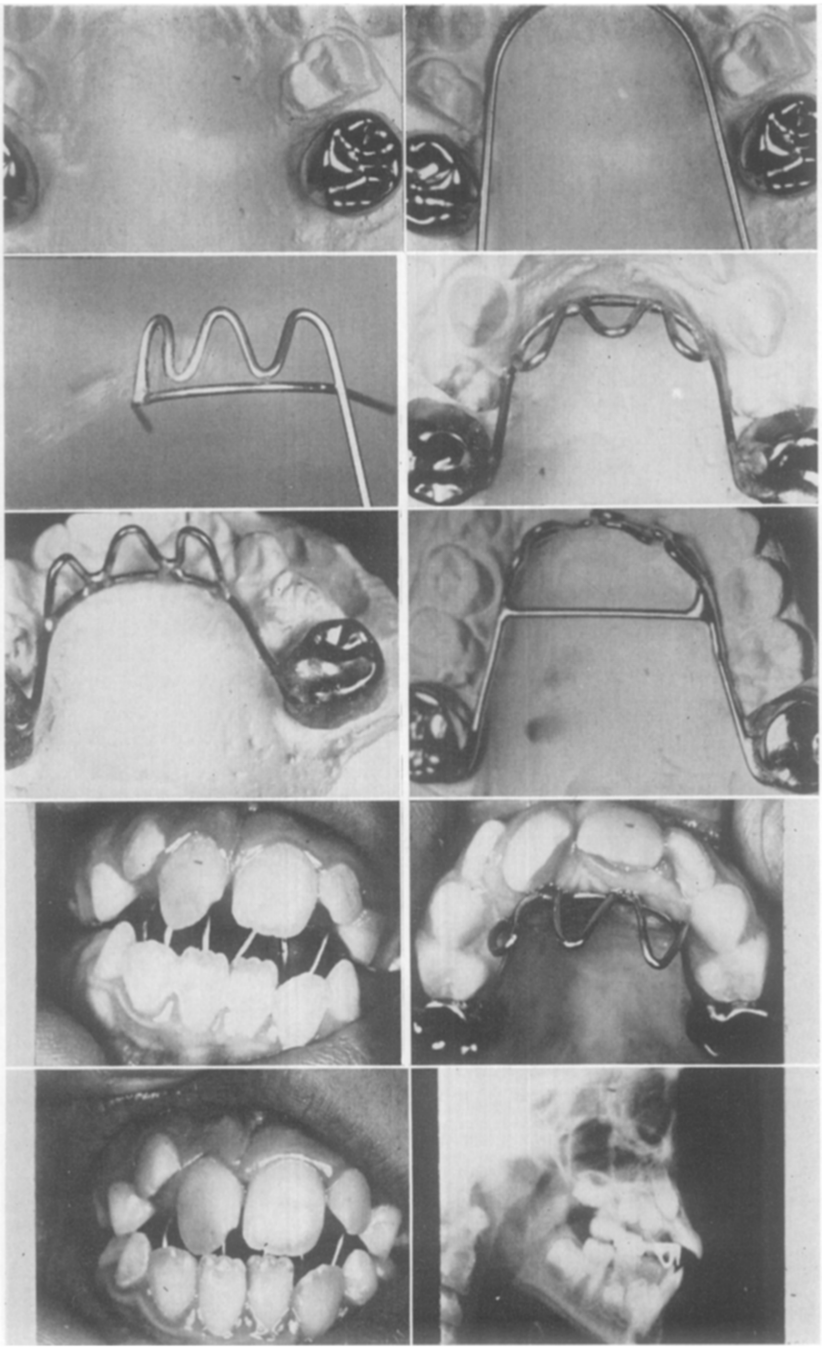

Fig. 17. Tongue-thrust appliance. Full metal crowns are used as abutments on second deciduous or first permanent molars. Lingual bar and loop assemblage of 0.040 inch stainless steel. Palatal bar and V-shaped loops terminate immediately lingual to occluding lower incisors. Care must be exercised so that projections do not impinge on gingivae. Buccal tubes may be added to crowns, anticipating possible need for extraoral force. Tongue crib may be modified by addition of a cross-palatal bar in the first deciduous molar area for patients with severe finger-sucking habits. Intraoral views show bite closure over a 3 week period. Head plate illustrates crib relation to incisors and open-bite.

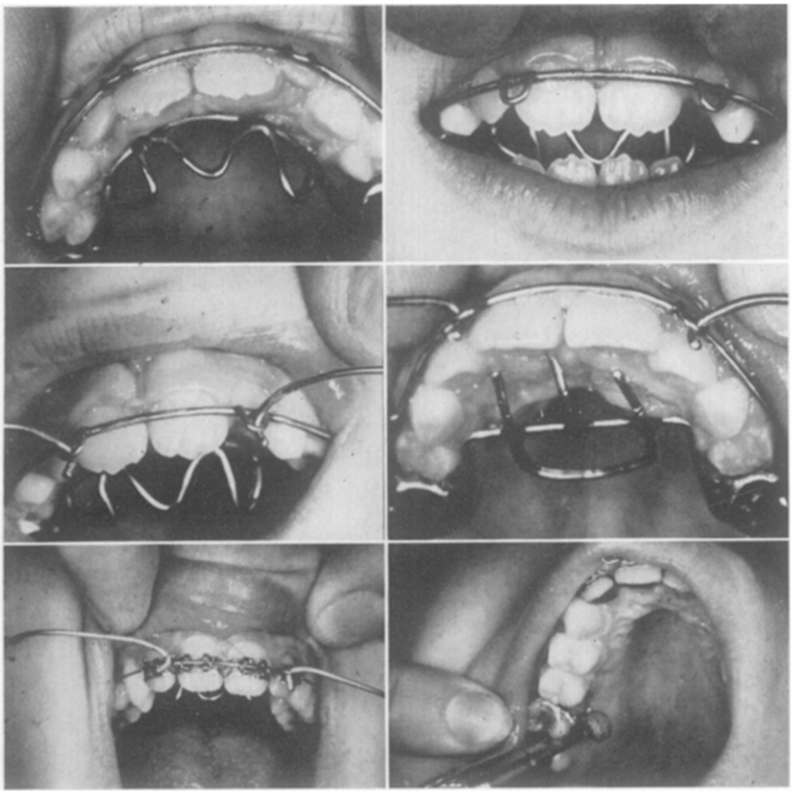

Fig. 18. Tongue and finger appliances incorporating extraoral force auxiliary. If incisors are not banded (and this is usually the case), a 0.040 inch arch wire with vertical spring loops at molars and soldered extraoral arm loops is fabricated. If incisors are banded, cervical anchorage assists in elongating incisors and closing bite. Lingual crib is then cut off and bands are polished down to permit finishing of the case with extraoral force.

If the occlusion has been sufficiently deformed by the finger habit, if a morphogenetic pattern of incisor protrusion has been aggravated by the finger habit to a degree requiring abnormal lip and tongue function of an adaptive nature, or if there is merely a retained infantile tongue-thrusting habit instead of the more mature somatic swallow, a tongue-thrust appliance is used (Fig. 17). Its function and action are similar to those of the finger appliance just described. The main purpose is to prevent the tongue from being inserted into the open-bite 1,200 to 1,600 times a day, as it would be if no appliance were present. The child is encouraged to learn the somatic swallowing habit by crowding back of the tongue and by the change in resting shape. Peripheral portions of the tongue occupy the interocclusal clearance and restore a normal interocclusal space and occlusal vertical dimension in harmony with the postural vertical dimension. The anterior open-bite closes down as the incisors erupt toward each other and as the teeth are molded by the lip action.

The strong action of the tongue working against the appliance may cause the overjet to be increased, and it is good practice to place a simple labial arch and to use cervical extraoral force to reduce the protrusion, thus offsetting the potent tongue force (Fig. 18).

If the open-bite is combined with an excessive overjet and the lower lip has already entered the picture, forcing the maxillary incisors further labially because of hyperactivity of the mentalis muscle, and if a flattening or crowding of the mandibular anterior segment is in progress, a lip appliance is constructed

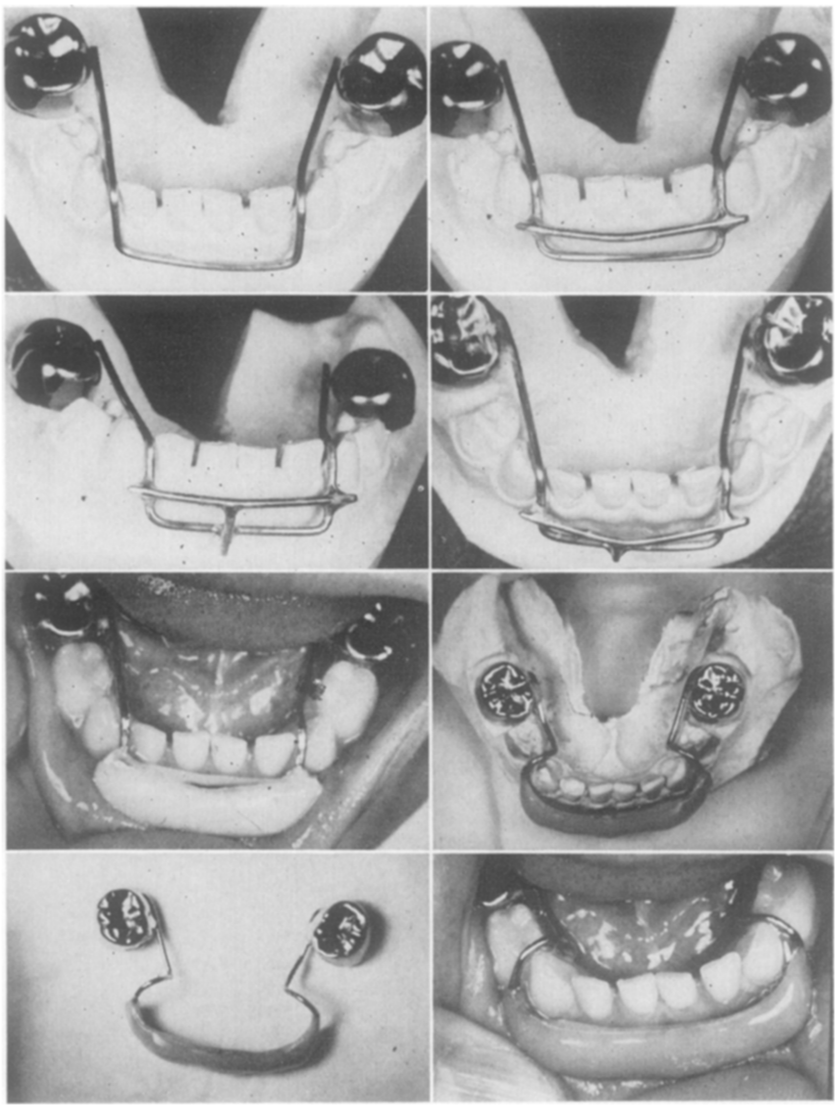

Fig. 19. Lip-habit appliance. A 0.040 inch bar is soldered to full metal crowns on second deciduous or first permanent molars. Bar may cross from lingual to labial either mesial or distal to canine, depending on occlusion and anterior spacing. The operator should be sure that labial assemblage is 2 to 3 mm. anterior to labial aspect of lower incisors. Model is foiled first before endothermic acrylic is adapted to wire framework. Appliance is cemented in place for a period of 3 to 6 months, depending on severity of lip habit and amount of overjet.

(Fig. 19). Usually this type of appliance is not necessary if extraoral force has been employed with the tongue-thrusting appliance. The mere elimination of the excessive overjet usually permits homeostatic changes in muscle function. The lip no longer cushions to the lingual of the upper incisors, and mentalis muscle activity disappears. If the problem is primarily a lip or mentalis muscle condition or a lip-sucking habit, a lip appliance proves effective.

The lip appliance is constructed so that the labial wire and the acrylic mass are sufficiently gingival to the mandibular incisal margin to permit the maxillary incisors to erupt into a normal overbite. Care must be exercised to make sure that the lingual surface of the appliance is at least 2 to 3 mm. labial to the mandibular incisors so that the tongue may move these teeth forward into a normal arc and contact relationship. This is necessary to re-establish the integrity of the lower anterior segment and reduce the horizontal overjet. The goal of therapy is to permit the mandibular incisors to move far enough labially and the maxillary incisors to drop far enough lingually to eliminate the excessive overjet and the space provided for abnormal lip action. Hyperactive mentalis muscle function will not disappear until excessive overjet is eliminated. The lip appliance is worn for 6 to 12 months, depending on the severity of the problem. Because of the obvious leverage problems and the forces working against the wire framework, regular orthodontic bands are usually inadequate. Full metal crowns serve as excellent abutments for these habit appliances, and they are easy to place. There is no need to grind down the occlusal surfaces of either the teeth or the crowns, since the open-bite created by the placement of these crowns quickly closes down within a week.

CLASS II, DIVISION 1 MALOCCLUSION

In contrast to Class I malocclusions, in which muscle function is usually normal (Fig. 1), with the exception of open-bite, the majority of Class II,

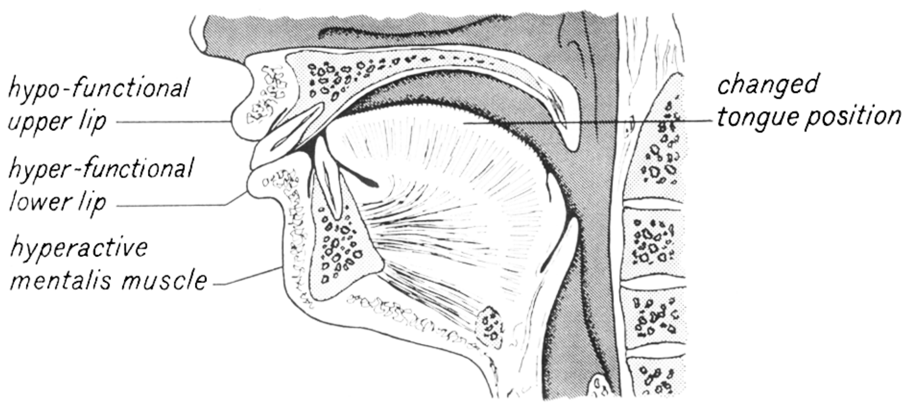

Fig. 20. Sagittal section illustrating Class II, Division 1 relationship. Compare with Fig. 1. Note lowered tongue posture, elongated functional position, narrowed buccal dental segments in maxillary arch, and lower lip cushioning to lingual aspect of maxillary incisors during rest and active function. Lip and tongue team up to accentuate deformity. (After Lischer, B. E., in Graber, T. M.: Orthodontics, Principles and Practice, Philadelphia, 1961, W. B. Saunders Company.)

Division 1 malocclusions do involve abnormal muscle activity in the beginning (Fig. 20). In Class II, Division 1 therapy, a change in muscle function *is* a requisite; expansion *is* a treatment objective. With a hereditary type of Class II malocclusion, the teeth merely reflect the abnormal anteroposterior jaw relationship, and the excessive overjet is a consequence. If we apply the same logic and the lessons that we learned in our analysis of the development of open-bites in Class I malocclusions, it is easy to see why compensatory and adaptive muscle activity of an abnormal nature will enhance and perpetuate the Class II malocclusion.[34] The finger-sucking habit or the retained visceral swallowing pattern is not a prerequisite to establishment of a favorable environment for abnormal muscle activity.[13] If a structural malrelationship exists, the muscle function adapts to this pattern as best it can in line with the requirements of mastication, deglutition, respiration, and speech. The lower lip cushions to the lingual of the maxillary incisors, both at postural rest and during active function (Fig. 13). In some instances a lip-sucking habit develops, with the lower lip mass almost constantly thrust into the excessive overjet. The lip itself may become hypertrophic as a result. The maxillary incisors move further labially, weakly resisted by a hypotonic and relatively functionless upper lip (Fig. 8). The lower incisors buckle as the mandibular segment is flattened by continuously abnormal mentalis muscle activity. The curve of Spee increases. With the compensatory tongue-thrust, lower tongue position, and increased buccinator muscle activity, the maxillary arch narrows and assumes the V shape so often associated with Class II, Division 1 problems. Thus, the picture is similar to the open-bite problem just described in Class I malocclusions.[6] Open-bite occurs in Class II malocclusions also, but it was described previously to emphasize the fact that it can occur despite a normal jaw relationship. Abnormal muscle activity can thus create a pseudo Class II, Division 1 malocclusion, even with harmonious anteroposterior jaw relations. A difference in true Class II, Division 1 problems is that the morphology and jaw relationship are abnormal to begin with and muscle activity has only accentuated an existing pattern. In Class I open-bite and in pseudo Class II, Division 1 malocclusions, abnormal finger, tongue, and lip activity initiated the morphologic changes which, in turn, called on further abnormal muscle activity to meet functional demands and to compensate for the structural changes.

Orthodontic treatment of Class II, Division 1 malocclusions should be directed first toward the creation of a normal basal bone relationship which permits the muscles to function properly. The establishment of a normal anteroposterior jaw relationship, eliminating the excessive overjet and overbite conditions which have fostered adaptive muscle function, permits normal muscle activity.[43] No longer is excessive buccal muscle pressure exerted on the posterior segments.[1] Expansion of the buccal segments and an increase in maxillary intercanine width occur autonomously or can be accomplished by means of orthodontic appliances. In line with our initial appraisal of the three-dimensional character of the muscle problem, this type of expansion is essential and quite stable after the removal of all appliances. Electromyographic research strongly substantiates this analysis.[2, 15]

CLASS II, DIVISION 2 MALOCCLUSION

The precise role of the musculature in Class II, Division 2 malocclusion is more difficult to establish. A hereditary pattern for the specific malocclusion characteristics seems the predominant consideration. Activity of the cheek and lip muscles is usually normal, contrary to Division 1. There is some evidence to support the contention that the tongue at least tends to accentuate the excessive curve of Spee and that it interferes with the eruption of the posterior teeth by occupying the interocclusal space (Fig. 21). If this is indeed true, the condition would tend to increase the interocclusal clearance—and it is a fact that in most cases of Class II, Division 2 malocclusion there is an excessive interocclusal space. Because of the lingual inclination of the maxillary central incisors, combined with the excessive interocclusal clearance and the infraclusion

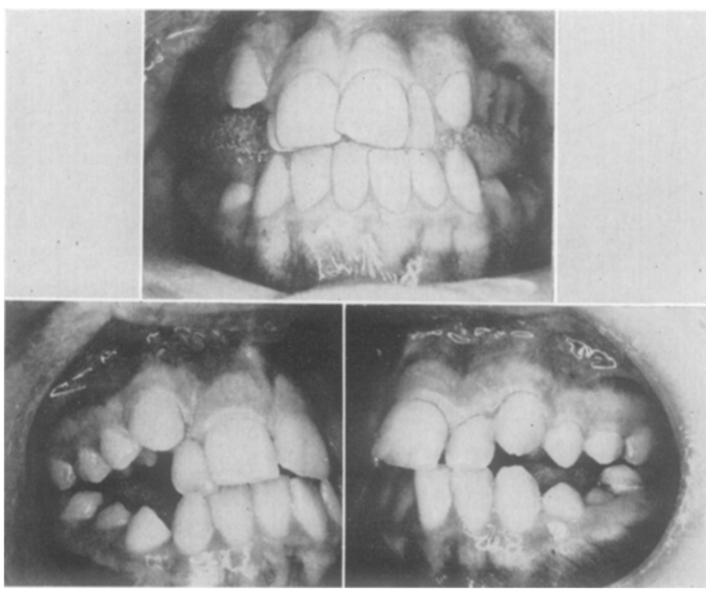

Fig. 21. Atypical Class II, Division 2 malocclusion showing lateral tongue-thrust. To a lesser degree, lateral tongue-thrust may be a factor in other Division 2 cases. (From Mayne, Warren, in Graber, T. M.: Orthodontics, Principles and Practice, Philadelphia, 1961, W. B. Saunders Company.)

of the posterior teeth, functional guidance of the mandible is quite common (Figs. 3 and 22). The mandible closes from postural resting position to the point of initial contact. The lingually inclined maxillary incisors then guide the mandible into a retruded position during the balance of the closing movement to full occlusal contact.[39] Electromyographic research shows that there is a compensatory muscle activity, with dominance of the posterior fibers of both temporalis and masseter muscles from the initial contact position to the position of habitual occlusion (Fig. 23). The posterior-fiber dominance is eliminated by properly guided orthodontic therapy which restores an occlusal vertical dimension that is in harmony with the postural vertical dimension, thus eliminating the "forced retrusion" phenomenon.

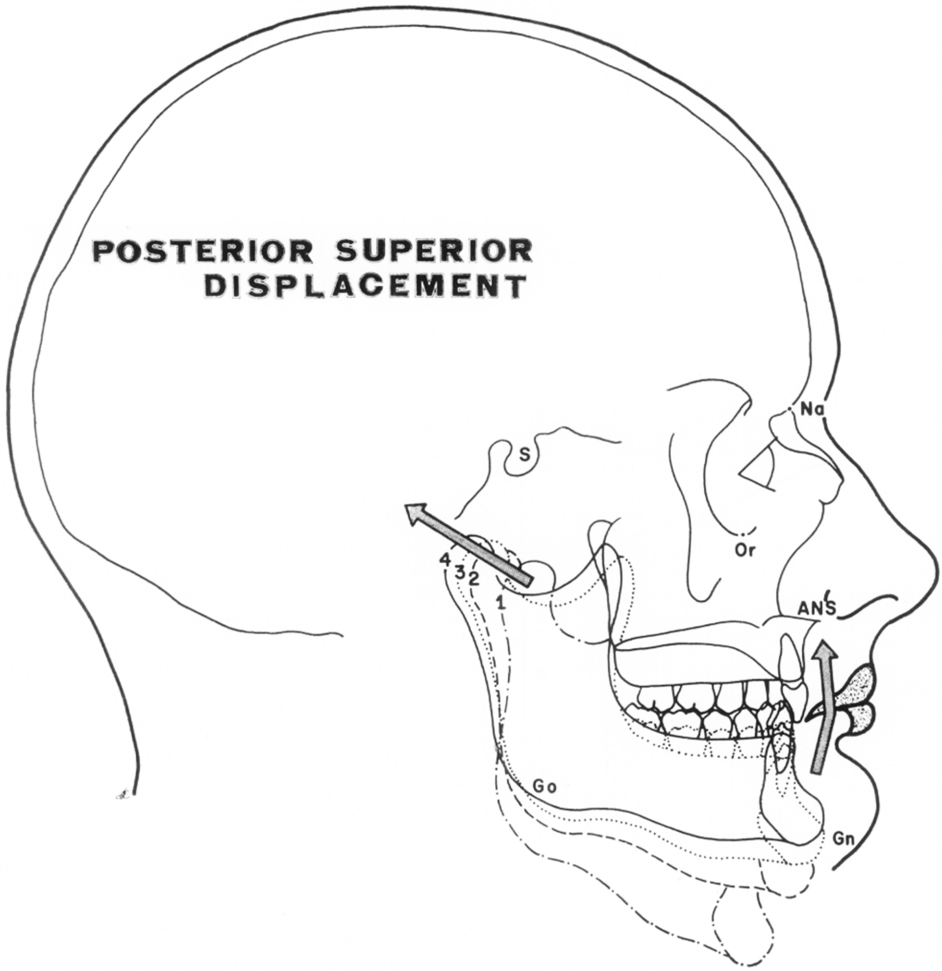

Fig. 22. Functional mandibular retrusion seen most commonly with a Class II, Division 2 malocclusion. Note overclosure and tooth guidance. *1*, open-mouth position; *2*, postural resting position; *3*, initial contact; *4*, habitual (retruded) occlusal position. With overclosure, the prospect is for reduced strength of muscle contraction and possibly reduced masticatory efficiency. (See Fig. 5.)

It is with tooth-guidance problems particularly, such as those encountered in Class II, Division 2 malocclusions, that temporomandibular joint problems arise,[11, 29] with clicking, crepitus, pain, and other vague but disturbing complaints. Posselt[39] graphs the distribution (Fig. 24) and frequency (Fig. 25) of symptoms in 731 patients by combining the studies of Söderberg,[45] Staz,[46] Lindblöm,[35] Hankey,[27] and himself.[38] In the truest sense, temporomandibular joint disorders may also be considered muscle problems. From such nonhomeostatic phenomena as the inability of muscles to adapt to morphologic variation and changing functional demands, their selective activity as shown by electromyographic research, their occasional disregard for proprioceptive warnings of the reflex arc, and their occasional trismic or uncoordinated response to these stimuli comes the temporomandibular joint symptomatology.

CLASS III MALOCCLUSION

In Class III malocclusion, as in Class II, Division 1, we are dealing with a dominant bone dysplasia, with adaptive muscle function and tooth irregularities reflecting a severe basal dysplasia. All three systems—bone, teeth, and muscles—are involved. Here again, there is a strong hereditary pattern. The upper lip is relatively short, though not necessarily hypotonic. The lower lip is hypertrophic and redundant and appears to be relatively passive during the deglutition cycle (Fig. 26). During swallowing, there is actually a greater activity of the upper lip. The tongue is a potent force, although it is not clear whether the tongue mass or tongue function is the basis for the lingual "cupping out" beneath the mandibular teeth. The tongue does appear to lie lower in the floor of the mouth. Since the maxillary arch does not have the balancing effect of tongue

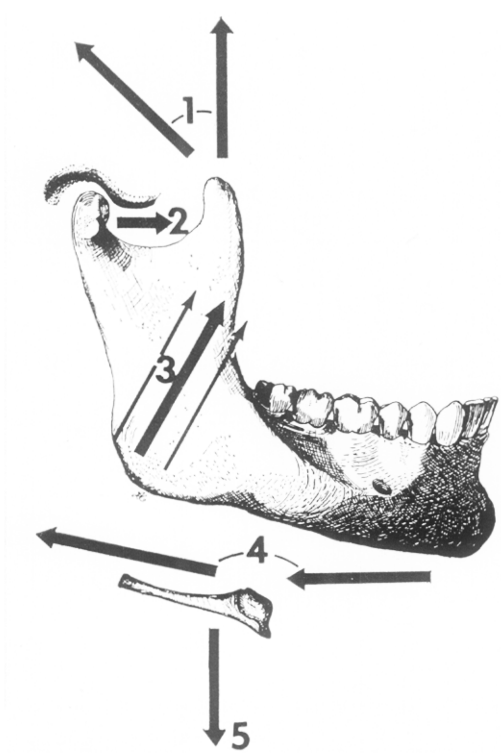

Fig. 23. Muscles primarily responsible for mandibular functional movements. *1*, Anterior and posterior fibers of temporalis; *2*, lateral pterygoid; *3*, anterior, middle, and posterior components of masseter; *4*, suprahyoid; *5*, infrahyoid. Medial pterygoid not shown. In forced retrusion, electromyographic records show a dominance of posterior temporalis, posterior masseter, and posterior suprahyoid muscles. Resistance to posterior condylar displacement by the lateral pterygoid muscles (*2*) is apparently insufficient, since primary function is that of opening, not closing, and secondary stabilizing assignment on closure can result in excessive forward movement of the articular disc on maximum contraction. (After Posselt, U.: The Physiology of Occlusion and Rehabilitation, Philadelphia, 1962, F. A. Davis Company.)

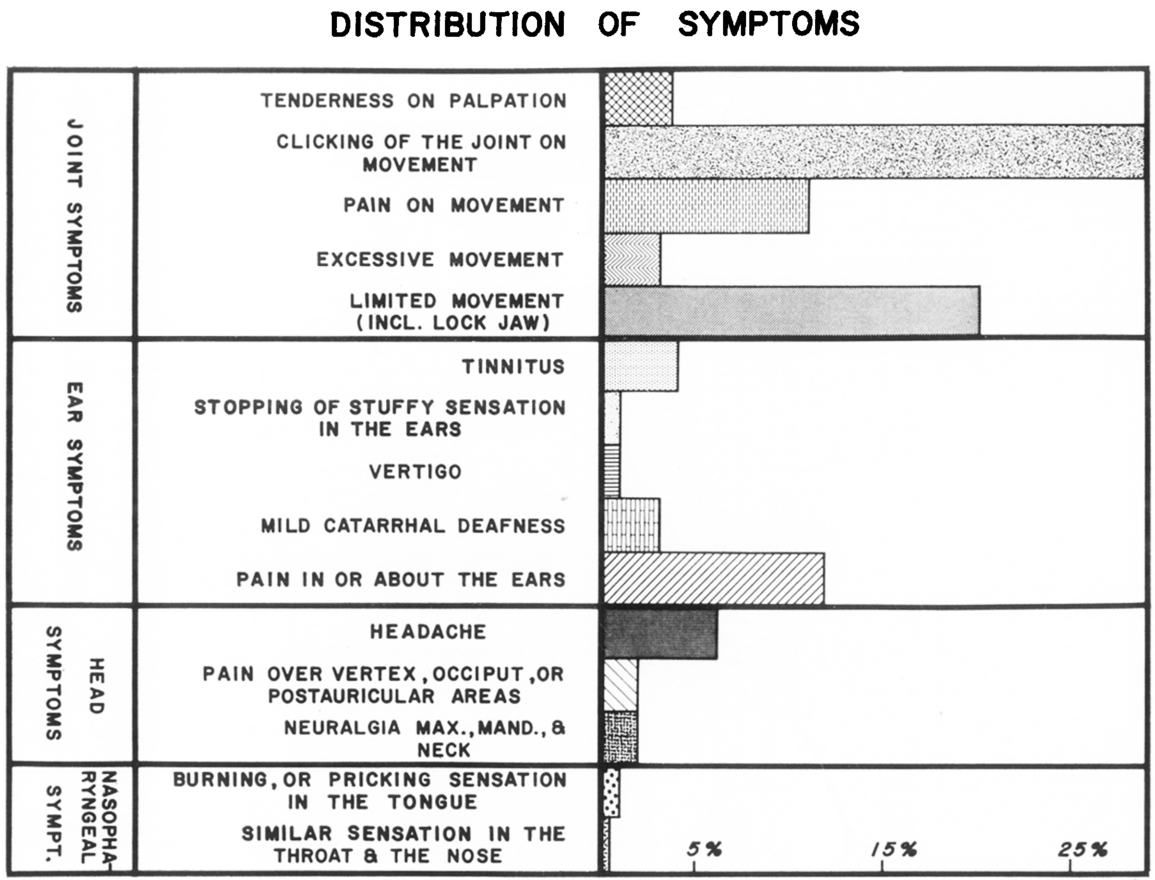

Fig. 24. Distribution of temporomandibular joint symptoms based on a compilation of studies by Söderberg,[45] Staz,[46] Lindblöm,[35] Hankey,[27] and Posselt.[38] The sample consists of 731 patients. Clicking is included only in conjunction with other complaints, not when it is the sole symptom. (From Posselt, U.: The Physiology of Occlusion and Rehabilitation, Philadelphia, 1962, F. A. Davis Company.)

mass, and since the peripheral portions of the tongue are less apparent between the occlusal surfaces, the maxillary arch is usually narrow and the interocclusal space is either very small or entirely absent. During the deglutition cycle, there is greater mobility of the hyoid bone as the suprahyoid and infrahyoid muscles demonstrate greater activity.

It is difficult to assess how much of the muscle activity is homeostatic, compensatory, or adaptive to the structural malrelationship and how much of it

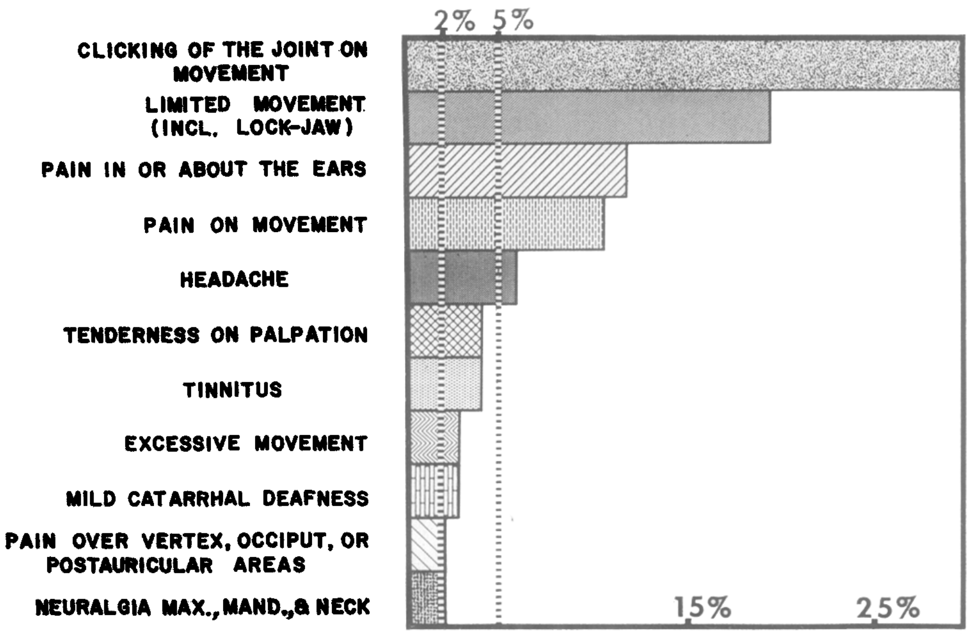

Fig. 25. Frequency of symptoms listed in Fig. 24. (From Posselt, U.: The Physiology of Occlusion and Rehabilitation, Philadelphia, 1962, F. A. Davis Company.)

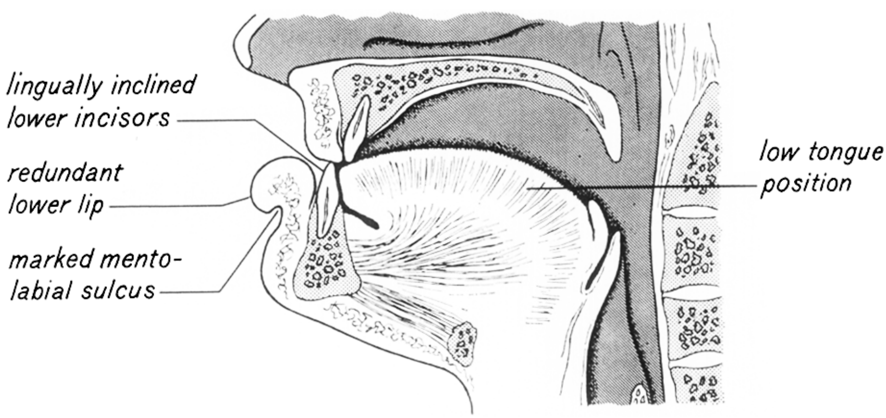

Fig. 26. Tongue and lip adaptation to Class III malocclusion. Relatively functionless lower lip is in marked contrast to excessive activity associated with Class II, Division 1 malocclusion. Lower tongue position is similar, but with no anterior thrust on deglutition. Greater upper lip activity is in evidence in the attempt to ''close off'' during swallowing.

is in itself due to morphogenetic pattern. Very probably, depending on the case, the proportions vary. As in the Class I and Class II malocclusions, the three-dimensional character of the muscle problem is again emphasized. Muscle forces are a significant factor of vertical, lateral, and anteroposterior dimensions.

SUMMARY

An analysis has been made of muscles and their relationship to structural configuration in Class I, Class II, and Class III malocclusions. The effect of muscle forces is three-dimensional, although most orthodontists have considered it only in one vector—that of expansion. Whenever there is a struggle between muscle and bone, bone yields.[5] Muscle function can be adaptive to morphogenetic pattern. A change in muscle function can initiate morphologic variation in the normal configuration of the teeth and supporting bone, or it can enhance an already existing malocclusion. In the latter instance, the inherent structural malrelationship calls for compensatory or adaptive muscle activity to perform the daily functions. The structural abnormality is increased by compensatory muscle activity to the extent that a balance is reached between pattern, environment, and physiology. At times it is impossible to assign a specific cause-and-effect role to any one factor. It is imperative that the orthodontist appraise muscle activity and that he conduct his orthodontic therapy in such a manner that the finished result reflects a balance between the structural changes obtained and the functional forces acting on the teeth and investing tissues at that time.

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