Equilibrium Theory Revisited: Factors Influencing Position of the Teeth

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It has been fifteen years now since Weinstein et al. in their paper entitled "On an Equilibrium Theory of Tooth Position" attempted to put the equilibrium theory of tooth position on a sounder scientific base.[1] This paper is presented with the same objective. It represents an attempt to review the considerable amount which has been learned during the past fifteen years, and to place equilibrium into perspective for practicing orthodontists.

The views of the dental equilibrium which have prevailed at different points in time have made a great deal of difference in the day-to-day practice of orthodontics. Malocclusion of the teeth and the broader spectrum of dentofacial deformity is due, of course, to an interplay between innate genetic factors and external environmental factors. The environment of the teeth and alveolar bone includes conflicting forces and pressures, primarily from muscular function, which in part determine tooth position. The more important these forces on the teeth are conceived to be, the more one takes an environmentalist view as far as the cause of malocclusion is concerned. The more one believes in inherited causes for malocclusion, the less attention he is likely to pay to the environment of the dentition. These different viewpoints go to the heart of the major diagnostic decision which is required in orthodontic practice, whether or not to extract some permanent teeth to properly align the others. Edward Angle believed that the environment of the dentition was a major cause of malocclusion, and that it was possible to produce a stable ideal occlusion without extraction of teeth because the environment could be modified by orthodontic treatment. It is well-known now that extraction of teeth is required in some cases, but the percentage of extraction cases varies greatly among orthodontists. That percentage reflects more than anything else a judgment as to the importance of modifiability of the equilibrium of environmental forces around the dentition.

There can be no doubt that there is an equilibrium. By definition, an equilibrium exists when a body at rest is subjected to forces in various directions, but is not accelerated. This requires that the opposing forces be balanced so that their resultant is zero. Such a description applies to the teeth, which are subjected to a variety of forces in multiple directions, yet remain stable (most of the time) in their positions in the dental arch. During mastication, not only do the teeth move slightly, but the alveolar bone and the basal bone of maxilla and mandible bend and flex. These changes occur in a matter of seconds, and the teeth and jaws are restored to their original positions as quickly as they were displaced. Whether the time span of observation is in minutes, hours or days, the teeth are stable despite the considerable forces exerted against them. Natural dentitions are stable over a time span of years after growth is completed. Orthodontic appliances produce changes in a time span measured best in days. These orthodontic movements are clearly different from the natural situation and are eloquent testimony that the appliance alters an equilibrium situation.

Angle felt that relapse after orthodontic treatment was due to forces on

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the teeth resulting from an improper environment. It is difficult even today to disagree with that view. As the French molecular biologist Jacob quotes an earlier physicist, however, there is always a desire in science to "explain the complicated visible by some simple invisible."[2] Tongue pressure, lip pressure, pressure from erupting third molars—all make nice "simple invisible" causes for orthodontic relapse. Unfortunately, the simple explanations have a way of being wrong at worst and misleading at best. Harold Frost proposes an interesting test: "When one truly understands how a given system works, it can be treated or intentionally manipulated with predictable success 98 times out of 100. If this cannot be done, then in spite of elaborate conceptualizations and verbalizations of the mechanism, (the system) is not adequately understood."[3] By that standard we are improving but still well short of understanding the dental equilibrium system.

In this presentation I plan first to consider the primary factors in the dental equilibrium, that is, the factors which directly create the equilibrium; second, to examine significant influences on the primary factors, and consider their modifiability; and finally, to summarize briefly by reviewing the probable importance of all these environmental factors as compared with inherited or innate characteristics in the etiology of malocclusion.

Primary Factors in Equilibrium

Four major primary factors in the dental equilibrium can be identified at present. There may be others, but it is likely that any other possibilities are special cases of these four. The four primary factors are:

1. Intrinsic forces by tongue and lips
2. Extrinsic forces: habits (thumb-sucking, etc.), orthodontic appliances
3. Forces from dental occlusion
4. Forces from the periodontal membrane.

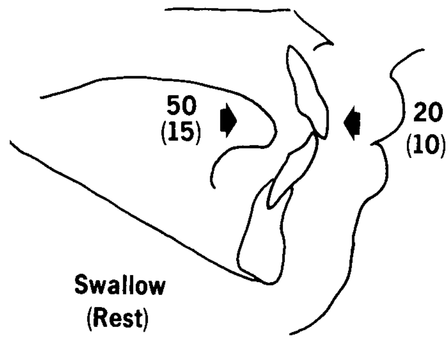

Fig. 1 Diagrammatic representation of tongue and lip pressures during swallowing and at rest. In both instances tongue pressure is greater than lip pressure with the usual ratio of tongue to lip pressure shown here.

Intrinsic Forces: Tongue Versus Lips

Since the teeth are positioned between the lips and cheeks on one side and the tongue on the other, the opposing forces or pressures from these organs should be major determinants of the dental equilibrium. In fact, many observers have concluded that the equilibrium is defined solely by opposing tongue and lip pressures. Diagrams can be found in current texts showing the incisor teeth positioned between the tongue and lips with arrows indicating precisely balanced opposing forces. Results from studies with modern electronic instrumentation indicate that this simplistic view of the equilibrium situation is incorrect (Fig. 1).

Even a superficial consideration of the dental equilibrium requires that a distinction be made between the *amount* of force generated against a tooth and the *duration* of force application. The first satisfactory electronic instrumentation for studying tongue and lip pressures became available at the height of orthodontists' enthusiasm for tongue thrusting as an etiological factor for malocclusion. That wave of enthusiasm was triggered by Walter Straub in the 1950's after he had decided from clinical observation that incorrect swallowing was a major cause of anterior open bite and incisor protrusion.[4] It seemed logical that patients who swallowed incorrectly should have protruding incisors or open bite because of different tongue and lip pressures. When pressures were studied, however, it quickly became apparent that tongue and lip pressures during swallowing varied greatly among individuals and did not correlate well at all with the position of the teeth. Furthermore, tongue and lip pressures during swallowing never balanced. The early investigators quickly noted that tongue pressures during swallowing always are several times higher than the lip or cheek pressures which should balance them. The logical next step is to think immediately of time as a variable, and to see if longer duration of lip pressures supplies the presumed balance. Again, the answer is no. When time-pressure integrals are compared (the areas under pressure curves), tongue and lips come closer to balance, but tongue pressure is still considerably greater than lip pressure. There is no balance of pressures for swallowing.[5]

Reasoning that other activities contributed to the over-all balance, Lear and Moorrees attempted to sum up opposing tongue and lip forces over a four-hour period and project them to twenty-four hours using a log of the subjects' activities.[6] This twenty-four hour summary of tongue and lip pressures brought the figures closer to equilibrium, but a considerable imbalance of total tongue and lip pressures still was observed in subjects with a stable dentition.

The dental apparatus is well-adapted to resist short-acting forces such as those generated during chewing, speaking and swallowing where the duration of force application is typically one second or less. Would a balance be observed if all short-duration forces, not just forces from mastication, were disregarded? Then only resting pressures of tongue and lips would be considered as factors in the equilibrium. This was and is a most reasonable suggestion, yet resting pressures do not balance.[7] Brader cleverly suggested that the geometric radius of curvature might supply the missing link, and that if resting pressure plus radius of curvature were taken into account, a constant relationship would be seen.[8] This, too, has not proved to be the case for individual patients.[7] The result of all these investigations is overwhelming evidence that the equilibrium defining tooth position is not determined solely by the opposing forces of tongue and lips. Other factors must be taken into account.

Extrinsic Forces: External Pressure Habits and Orthodontic Appliances

Insight into the importance of force duration in moving teeth can be gained from considering the effect of externally applied forces. All clinical orthodontics is based on moving teeth by deliberately altering the force equilibrium on the dentition. Teeth can be moved effectively by a force of only a few grams provided that the force is maintained continuously. Too much force is destructive, but a relatively wide range of orthodontic forces can be effective if the duration is long enough. The duration of force is a more critical variable in orthodontic treatment than force magnitude. The same is true for external pressure habits, such as thumbsucking. The greater the duration of the habit, the greater its impact on the teeth is likely to be. For both orthodontic appliances and habits, durations must be measured in hours per day to produce significant changes in tooth position.

Extrinsic forces can be quite effective when their duration approaches fifty percent of the time, and some impact apparently can be produced by durations of only a few hours. Below that, no effects are observed. By analogy, resting pressures of tongue and lips have durations which are entirely consistent with importance in equilibrium; but short-acting pressures during speaking and swallowing should be discounted because the total duration of these pressures is a few minutes per day.

To this point the discussion has related largely to tooth position in the anterior-posterior and transverse planes of space. What about the vertical plane of space? Vertical tooth position certainly can be influenced by environmental factors. In fact, the clinical problems which are usually cited as related to environment have a strong vertical component. Tongue, lips and extrinsic forces are possible influences on vertical positions of the teeth. Other factors which come to mind immediately are forces of occlusion and forces of eruption. This will be discussed below.

There is clear evidence that sucking habits in children are strongly correlated with anterior open bite.[9] Despite the common belief among orthodontists that the tongue activity in swallowing is an important cause of open bite, little experimental work has been done on tongue and lip pressures as determinants of vertical position of teeth. Studies by Wallen[10] indicate that vertically directed pressures during swallowing actually are less in patients with anterior open bite than in patients with normal vertical relationships (Fig. 2). If the tongue pressures were greater in the open bite patients than in the normal occlusion patients, it would be easy to understand how the tongue was pre-

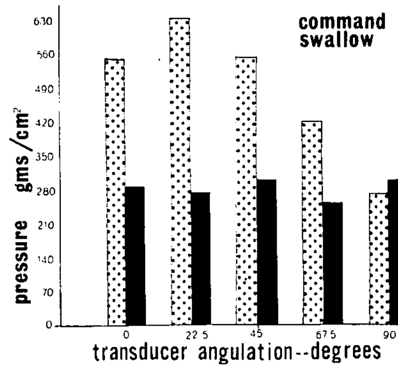

Fig. 2 Comparison of tongue pressures during swallowing in patients with anterior open bite (solid bars) and patients with normal occlusion (dotted bars). A variable angle pressure transducer was mounted so that pressures could be recorded perpendicular to the long axis of the maxillary central incisor (90°), parallel to the long axis (0°), and at intermediate angles. Note that the normal subjects had considerably more vertically directed tongue pressure than the open bite subjects, all of whom created an anterior seal by placing the tongue between the anterior teeth against the lower lip (from Wallen[10]).

venting eruption. If the pressures were the same in open bite or normal occlusion, one could say that the teeth were being impeded by this pressure and held at a higher level. But the data show, not higher or equal pressures, but consistently lower pressures. It appears that the relatively high position of the incisors keeps the tongue from contacting them quite so much during swallowing. This does not support the idea that tongue placement during swallowing causes open bite. Certainly forward tongue position during swallowing, which usually is called tongue thrust, is associated with open bite, but it seems more likely to be effect than cause. There are many possible causes of open bite. As we will discuss below, jaw posture, occlusal forces, and eruption forces from the periodontal membrane must be considered. Resting tongue and lip pressures might logically affect the vertical position of teeth, just as they affect positioning in other planes of space. There is no reason to attach special importance to tongue pressures during swallowing except that an unusual tongue position in swallowing may also indicate an altered resting posture.

Forces from Dental Occlusion

The attachment apparatus of all teeth is an effective hydrodynamic damping system, like an automobile shock absorber, and is well-designed to withstand occlusal forces. If teeth did reposition themselves in response to occlusal forces, it would not be necessary for dentists to be so careful with occlusal relationships. The teeth would make minor corrections for themselves. This does happen just after the completion of orthodontic treatment, when the teeth are hypermobile and the attachment apparatus is reorganizing. Otherwise, it is common experience that teeth remain in positions of traumatic occlusion rather than moving away from the offending occlusal contacts.

Despite the mechanism to dissipate short-duration occlusal forces so that teeth do not permanently intrude or move buccally or lingually because of occlusal forces, occlusal forces can be important in equilibrium related to vertical tooth position. The vertical position of the teeth is determined by a balance between the forces which oppose eruption and those which promote it. Occlusal forces have an influence related to this.

From numerous studies of occlusal forces it is known that a maximum force of one hundred kilograms or more, sustained for only a fraction of a second, can be exerted against a single tooth during occlusion. Forces exerted against artificial teeth, particularly if complete dentures are worn, are only a fraction of forces against the natural dentition.[11] Evaluation of the force of occlusal contact has been hampered, even in the era of modern electronic instrumentation, by the thickness of the force measuring devices. If the pressure measuring devices used for evaluating tongue and lip pressures can be kept under two millimeters or so in thickness, errors in evaluating lip forces are minimal.[12] The potential for error in measuring tongue pressures is less easy to identify, but appears to be about the same as for lips. Because occlusal forces are much heavier, instruments to evaluate them have had to be several millimeters thick. Placing an object this large between the teeth does introduce significant changes. Until recently, the only way around this was to use subjects who had at least one missing tooth, so that the force measuring instrument could be placed in the space like a bridge pontic.[13] As a result, little information is available as to how occlusal forces vary according to type of malocclusion, vertical dimension of the face, and other important orthodontic variables. It has not been possible to study subjects with an intact natural dentition.

During the past year we have been able to fabricate a new type of occlusal force transducer in our laboratories at North Carolina.[14] The active element is a piezoelectric film (polyvinylidine fluoride) which has the property that its electrical characteristics are altered as the internal structure is distorted by force application. The foil is only 0.1 mm in thickness, less than the thinnest articulating papers. Although protective coatings must be added to make a satisfactory occlusal force measuring device, the total thickness can be held under 0.5 mm. Only preliminary data for a few subjects are available as yet, but it is clear that a very thin occlusal force transducer can be manufactured satisfactorily. We anticipate interesting data on occlusal contact characteristics of various types of patients in the near future. Is a reduction in biting force, which allows more eruption of posterior teeth, one factor in producing an open bite? No one knows, but now it is possible to test such an hypothesis.

In patients who have lost their natural teeth, the resting position of the mandible is determined independently of the vertical level of replacement teeth. It is critically important for the prosthodontist to accurately evaluate and determine a rest position compatible with placement of denture teeth. Although there may be several compatible positions for any patient, there is a limit of jaw opening which will be tolerated. For a long time this prosthodontic concept was applied uncritically to the natural dentition. It is now known that changing the vertical level of the natural teeth can cause an alteration in rest position of the mandible. If the molar teeth are extruded by orthodontic forces, the mandible will rotate downward and backward as the occlusal contact and rest positions change. Once a natural tooth has erupted or been extruded, the musculature adapts to its position. Similarly, if the maxillary posterior teeth are intruded surgically, the mandible will rotate closed, and a new rest position as well as occlusal position is observed. These changes may be mediated by proprioceptors in the periodontal membrane, although there is no direct evidence as to the mechanism. How mandibular positioning during growth influences eruption and the final vertical position of the teeth remains entirely unknown. Occlusal forces during growth probably play a significant role.

Forces From the Periodontal Membrane: Eruption Forces

Despite intensive continuing investigations, the cause of eruption of the teeth remains unknown. In some way an eruption force is generated which moves a tooth through bone and continues to move it after it has broken into the oral cavity. The eruptive force remains active after a tooth has come into occlusion and function has been established. Eruption continues along with vertical growth of the face. A maxillary first molar typically erupts for a centimeter or more between age six when it first comes into occlusion and the time in the late teens when vertical jaw growth ends. If its antagonist is extracted, any tooth may erupt again years after its vertical position apparently was stable, indicating that the eruptive mechanism remains intact and capable of generating forces which can move a tooth.

Although many theories to account for tooth eruption have been proposed, they can be divided into three major groups: 1) theories based on cell proliferation at the root apex; 2) theories based on blood pressure-blood flow differentials in the periodontal membrane; or 3) theories based on metabolic changes in the periodontal membrane, usually involving collagen polymerization.[15] Experimental manipulation of these variables is difficult because of the small forces and slow rates of tooth eruption. The weight of present evidence indicates that eruptive forces are generated in the periodontal membrane rather than at the root apex, but exactly how remains unclear.

In our laboratory at UNC we have also made progress in the past year toward developing electronic instruments which will allow changes in eruptive force and rate to be studied in short-term experiments[16] so that the effect on eruption of altering potentially important variables can be observed directly and immediately. For example, the effect of elevating the blood pressure on eruption force could be studied. The continuously erupting incisors of rodents are chosen for such investigations

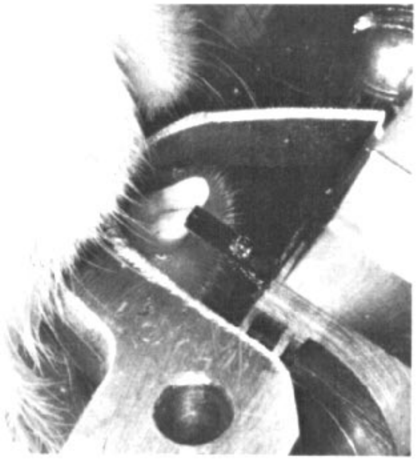

Fig. 3 Strain gauge pressure transducer placed against the erupting incisor of a guinea pig to measure the force of eruption.

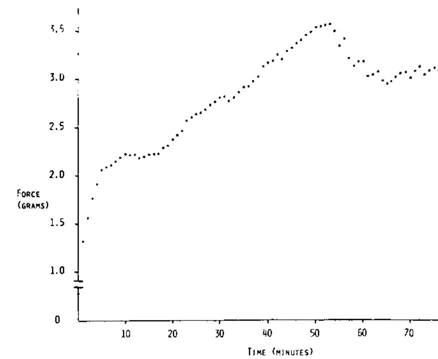

Fig. 4 Eruption force of a guinea pig incisor. After 50 minutes of continued eruption against the transducer, which exerts an increasing force as it is deflected, eruption stopped and the tooth settled slightly back into its socket. In this instance the eruption force was 3.0-3.5 grams.

because they erupt much more rapidly than other teeth. If satisfactory instrumentation for studying rodent incisors can be developed, however, it should be possible to improve it to study more slowly erupting teeth in dogs and primates and, ultimately, in humans. Our approach has been to adapt the strain gauge technology with which we have become familiar in studying tongue and lip pressures to produce a very sensitive and highly stable transducer which can be placed against the tip of an erupting incisor (Fig. 3). Both the transducer and the animal must be positioned very precisely, since the eruption rate is in microns per hour. As the tooth erupts against the transducer, a force opposing eruption is generated which increases as the transducer lever arm deflects. Eventually, the force opposing eruption equals the force promoting it, and eruption ceases. Eruption rate as a function of the increasing load can be read directly from a graph (Fig. 4). By positioning the pressure transducer a precise distance away from the erupting incisor and observing the time between positioning and initial contact with the transducer, an unimpeded eruption rate can be calculated precisely. By moving the transducer support in parallel with the erupting tooth, the effect of constant forces opposing eruption can be studied. This instrumentation also is new and only preliminary data are available now. We believe that with it a whole new series of experiments can be set up which will allow physiologic rather than histologic investigation of some of the parameters relating to eruption.

Although no investigator has produced quantities of data for eruption force under varying conditions, eruption forces have been measured in several different ways by varying researchers.[17,18] The eruption force always is evaluated as between two and ten grams. Smedley,[19] working in Bond's laboratory at Temple University, found that the eruptive force of a human second premolar in the prefunction phase was about five grams (technical difficulties were so great that he was able to obtain data on only a single patient). Nothing is known about the duration of this force, but it seems reasonable that the duration is quite long even if the force is not constant.

TABLE I
EQUILIBRIUM COMPONENTS

Of the primary factors which might be involved in the dental equilibrium it appears that *resting* pressure of tongue and lips, and eruption forces have the proper force and time characteristics to relate to tooth position.

Component	*Intensity*	*Duration*
Forces of Occlusion	Very High	Very Short
Lip or Tongue Pressure		
—Swallow	High	Short
—Speech	Low	Short
—Rest	Low	Long
Forces of Eruption	Very Low	Long

Forces from the periodontal membrane quite possibly could play an important part in stabilizing teeth after their final vertical positions have been attained. This is probably the source of the forces which maintain teeth in stable positions despite an imbalance between resting tongue and lip pressures. One line of evidence suggesting this is the migration of teeth which often is observed as periodontal breakdown occurs. For example, many patients report that the maxillary incisor teeth have begun to migrate forward at age 40 or 50. Periodontal breakdown around the incisors invariably is observed, but usually the tooth movement is blamed on the tongue. In this instance the destabilizing factor probably has been loss of stabilizing forces from the periodontal membrane, so that unbalanced tongue-lip forces cannot be counteracted any longer.

In summary, then, it appears that two major primary factors are involved in the equilibrium which determines the final position of the teeth (Table I). These are, first, the *resting* pressures of lip or cheek and tongue; and second, forces produced by metabolic activity within the periodontal membrane. Extrinsic pressures also can play an important part provided that these pressures are sustained for a matter of hours each day. Some things which traditionally have been considered important, particularly tongue pressures during swallowing, seem upon further investigation to have little importance, probably because the duration of the pressure is not nearly long enough to be effective.

Secondary Factors in Equilibrium

If pressures produced by the resting posture of the head, jaws, tongue and lips are important in the dental equilibrium, and if the same is true of forces produced by metabolic activity in the periodontium, is it possible to identify significant secondary factors which influence the way these primary factors are brought into play? There is considerable information about influences on resting posture in the stomatognathic system. Although less is known, some information can be collected about the periodontium as a generator of tooth-stabilizing forces.

Influences on Postural Relationships in the Stomatognathic System

The postural position of the head is the relationship the head has with the neck and the rest of the body, not when the musculature is at rest, but when no purposeful attention is being paid to head position. The relationship is established at a subconscious level. The same is true for the postural position of the mandible, the tongue, and associated structures. In all three instances there is a variety of positions in which the organs could be stabilized; but one consistent position normally is maintained by the musculature under control from medullary and high spinal-cord levels. Since postural relationships can be and are altered to meet functional needs of the moment, they can be difficult to study. Fortunately, the three postural relationships which concern us here, those of the head, mandible and tongue, tend to vary together in response to the same influences.

The importance of these postural relationships in ultimately determining form has been shown in a number of ways, but most recently and quite interestingly by Solow and Tallgren.[20,21] These investigators demonstrated a relationship between the craniocervical angulation (the way the head is carried on the neck) and both facial proportions and dentoalveolar proportions. The farther the head is carried forward on the neck, the more likely the face is to be long vertically, and vice versa. There are corresponding differences in dentoalveolar morphology relating to head posture. For instance, the more the head is held forward, the more likely it is that upper dentoalveolar height will be increased, especially in its basal portion. Forward head posture also correlates strongly with a steep occlusal plane.

Solow and Tallgren point out that normally the dentition and alveolar process compensate for deviations in jaw relationships so that normal dental occlusion is maintained. When these compensations have not been possible, head posture also correlates with the other facial and dental characteristics of the "long face syndrome" which has been the subject of considerable recent discussion in the surgical-orthodontic literature. It seems highly likely, though it has not been definitely demonstrated, that a forward position of the head on the neck is linked with a low position of the mandible relative to the maxilla and low tongue posture. Low mandibular and tongue posture would tend to favor increased eruption of the posterior teeth. This posture also could lead to constriction of the maxillary dental arch because of the removal of resting pressure of the tongue due to the low tongue posture, and perhaps to anterior open bite because of differential eruption anteriorly and posteriorly. In short, altered postural relationships of the head, jaw and tongue are characteristic for patients with the "long face syndrome." Can these findings be tied together by logical reference to physiological needs?

A link between dentofacial morphology and respiration has been commented upon in the orthodontic literature for many years, going back at least into the early 1900's. If there is difficulty in nasal breathing, physiological adaptations which facilitate mouth breathing include a forward positioning of the head on the neck, a lowered position of the mandible, and a low and forward tongue posture. It is not coincidence that respiratory difficulties are associated with the long face syndrome. Experimental work with primates and observation of human subjects support the concept that postural relationships are changed to meet respiratory needs. Alterations in the growth of the jaws and teeth can be produced experimentally by requiring mouth breathing. Both Harvold[22] and McNamara[23] have produced dentofacial deformities in monkeys in this way. Pathologic conditions in humans which alter postural relationships can produce bizarre types of malocclusions which resemble the primate models. An excellent example is the extremely long face and excessive eruption of the teeth found in patients with severe muscle weakness (Fig. 5). In such patients the mandible literally drops away from the maxilla creating an exceptionally steep mandibular plane angle and severe anterior open bite related to excessive eruption of posterior teeth. Anatomic changes of this extent require physiologic adaptations in speaking and swallowing. These functions adapt to the altered form rather than causing the anatomic changes. The clinical significance of an altered pattern of swallow probably

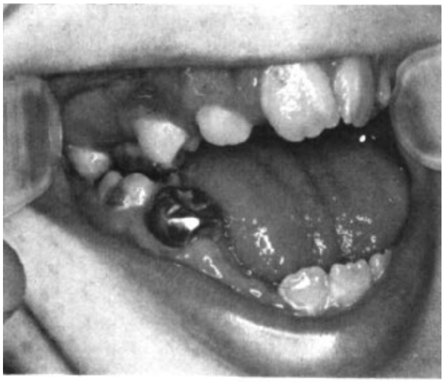

Fig. 5 Above, severe anterior open bite (26 mm) in ten year old girl with a generalized muscular weakness syndrome; below, cephalometric radiograph showing extreme downward and backward rotation of the mandible.

lies in its relationship to a different resting posture rather than with the swallowing act itself. The same is true for other aspects of oral function such as speaking, chewing, sucking, etc.

Secondary Factors Relating to Eruption Forces

The vertical position of the jaws is linked to eruption of the teeth, but exactly how remains almost totally unknown. It seems reasonable to presume that, with growth, the mandible moves away from the maxilla creating a space into which the teeth erupt. Once eruption has occurred, pressure receptors and proprioceptors in the periodontal membrane serve to protect the teeth. Excessive biting on natural teeth does not result in their intrusion. Successful orthodontic intrusion requires relatively light but long-lasting forces, and so it is likely that both the magnitude and duration of occlusal forces are wrong for producing tooth movement. Yet it is obvious from the renewed eruption when an antagonist tooth is removed that occlusal forces do play a role in determining the vertical level of teeth, and how this is mediated simply is not understood.

Occasional patients are seen in whom there has been an apparent primary failure of eruption. This is a feature of cleidocranial dysostosis, but it occurs in patients who do not have this syndrome (Fig. 6). The teeth are not ankylosed, or at least cannot be demonstrated to be ankylosed either radiographically or on clinical examination. For some reason they just do not erupt. Patients with this problem have an over-closed appearance with a short lower face height. Presumably, there is a defect in the eruptive mechanism itself. Clinical investigations of the eruptive mechanism in such patients might well shed some light on the normal eruptive mechanism and on the role of tooth eruption in determining vertical height of the face. Whether there is a parallel syndrome of hyperactivity of the eruptive mechanism, which easily could result in excessive vertical dimension because of the known adaptation of the musculature to the position of teeth once they have erupted, simply is not known.

It is difficult to place the components of the dental equilibrium in perspective as etiologic factors in malocclusion and dentofacial deformity. Every patient, unfortunately, does not have the innate potential to have normal dental and facial relationships. Inherited disproportions are a major influence on all types of malocclusion including the

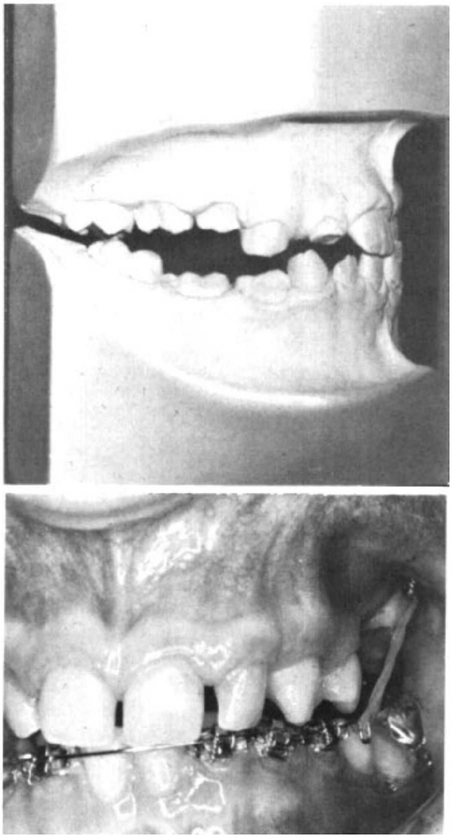

Fig. 6 Above, complete posterior open bite in an eight year old boy with a possible eruption failure syndrome. Only the central incisors are in occlusion. Below, failure of molar eruption in a thirteen year old girl. The teeth did not appear ankylosed when exposed, but became ankylosed after moving a short distance.

vertical dysplasias which also are capable of being produced environmentally. One measure of the importance of inherited characteristics is the different incidence of vertical problems in the black and white populations of the United States.[9] Clinically significant open bite problems occur ten times more frequently in blacks; deep bite problems are six times more frequent in white (Table II). These differences

TABLE II

Comparison of incidence of open bite and deep bite problems in American white and black children. The large racial differences in type of vertical problems probably reflect racial differences in facial proportions rather than only environmental differences (From Kelley et al.).[9]

DEEP BITE—OVERBITE INCIDENCE

Overbite > 6 mm.	6.6%	White	7.6%
		Black	0.8%
Open bite > 2 mm.	2.5%	White	1.4%
		Black	9.6%

reflect underlying differences in inherited skeletal proportions. Perhaps environmental influences on dentofacial development are important primarily in patients whose inherited facial and dental characteristics make them particularly susceptible. For the orthodontist, subtleties of inherited facial proportions still are a vital part, perhaps the more important part, of the "simple invisible" cause of clinical problems.

Summary

The major primary factors in the dental equilibrium appear to be resting pressures of tongue and lips, and forces created within the periodontal membrane, analogous to the forces of eruption. Forces from occlusion probably also play a role in the vertical position of teeth by affecting eruption. Respiratory needs influence head, jaw and tongue posture and thereby alter the equilibrium. "Deviate swallowing" is more likely to be an adaptation than a cause of tooth changes. Patients with failure of eruption have been recognized and alterations in the eruption mechanism may be more important clinically than has been recognized previously.

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