The Influence of Maximum Perioral and Tongue Force on the Incisor Teeth

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Introduction

The theory advanced by Tomes[1] almost one hundred years ago that it is the perioral musculature and tongue which principally determine the position of the teeth has long been accepted by the dental profession. As Tomes put it, "The agency of the lips and tongue is that which determines the position of the teeth themselves." If this widely accepted concept is correct it would be of great value to the orthodontist to know the extent of this influence during initial patient examination and subsequent treatment. Information as to the effects of perverted lip and tongue function is fairly extensive.[2,3,4,5] An evaluation of the clinical evidence due to this abnormal function may be readily made during preliminary patient examination. A method whereby one could quickly assess the influence of lips and tongue on the dentition of patients not affected by habits is, however, not available. Orthodontists have in fact described lips as hypoactive or hyperactive, flaccid, hypotonic or hypertonic; these terms are mainly subjective and generally convey different meanings to different orthodontists. When one speaks of hypotonicity and hypertonicity of the perioral musculature, how does one determine which it is? Where is the dividing line? Where does one stop and the other begin? What are the limits of each? How small or how great an influence is the force of the perioral musculature and tongue on the dentition?

Review of Literature

Varied opinions have been expressed since Tomes first enunciated his concept in 1873 that the lips and tongue are two of the factors which determine the position of the teeth. This theory has been supported by Rogers,[6] Swinehart,[7] Ballard,[8] Brodie[9] and Strang.[10] Not everyone has agreed with this hypothesis. Scott[11] questions this accepted dogma that muscle pressure determines tooth alignment or arch form. He feels that it is more likely that the tongue form is determined by the arch enclosing it.

In 1926 Friel[12] pointed out that tongue pressure generally exceeds lip pressures. This concept was subsequently confirmed by Hopkins and McEwen,[13] Sims,[14] Winders[15,16] and Kydd.[17] Winders found that, during swallowing, the tongue exerts a greater pressure on the teeth than does the perioral musculature. Kydd stated that the maximum force created by the tongue when pressed against the lingual aspect of the maxillary incisor teeth was 8.05 pounds per square inch, while the maximum pressure exerted by the lips against the incisor teeth was 4.4 pounds per square inch. Both Winders and Kydd hypothesize that this imbalance may be equalized by other forces such as those of occlusion, design of roots, inclination of teeth, density of alveolar bone, length of crowns, etc. Lear and Moorrees[18] studied buccolingual muscle forces on teeth in seven students over a twenty-four hour period. They found that, in the majority of the premolar regions, lingual force was greater than buccal force, yet the arch form was uniform in that area. They also suggested that other forces may be present to balance this greater lingual force.

Tisdale,[2] Swinehart,[3] Tulley[4] and

Read at the January, 1971 meeting of the Midwestern Component of the Angle Society.

Straub[5] have emphasized that whenever there is an imbalance in the musculature as those which are caused by habits, certain malocclusions will result.

Varied methods of measuring perioral and tongue forces have been described. Friel used three types of dynamometers to measure maximum forces created by the tongue, lips and buccinator. Howell and Manley[19] described an electronic strain gauge for measuring oral forces in 1948. Moyers[20] used electromyography as a method of analysis of muscles involved in temporomandibular joint movements. Feldstein[21] utilized the principle of hydraulics to measure perioral and tongue forces. Alderisio and Lahr[22] made use of an electronic technique for recording myodynamic forces of cheeks and tongue. Margolis and Prakash[23] described the photoelectric myodynagraph for recording muscle forces. Winders[15,16] in 1956 used the electronic strain gauge to measure forces on teeth. Other methods are described by Gould and Picton,[24] Weinstein et. al.,[25] McNulty, Lear and Moorrees,[26] and Savage.[27] Clinicians have long recognized the importance of the role of the musculature in orthodontic treatment and retention. Downs[28] called attention to the musculature as it affects function, appearance and position of the teeth. Mayne[29] in discussing serial extractions noted that the state of the perioral musculature must be considered and signs of strain, hypotonicity and hypertonicity should be taken into consideration. Riedel[30] in writing about retention states "that although a great deal has been learned about the functioning of the perioral musculature, little of this information has been translated ito useful clinical procedures."

Statement of Problem

To further substantiate some of the questions raised in this paper, four malocclusions observed by the author will be described here.

Patient A.B. (Fig. 1A)

This boy, ten years of age, has good facial balance. One notes in this Class I malocclusion that there is insufficient space to accommodate all the canine teeth. The overbite is not excessive and the angulations of the incisor teeth to each other are normal. In treatment planning one would be inviting relapse if expansion of the arches was undertaken in order to accommodate all the canines. For this patient, four first premolars were serially extracted. The result is seen ten years after retention and subsequent eruption of the third molars (Fig. 1B).

Patient F.M. (Fig. 2A)

This patient, also ten years of age, has a Class I malocclusion similar to patient A.B. (Fig. 1A) in certain respects, but different in others. He too possesses good facial balance. Like A.B. there is insufficient space to accommodate all the canine teeth, but note the marked difference between this case and the former with regard to the angulation of the maxillary and mandibular incisor teeth to each other. In this patient the incisors are inclined lingually and consequently the angulation is much greater than in the case of A.B. Also the overbite is greater, almost one hundred percent, as compared with a normal overbite in patient A.B. This patient's occlusion would be mutilated if serial extractions were carried out. Treatment consisted of moving and torquing the maxillary and mandibular incisors toward the anterior part of the mouth, elevating the maxillary incisors, and depressing the mandibular incisor teeth very slightly. Space is being created for the canines with a great improvement in the overbite. (Fig. 2B).

Patient K.B. (Fig. 3A)

This is a female patient age nine years. She has a Class II, Division 2 malocclusion. Her facial appearance is good and she is able to keep the lips

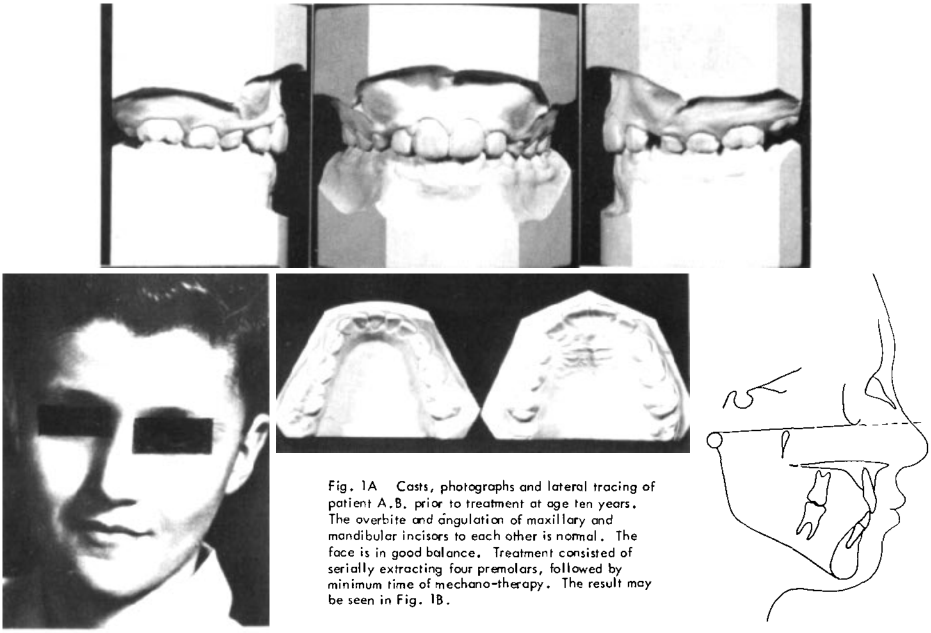


Fig. 1A Casts, photographs and lateral tracing of patient A.B. prior to treatment at age ten years. The overbite and angulation of maxillary and mandibular incisors to each other is normal. The face is in good balance. Treatment consisted of serially extracting four premolars, followed by minimum time of mechano-therapy. The result may be seen in Fig. 1B.

Fig. 1A

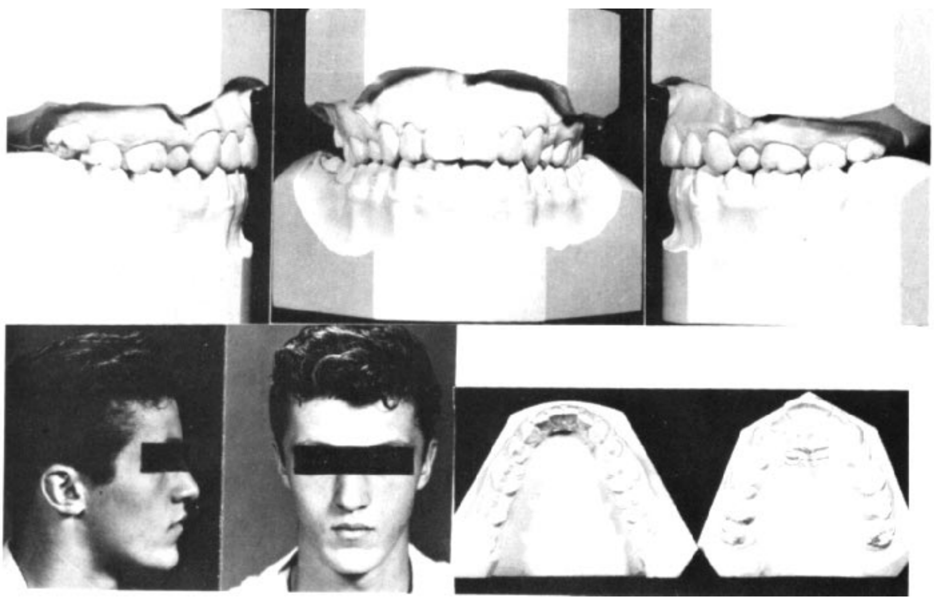
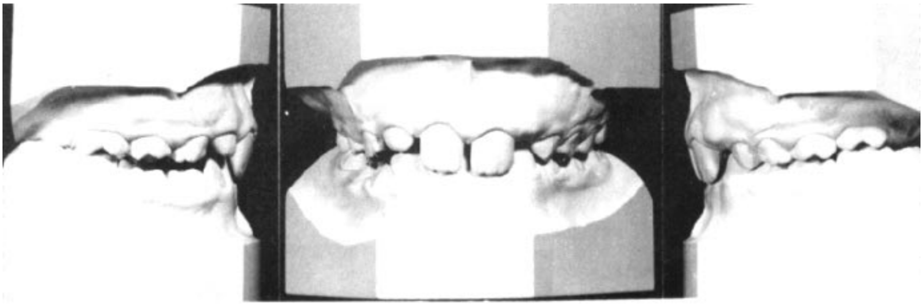
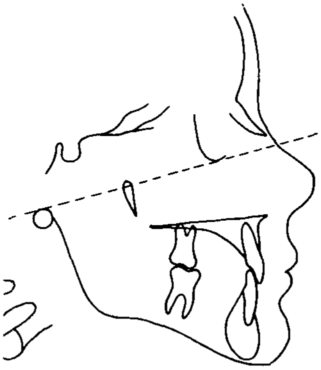


Fig. 1B Models and photographs of patient A. B. ten years after treatment. The overbite has not changed appreciably and the face is in good balance. The angulation of maxillary and mandibular incisors to each other has not changed.





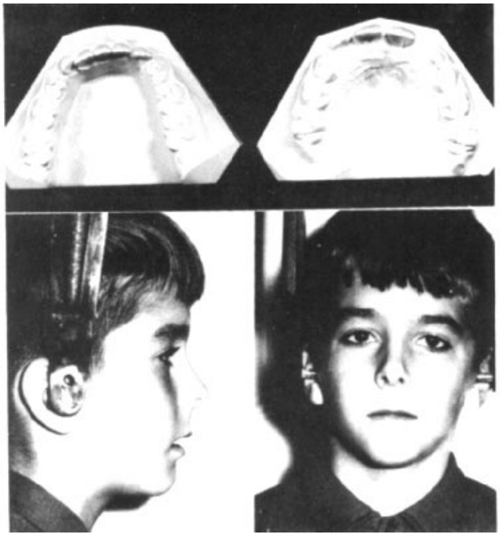


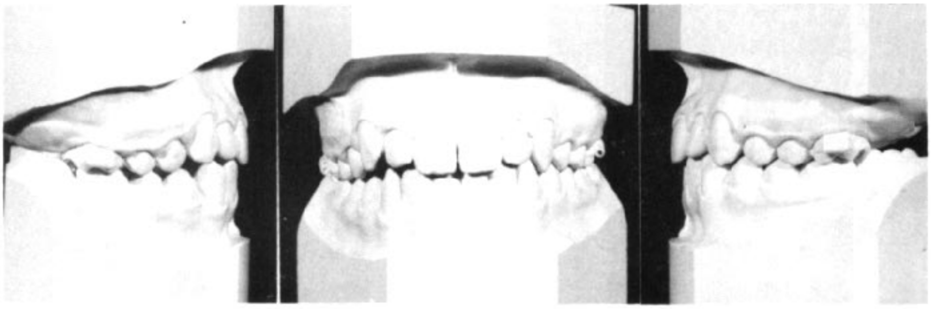
Fig. 2A Casts, photographs and lateral tracing of patient F.M. age ten years prior to treatment. The overbite is excessive the maxillary and mandibular incisors are angulated toward the posterior. The face is in good balance. Treatment consisted of torquing the incisors toward the anterior thus accommodating all the teeth. Treatment progress may be seen in Fig. 2B.

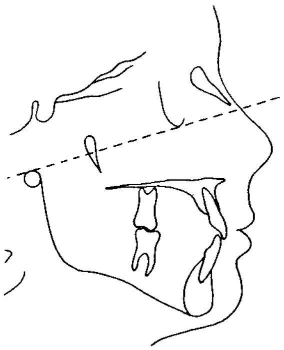
Fig. 2A

closed without effort. Here too, as in patient F.M. (Fig. 2A), there is insufficient space for the mandibular canines; the mandibular incisors are inclined lingually. The maxillary central incisors are tipped lingually and the lateral incisors inclined slightly labially. A marked overjet exists between the maxillary and mandibular arches. In this patient space was created in the mandible for the canines by moving and torquing the mandibular incisors toward the anterior. The maxillary central incisors were aligned by moving the crowns labially and the roots lingually. The final result may be seen six years out of retention (Fig. 3B).

Patient P.C. (Fig. 4A)

This is a female patient age ten and a half. The malocclusion may be described as a bimaxillary dento-alveolar protrusion. Her facial appearance is poor. The lips are continuously parted in repose. The mandibular left first permanent molar has been lost through caries. The maxillary and mandibular incisors are positioned excessively forward and the angulation of the maxillary and the mandibular incisors to each other is small. The treatment plan consisted of removal of dental units; the procumbency of the incisor teeth was reduced sufficiently so that the patient was able to keep the lips closed in re-





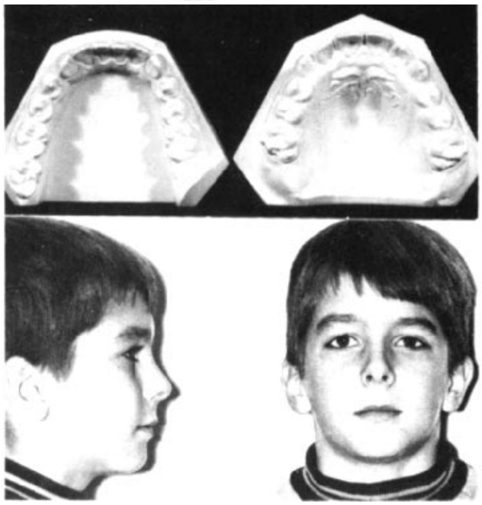


Fig. 2B Models, photos and lateral tracing of patient F.M. first seen in fig. 2A after eighteen months of treatment. The overbite has improved, all teeth are being accommodated and a more favourable angulation of maxillary and mandibular incisor teeth may be noted.

Fig. 2B

pose. Facial balance has improved and the final results may be observed in Figure 4B.

Certain questions arise as a result of treating these four patients.

1. In the Class I case of patient F.M. (Fig. 2A) why and when did the maxillary and mandibular incisor teeth become inclined lingually?
2. In the Class II, Division 2 of patient K.B. (Fig. 3A) why and when did the maxillary central incisors and also the mandibular incisors become inclined toward the lingual?
3. Why was the overbite excessive in patients F.M. (Fig. 2A) and K.B. (Fig. 3A)?
4. Why did the above conditions not occur in the malocclusion of the patient A.B. (Fig. 1A)?
5. How does one explain the procumbency of the maxillary and mandibular incisor teeth of patient P.C. (Fig. 4A)?
6. Why is there a difference in the angulation of the incisor teeth to each other in the four malocclusions?
7. Why are the lateral incisors in Class II, Division 2 of patient K.B. (Fig. 3A) slightly inclined toward the labial?

Concerning the times when the incisors assumed the lingual inclination of the crowns in patient F.M. (Fig. 2A) and also in the Class II, Division 2 of patient K.B. (Fig. 3A), the dentist reported that the deciduous teeth were in good acceptable occlusion, the inclination of the deciduous incisors was normal and the overbite was not excessive.

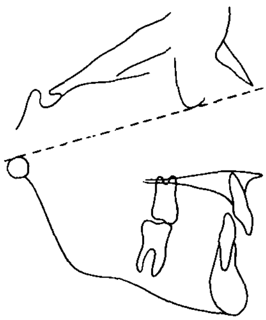
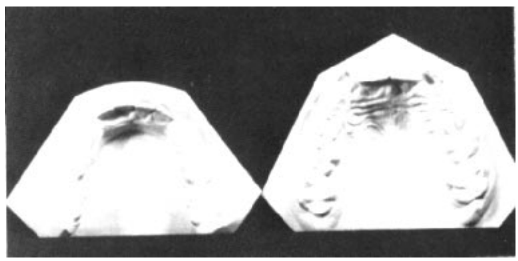
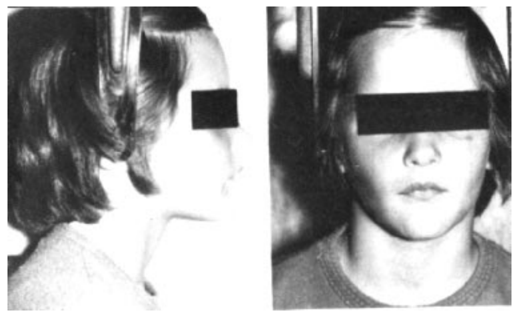




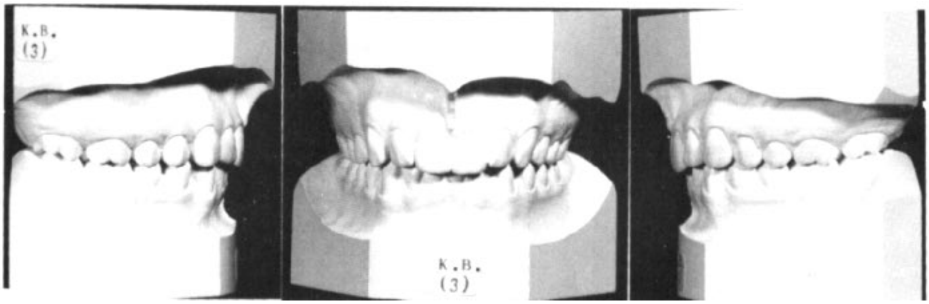
Fig. 3A Patient K.B. age 9 years exhibiting a Class II division 2 malocclusion. The excessive overbite, lingual inclination of the central incisor may be noted. The lips are hypertonic. The treatment results may be seen in Figure 3B.

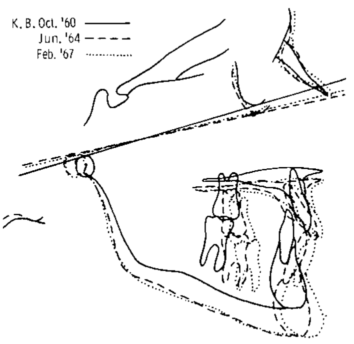
Fig. 3A

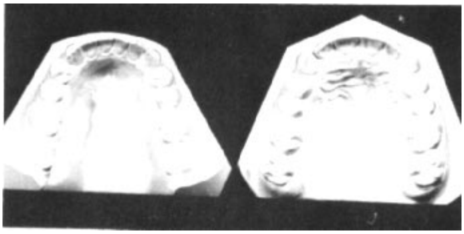
It was during the transitional dentition stage, then, that the permanent incisors were observed to have erupted with a lingual inclination and the excessive overbite became evident. It might be well to present a hypothesis to explain what has been observed in these two cases, F.M. (Fig. 2A) and K.B. (Fig. 3A), and compare these with the previous one, A.B. (Fig. 1A).

Hypothesis

It may be assumed at the outset that patients F.M. and K.B. have a "very tight" or hyperactive type of perioral musculature and that the transitional period of eruption of the incisor teeth is a slow process. The hypertonic perioral musculature is ever present becoming stronger with age. This "rubber-dam-like" pressure influences the position of the incisor teeth as they erupt over a relatively long period of time of two or three months. It may be assumed further that tongue pressure, although greater than lip pressure, on the dentition is of no consequence as it is suspended in the "mandibular trough." Although the dorsal surface of the tongue contacts the palate and the tip of the tongue is in contact with the lingual surfaces of the incisors,[7,17] the tongue is contained within the oral cavity so that its inherent potential muscle strength does not extend beyond contacting the palate and incisor teeth. As the hyperactive labial musculature continuously exerts a strong force on the incisor teeth, they assume a more lingual inclination. During orthodontic treatment the incisor crowns are moved to-







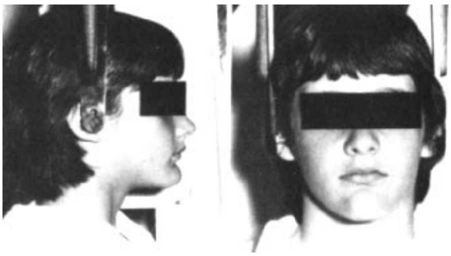
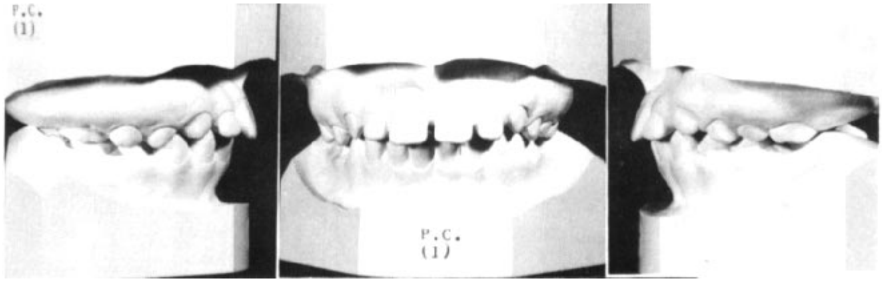


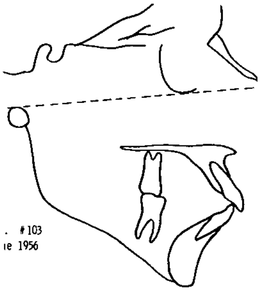
Fig. 3B Records of patient K.B. (Seen previously in Fig. 3A) a Class II division 2 malocclusion six years out of retention. The favourable result is due to early conservative treatment in a patient with hypertonic perioral musculature.

Fig. 3B

ward the anterior and repositioned (labial crown torque), thus providing more space for the erupting laterals and canines. Once these teeth, the premolars, and second permanent molars are all aligned into a continuous arch, the effect is to prevent the extreme perioral pressure from destroying the new alignment or arch form. In fact, this alignment might only be altered if permanent teeth were to be lost distal to the central incisors, particularly in the premolar region. The question naturally arises as to why the same sort of clinical characteristics did not appear in the case of A.B. (Fig. 1A). One can only suggest that the pressure of the perioral musculature was not excessive. How does one explain the development of a bimaxillary dento-alveolar protrusion? Since the lips in this malocclusion are continuously parted, the patient does not have the benefit of the retentive force of the lips so the teeth migrate excessively toward the anterior part of the mouth.

If one assumes that it is the forces of the perioral musculature and tongue which primarily influence the position of the teeth in an anteroposterior direction, how might this assumption be tested? One could conceivably place in the mouth some quite sensitive instruments to continuously monitor the pressures created and brought to bear on the teeth by the perioral musculature and tongue over a period of two or three months or even longer. This method has so far been impractical. A method which is both applicable and practical, designed by the author, is now available.





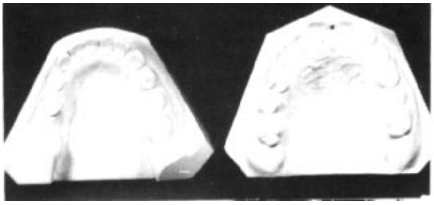


Fig. 4A Casts, lateral tracing and photographs of patient P.C. a bimaxillary dento-alveolar protrusion seen at age ten and a half years. Facial balance is poor because of the protrusion of maxillary and mandibular incisor teeth. The results of compromised treatment may be seen in Fig. 4B.

Fig. 4A

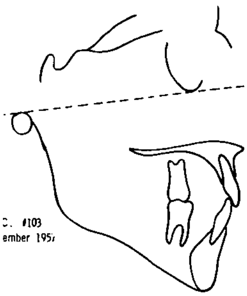


Fig. 4B Records of the treated bimaxillary dento-alveolar protrusion of patient P.C. (Fig.4A) is seen above. The incisor teeth were moved to the posterior resulting in improved facial balance and perioral function.

Fig. 4B

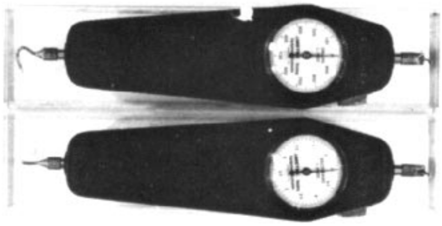


Fig. 5 Two gauges calibrated to give maximum readings of 1000 grams for maximum lip force and 5000 grams for measuring maximum tongue force. Each gauge registers when pulling at one end or pushing at the other end.

The underlying principle of the method about to be described is based on the simple fact that the muscles of the right arm of the village blacksmith (provided that he is right handed) are more developed and stronger than the muscles of his left arm. Thus, if the right arm rests or acts on an object continuously, it would exert a greater force than would his left arm resting on the same object. When one transfers this concept to the areas of the lips, a certain parallel may be noted. The hypertonic perioral muscles resting or acting on the teeth will exert a greater force on the dentition than would less developed or hypotonic perioral muscles. This method involves an instrument designed to measure maximum lip and tongue force at any given time and in a relatively short period of three or four minutes. The assessment of maximum perioral and tongue force may be conveniently and accurately measured and the information made available at the time of initial patient examination.

The purpose of this method of study is:

1. To ascertain whether or not a relationship exists between maximum perioral and tongue force with the final position and angulation of the maxillary and mandibular incisor teeth in an anteroposterior direction.
2. To find out whether this relationship is associated with the cause or causes of certain malocclusions.
3. If such a relationship does exist, how does it affect clinical treatment?

Method

The instrument to be used is made up of two Hunter gauges (Fig. 5). The gauges are calibrated to give maximum readings of one thousand and five thousand grams. These are capable of registering forces of pull and push by either pulling at one end of "A" or pushing at the other end at "B" (Figs. 6 and 7). It is equipped with a maximum hold knob "C" which stops the pointer when the maximum reading is registered on the scale "D". The pointer will return to zero when the knob "C" is pushed back.

In Figures 6 and 7 it is seen that each gauge is mounted on plexiglass 2¼″ × 9¼″ × 5/16″ as seen as "E" on the diagram (Fig. 6). The long sides of the plexiglass are thinned to ⅛″ so that it slides into two tracks also made of plexiglass 3½″ × 9¼″ × ¾″ seen as "F". "F" is mounted on a wooden board "G" 18″ × 4″ × ¾″. The gauges are mounted on two similar pieces of plexiglass "E" by means of two bolts and "E" slides into the platform "F". A bolt "N" is tightened so that the plexiglass on which the gauge is mounted can no longer slide back and forth once it is locked. A separate arm "H", the dimensions of which are 10″ × 1¼″ × ⅛″, is moulded and shaped so that one end is turned at right angles at "I" to receive a metal sleeve "K" to which the end of the Hunter gauge attaches at either "A" or "B". The plexiglass arm "H" is bevelled along its length to slide into two sleeves "M" and "M" which in turn is fastened to the wooden board "G" allowing the arm "H" to slide backward and forward along the wooden board between the tracks "M" and "M". At the other end of the arm "H" a horizontal piece of plexiglass ¼″ in diameter is fastened

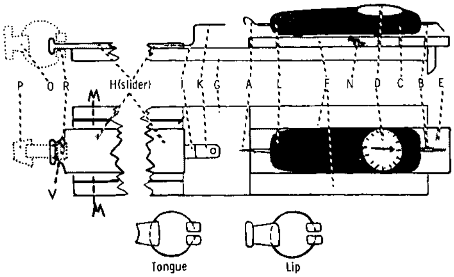


Fig. 6 Cross-section view of the pommeter, the instrument used in measuring maximum perioral and tongue strength.

at "V". This is the part which will receive attachments for the lips and tongue to measure maximum lip and tongue strength.

The Mouthpiece

The mouthpiece (Fig. 8A) is constructed around a "C" spring to which plexiglass is secured by fast curing acrylic "O and R". The straight part "O" is made just large enough to be gripped by the lips. The horizontal part of "O" is 3/4″ long, 5/16″ wide and 3/16″ in thickness. This size was chosen because the patients were able to grip this size most efficiently. The other end of the mouthpiece has plexiglass "R" attached to the "C" spring which clips to the main arm at "V".

The Tongue Piece

This also is made around a "C" spring but the horizontal part of "O" was made concave to receive the tongue (Fig. 8B). Its size is 1¼″ long × ½″ wide and 3/16″ thick. The tongue piece clips on to the end of "V" by means of the "C" spring to which plexiglass "R" is attached. Both mouth and tongue pieces are easily removed from "V" for sterilization.

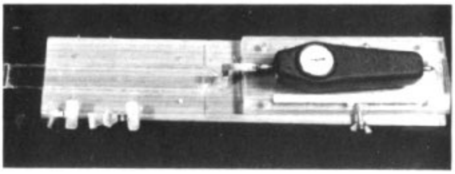


Fig. 7 Gauge setup on pommeter for measuring maximum tongue strength.

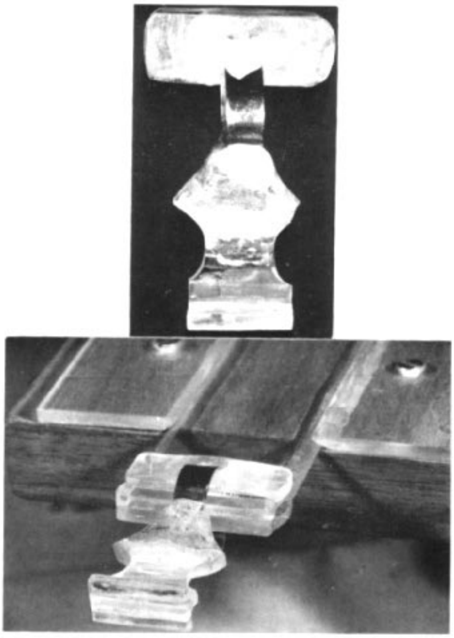


Fig. 8A The mouthpiece used for recording maximum lip force and its attachment to the main body of the pommeter. It is easily removed for sterilization.

Measurement of Maximum Lip Force

The patient is seated upright at the edge of the chair and away from the head rest. The chair is adjusted so the mouth of the patient is in line with the mouthpiece clipped to the measuring instrument "G" at point "V" (Figs. 6 and 9). The patient is asked to bring the teeth into occlusal contact. This will prevent the gripping of the mouthpiece with the teeth. The patient is instructed to grip the mouthpiece with the lips with as much force as possible and pull the head as far back as possible (Fig. 9). The pointer on the Hunter gauge then records a reading on the dial of the gauge. The pointer will *remain* at the maximum point reached because the maximum-hold knob "C" is locked into place. This reading is recorded and the patient is rested for approximately one minute. The knob "C" is released, the pointer registering zero again. "C"

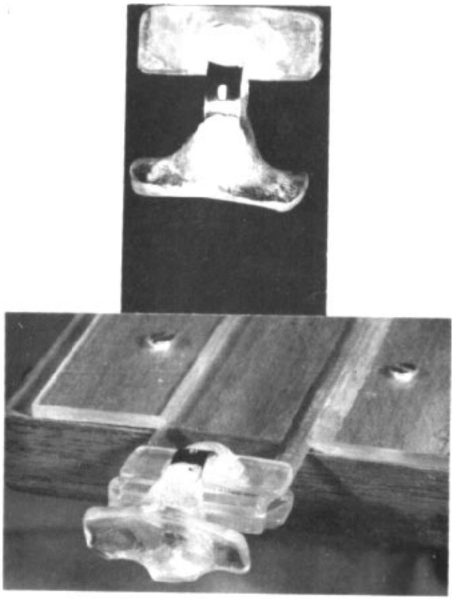


Fig. 8B The tongue piece used for recording maximum tongue force. Its attachment to the main body of the pommeter is shown.

is locked once more, the same procedure repeated, and another reading is recorded. Generally, the first reading is higher than the second; the variation may be between 5 to 10 grams. The highest reading is the one recorded for the patient, generally the first recording; muscular fatigue is likely to reduce the second recording if no rest period is allowed. The method described may be repeated after a few hours or days, the results are reproducible, and the differences quite insignificant.

Whereas maximum lip force is registered by gripping the mouthpiece with the lips and pulling back the entire head, maximum tongue force is measured by pushing with the tongue against the concave part of the tongue piece at "P" (Figs. 6 and 8B). In order that the pushing is done by the tongue only, and not by the other muscles of neck and shoulder, the patient is securely positioned in a cephalostat (Figs. 10 and 11). The 1000 gram gauge is

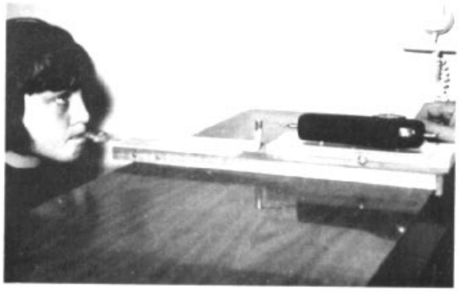


Fig. 9 Patient is pulling on mouthpiece in the process of testing maximum lip force. He is pulling back his head as far as possible without losing the grip on the mouthpiece.

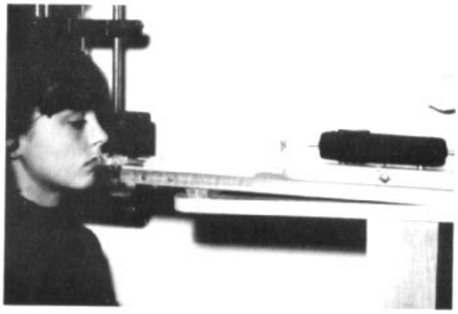


Fig. 10 The pommeter is placed on a special stand in front of the cephalostat. The tongue piece is in front of the lips.

now replaced by a 5000 gram gauge and secured to the main board "G" by a bolt "N" (Fig. 6). The gauge itself is reversed as compared with the position of the gauge when maximum lip strength was recorded. The attachment "B" of the gauge now attaches to the metal sleeve at "K". This reversal will record the maximum force of the tongue. The board "G" is placed on a special stand in front of the patient in the cephalostat. The concave tongue piece "P" now attached at "V" is brought as close as possible to the patient and in line with the incisal edges of the mandibular incisor teeth. The patient is asked to push with the tongue as far forward as possible against the concave surface of the tongue piece. The maximum reading is registered on the gauge and recorded.

Fig. 11 Maximum tongue force is being tested. The pommeter is held on the stand; the tongue is pushing against the tongue piece as hard as possible.

To properly evaluate maximum perioral and tongue force of patients with malocclusions at various age levels, it was necessary to determine the maximum lip and tongue forces of similar age groups of individuals with normal occlusion (normal standards). Arrangements for access to primary and secondary schools were made through the Department of Dental Public Health. Children were selected for these normal standards on the basis of good facial balance and acceptable Class I occlusion. The ages ranged from eight to eighteen years for Caucasion boys and girls, specifically eight, ten, twelve, sixteen and eighteen years of age.

Table I illustrates the maximum perioral and tongue forces recorded for the above groups. The means, standard deviations and ranges for the various ages are recorded for females and males.

Perioral Forces

The table dealing with acceptable Class I occlusion and good facial balance was analyzed by the statistician for the Dental Faculty. From these groups with normal occlusion (Table I and Fig. 12), the following may be noted:

1. No sex difference with regard to maximum perioral force is apparent at ages eight, ten and twelve. At ages sixteen and eighteen, however, the trend for maximum lip strength of males begins to increase when compared with the same groups of females. A regression analysis to test for sex differences in slope was done. It was found that the slope of the regression of lip force on age was significantly different, i.e., sex differences in slope exist ($F = 14.8$, $P < .005$ for degrees of freedom (1, 128). (See Table I and Fig. 12).
2. It is apparent that maximum perioral force tends to increase with age, an observation which might be expected. The correlation between maximum lip strength and age over the range studied for each sex in normal occlusion is positive and sig-

		FEMALES							MALES						
			Maximum Lip Force			Maximum Tongue Force				Maximum Lip Force			Maximum Tongue Force		
Occlusion Group	Age Group	N	Mean	S.D.	Range	Mean	S.D.	Range	N	Mean	S.D.	Range	Mean	S.D.	Range
Normal	8	15	129.0	30.5	90-180	1313.3	280.4	600-1700	13	132.7	25.3	90-190	1255.4	332.6	800-2020
Normal	10	12	171.3	39.1	120-250	1443.8	325.3	850-1875	14	176.4	25.6	120-220	1512.5	299.3	800-1975
Normal	12	18	193.9	34.7	150-260	1865.8	334.3	1160-2350	19	212.4	34.7	160-285	1818.2	408.0	1140-2500
Normal	16	13	260.8	70.5	160-400	1905.8	296.0	1350-2350	13	291.2	88.2	160-440	1903.1	215.7	1450-2275
Normal	18	10	251.5	57.5	180-360	1997.5	376.5	1300-2500	8	348.8	73.6	260-500	2090.6	283.5	1700-2500
Malocclusion treated to Normal	10-14*	17	190.0	43.4	140-275	1524.7	272.7	1050-1950	8	228.1	41.2	185-280	1587.5	133.6	1375-1800

Table I Maximum perioral and tongue forces recorded in grams for white Caucasian boys and girls at ages eight, ten, twelve, sixteen and eighteen years. Each age group exhibited good facial balance and acceptable normal occlusion. * For these groups the age range, youngest female or male to oldest female or male is given.

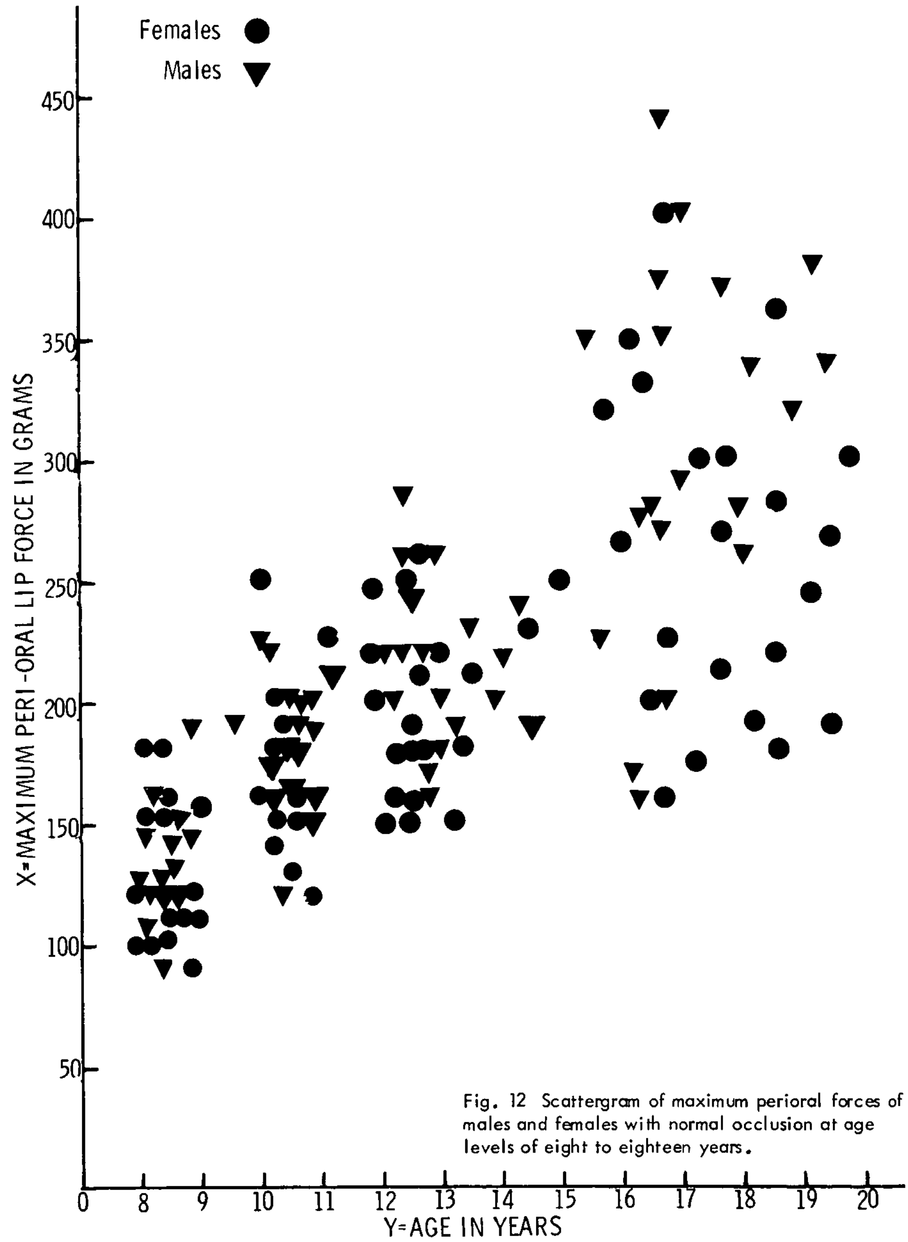

Females
Males
X=MAXIMUM PERI-ORAL LIP FORCE IN GRAMS
450
400
350
300
250
200
150
100
50
0
8
9
10
11
12
13
14
15
16
17
18
19
20
Y=AGE IN YEARS
Fig. 12 Scattergram of maximum perioral forces of males and females with normal occlusion at age levels of eight to eighteen years.

Fig. 12

nificant, r = (males + 0.828; females + 0.667).

3. The range in maximum perioral force in individuals with normal occlusion is quite wide in each group. A close examination revealed that individuals showing a higher recorded maximum lip force exhibited less incisal procumbency than those individuals with a lower recording.
4. There is no significant difference in maximum perioral force between the normal groups and those groups whose malocclusions were treated to normal occlusion and good facial balance (Table I). Treated Class II, Division 2 malocclusions exhibited, however, a higher maximum perioral force than the same age group of Class II, Division 1 and the majority of Class I malocclusions. The Class I type with a similar high maximum perioral force was that whose maxillary and mandibular incisors were inclined lingually (Fig. 2A).

Maximum Tongue Force in Normal Occlusion

From Table I, it is apparent that registrations of maximum tongue force are higher than those of maximum perioral force. It is obvious that the tongue is capable of maximum effort as early as eight years of age. Maximum tongue force tends to increase with age, yet the range is wide and the highest range at age eight and a half years is not much lower than at the age of eighteen, 2020 grams for males at age eight and a half and 2500 grams at age eighteen.

There is no significant difference between males and females in maximum tongue force at the various ages studied. There is no correlation between high recordings of maximum tongue force and high or low readings of maximum perioral force, i.e., if a patient has a high maximum lip force it does not follow that maximum tongue force is proportionately higher. Similarly, in low registrations of maximum lip force the maximum reading for tongue force might be high or low.

Patients, whose malocclusions were treated to normal occlusion, and Class 1 untreated malocclusions showed average maximum tongue forces similar to those of normal occlusion.

Maximum Tongue Force in Groups With Malocclusion

From Table II dealing with malocclusions it is noted that maximum tongue force is much higher than maximum perioral force. All groups with malocclusions, males and females, exhibited maximum tongue force which paralleled those with normal occlusion. Individuals with normal occlusion showed a wide range of maximum tongue strength in the age group from eight to eighteen. The range was 600-2500 grams. In Class II, Division 1 the range was 700-2200 grams in an age range of seven and a half to sixteen years. In Class II, Division 2 the range was 950-2075 grams for an age range of eight to eighteen years. The bimaxillary protrusion range was 900-2300 grams in an age range of eight and a half to twenty-four years.

Maximum Perioral Force of Class II and Bimaxillary Alveolar Protrusions

With these three groups with malocclusions, tests of significance were ill advised because of the age spread of the samples (Table II). A scattergram (Fig. 13), however, reveals the following trends:

1. The tendency for maximum lip force to increase with age was not evident in bimaxillary dento-alveolar protrusions.
2. As one goes from bimaxillary dento-alveolar protrusions to Class II, Division 1 and to Class II, Division 2 malocclusions, there is a tendency, with some overlap, for maximum lip force to be low or high.

		FEMALES							MALES						
			Maximum Lip Force			Maximum Tongue Force				Maximum Lip Force			Maximum Tongue Force		
Occlusion Group	Age Group	N	Mean	S.D.	Range	Mean	S.D.	Range	N	Mean	S.D.	Range	Mean	S.D.	Range
Class I Untreated	9.0-14.6*	9	178.3	40.8	110-230	1390.0	330.6	900-2000	13	222.7	49.5	160-310	1710.0	424.6	800-2425
Class II Div.I Untreated	7.1-16.0*	7	159.3	52.5	100-240	1633.6	299.9	1220-2000	13	153.5	41.0	95-250	1478.5	432.5	700-2200
Class II Div.2 Malocclusion	7.4-16.9*	10	283.5	94.3	200-500	1625.0	352.6	950-2075	8	292.5	78.6	235-460	1505.6	367.2	970-2000
Bimaxillary Alveolar Protrusion	8.3-25.0*	14	120.4	20.0	90-150	1626.8	373.8	1100-2300	8	124.4	23.8	90-150	1368.8	225.1	900-1600

Table II Maximum perioral and tongue forces recorded in grams for white Caucasian boys and girls at various age levels and malocclusions of Class I, Class II, Division 1, Class II, Division 2, and bimaxillary dento-alveolar protrusions.

* For these groups the age range, youngest female or male to oldest female or male, is given.

3. Maximum lip force in Class II, Division 2 is high when compared with similar age groups with normal occlusion and shows a tendency to increase with age. It is also noted that the average maximum lip force is significantly higher in this class of malocclusion than either the normal occlusion or in those other malocclusions studied. For example, the average maximum lip force for age eight and a half years is approximately 130 grams; the average at the same age for Class II, Division 2 malocclusion

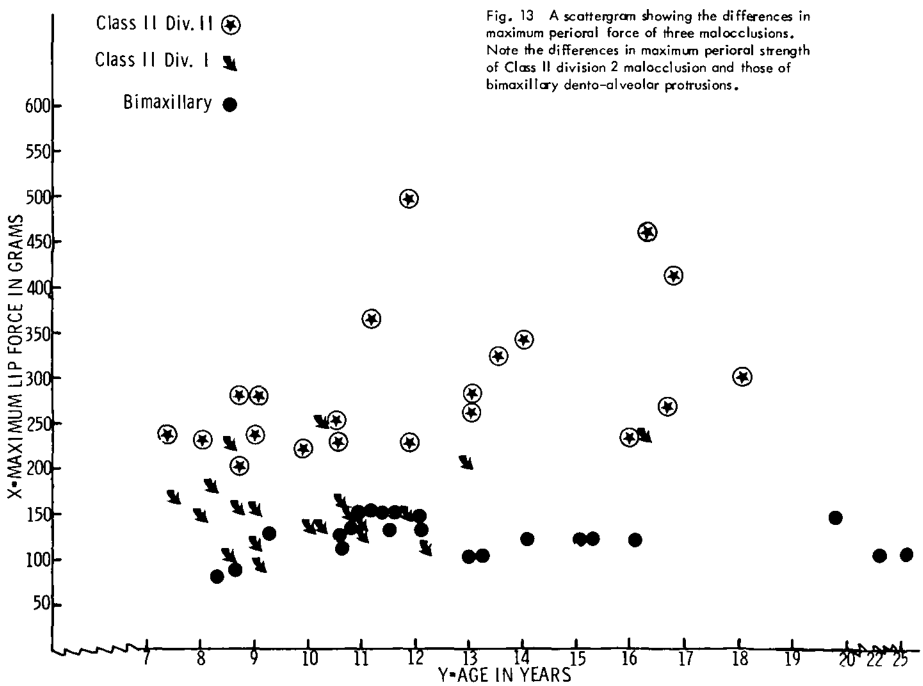


Fig. 13 A scattergram showing the differences in maximum perioral force of three malocclusions. Note the differences in maximum perioral strength of Class II division 2 malocclusion and those of bimaxillary dento-alveolar protrusions.

Fig. 13

is approximately 240 grams.

4. Bimaxillary alveolar protrusions showed a very low maximum perioral force for the ages shown. The range was 90-150 grams for ages eight and a half years to twenty-five years.
5. Class II, Division 1 showed no significant difference in maximum lip force when compared with the corresponding age groups of those with normal occlusion. There is one group in this class, however, which showed a significant low lip force (100-130 grams) in an age range from eight and a half to twenty-four years. This maximum force is very similar to bimaxillary alveolar protrusions. Salzmann[38] classifies and describes eight types of Class II, Division 1 malocclusions. This one resembles type "H" described by Salzmann. Here one notes a poor skeletal pattern, a short, nonfunctional upper lip and a large overjet (Fig. 14). The mouth, habitually open, is one which invariably registers a low maximum lip force. This patient according to Downs analysis[39] shows a low facial angle, a high angle of convexity, a large "AB" difference and a high mandibular plane angle. This type is difficult to treat and requires retention of long duration.

Class I Malocclusions

From Table I dealing with Class I malocclusions at ages nine to fourteen years, it is noted that maximum tongue force and maximum perioral force approximate those with normal occlusion at the same age level. None of these patients had any breathing difficulties, their lips were closed in repose and their facial muscle balance was normal in rest position. Those whose maximum perioral force was in the higher range when compared with those with normal occlusion at the same age exhibited a more lingual incisor position. Those whose maximum perioral force was in the lower range showed incisors which were more procumbent.

Discussion

The Role of the Tongue

The tongue is very well-developed at birth filling the entire oral cavity and overflowing the maxillary and mandibular gum pads. In the newborn it is in continuous contact with the lips.[40] Because of its continuous contact with the palate and alveolar processes of the maxilla and mandible, it influences to some extent the position of the erupting maxillary and mandibular incisor teeth.[7] This conclusion is supported by the fact that patients suffering from congenital aglossia show maxillary and mandibular incisor teeth erupting lingual to their normal erupted positions.[32] As children with normal tongue function continue to grow, the jaws increase in size and the teeth erupt. The tongue no longer "overflows the gum pads" but now has sufficient space to be accommodated and confined within the jaws and teeth. It is reasonable to assume that, in spite of the fact that the tongue applies greater force against the teeth during normal deglutition,[15] the teeth are not moved excessively forward by this act. The explanation for this resistance to forward migration has been previously suggested[16,17,18] and it may well be due to the fact that in the normal act of swallowing all the teeth are in occlusal contact. The articulation of the incline planes of the teeth, the roots set in the periodontal ligament and strong alveolar bone are more than sufficient to overcome the force of the tongue in normal function. This is further supported by the fact that when there is an abnormal swallowing habit, i.e., the maxillary and mandibular teeth are not in occlusal contact, the maxillary incisor teeth are often displaced forward by abnormal function of the tongue creating a large overjet (Fig. 15). From Table I showing normal occlusion of

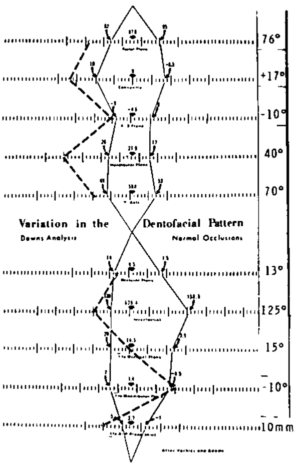


Fig. 14 Patient G. E. age 8-1/2 years has a Class II division 1 malocclusion whose maximum perioral force is 100 grams. He has breathing difficulties, a short upper lip and a poor skeletal pattern. This type of Class II division 1 malocclusion is most difficult to treat and to retain.

Fig. 14

eight year old males and females dealing with maximum tongue force, the range for females is quite wide, 600-1700 grams, as it is for males, 800-2020 grams. These ranges increase with age.

Every group exhibited a high maximum tongue force when compared with maximum perioral force. If each individual were to utilize the maximum of this potential tongue force in normal function, the majority of our patients would have protrusive dentitions. Those patients who had high maximum tongue forces did not exhibit dentitions that were more protrusive than those individuals who had low forces. This is a strong indication that in normal function the tongue does not exert the maximum force on the dentition of which it is capable. While it may be true that the tongue is an influencing factor in guiding the teeth toward the crest of the arches,[32] this study has shown that in normal function the effective role of the tongue as a factor in angulation and final position of the incisor teeth is minimal. In other words, the tongue assists in guiding the teeth toward the crest of the dental arches; however, once the teeth have erupted through the crest of the ridge, the original hypothesis "that tongue pressure although greater than lip pressure is of no consequence" applies. This is supported by the fact that there is no significant relationship between maximum tongue force and final incisor position. This study supports the assumption that the tongue, in normal function as in deglutition and speech, does not exert a force strong enough in an anterior direction to overcome the containing force of the lips or other fac-

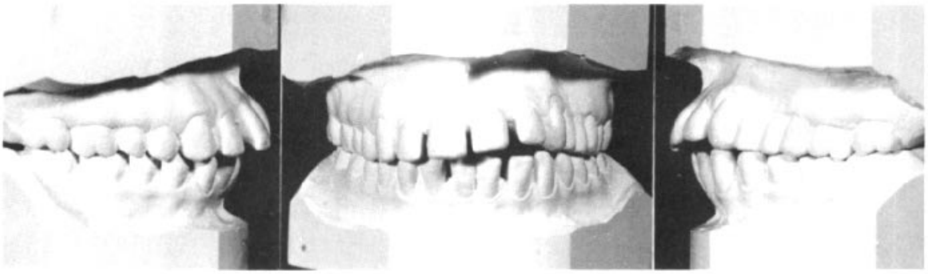


Fig. 15 This is a malocclusion caused by tongue thrusting. When there is abnormal function of the tongue, the maximum force of the tongue will easily overcome maximum perioral force causing the incisor teeth to be displaced forward. Maximum tongue force in this adult malocclusion is 2325 grams and maximum perioral force is 260 grams.

tors such as occlusal contact, length of roots, etc.

The Role of the Lips

We have shown the type of maximum force and pressure capable of being exerted by the perioral muscles on the dentition of various types of malocclusions. Although a cause-and-effect relationship has not been established, a very definite association has been demonstrated quantitatively for the first time.

In Class II, Division 2 malocclusions maximum perioral force has been found to be significantly higher than in any other malocclusion. In discussing the causes for Class II, Division 2 malocclusions, Angle[33] noted that all malocclusions in this class were characterized by a distal positioning of the mandible. Hellman[34] studied dry skulls and concluded that in Class II, Division 1 the mandible assumes a more posterior position in relation to the skull, whereas Class II, Division 2 showed a more anterior position. Baldridge[35] asserted that in Class II, Division 2 the mandible was in correct anteroposterior relationship. Swann,[36] in attempting to explain the etiology of Class II, Division 2 malocclusion, hypothesized that the reason the maxillary laterals assumed a more labial position is because the maxillary second permanent molars developed ahead of the development of the tuberosity. This in turn causes a forward tipping of the maxillary buccal segments, i.e., there is a forward migration of the unerupted permanent teeth causing the lateral incisors to assume a more labial position. This hypothesis fails to explain why it is that the crowns of the maxillary central incisors are tipped lingually.

Since maximum tongue force is not significantly lower in Class II, Division 2 when compared with that of normal occlusion or any other malocclusion, one may therefore assume that the role of the tongue in the etiology of this malocclusion is minimal. The evidence is strong that it is the significantly great lip force that is a contributing factor, or indeed the main cause for the central incisors assuming this lingual inclination. The explanation is that when the maxillary central incisors erupt toward the lingual, arch length is shortened. The maxillary lateral incisors are forced to assume a more labial position because they are squeezed between the deciduous canines and the lingually erupted central incisors.

The evidence presented so far seems to indicate rather strongly that in Class II, Division 2 (Fig. 3A) and in some types of Class I (Fig. 2A) the incisors are positioned lingually as a result of the activity of a strong perioral musculature. These indications suggest two possible courses of treatment for the orthodontist. First, if one assumes that the activity of the musculature is strongly controlled by hereditary factors, then it would be argued by some that it is pointless to move the incisors into a more forward position because they would only be overcome by the force of the musculature and would relapse. This means that a change in environment, i.e., an altered tooth position, cannot overcome a strong genetic force and one would therefore have to apply extraction therapy. On the other hand, if one were to assume that by torquing and moving the incisors in a more labial position, thus accommodating the canines, these incisors may be maintained even in the face of a strong genetic force exerted by the musculature, then one would be inclined to follow nonextraction therapy. Since the observations made from this study serve to illustrate that the maxillary central incisors assume a more lingual position because of excessive perioral pressure, then the hypothesis set forth at the beginning of this paper appears to be correct. As a consequence of these observations one would therefore be inclined to follow the second course of therapy, nonextraction. In these particular circumstances of Class II, Division 2 or lingually positioned incisors of a Class I malocclusion, one can overcome a strong genetic force exerted by the soft tissue by changing the position and environment of the hard tissues or teeth. In this essential conservative approach to treatment, borne out by clinical results, it must be recognized by the orthodontist that more than one period of treatment will be necessary. Treatment begins soon after the completed formation of the roots of the maxillary central incisors. Interceptive procedures are designed to torque the central incisor crowns from their lingual positions to a more labial axial inclination. This creates more space for the erupting lateral incisors preventing these teeth from assuming a more labial position so often seen in this type of malocclusion. At the same time maxillary cervical traction is initiated to align the posterior teeth in a Class I relationship. Treatment time is necessarily of long duration. Retention is designed to hold the new position of the maxillary arch in anteroposterior and vertical planes. The stability of this essential conservative treatment approach depends on the alignment and maintenance of the teeth in a continuous arch in the mixed as well as in the permanent dentition.

Bimaxillary Dento-Alveolar Protrusions

Bimaxillary dento-alveolar protrusion is a Class I malocclusion generally characterized by excellent interdigitation of posterior teeth and a marked procumbency of maxillary and mandibular incisor teeth. The mandibular incisors may be crowded or well-aligned. The patient's lips are always parted in repose and the lips cannot be closed for any period of time; if the mouth is closed the lips appear strained.* When these patients were tested for maximum lip force they invariably exhibited a significantly low reading regardless of age (Table II and Fig. 13). The range in this group was 90-150 grams. Maximum tongue force remained the same, not being significantly higher or lower when compared with the normal groups or those with other malocclusions.

How does one explain the protrusive position of the incisor teeth in bimaxillary dento-alveolar protrusions? The evidence, so far, strongly indicates there is a definite association of weak perioral musculature and relatively normal tongue pressure. When one compares the opposite effect on the position of the teeth by a strong perioral muscu-

* Individuals whose dentition may appear protrusive but who are able to keep the lips closed in repose without effort or strain were not considered in this group.

lature as in a Class II, Division 2 malocclusion, it becomes evident that the perioral musculature plays a very important role in incisor tooth position. Thus, because of weak perioral muscle force the mandibular and maxillary incisor teeth assume a more protrusive position.

This investigation supports the hypothesis as to how some children develop into a bimaxillary dento-alveolar protrusion. The causes for patients habitually keeping the mouth open may vary. For example, patients experiencing breathing difficulties at an early age tend to keep the mouth open continuously. Children with large adenoids and tonsils, or those suffering from allergies which affect normal breathing invariably keep the mouth open so normal lip function is impossible. Even if normal breathing is eventually restored through medical treatment, the teeth may have migrated too far forward for normal perioral function to take place. Because normal breathing and function do not occur, the perioral musculature never reaches its potential strength and remains weak. When patients who have this type of malocclusion also develop a tongue thrust, the teeth may be pushed forward beyond the limits of alveolar retention causing severe periodontal problems at a relatively young age.

From a clinical point of view once the habits are controlled and the causes for the breathing problems are removed, orthodontic treatment will be successful. The aim in treatment is to move the incisor teeth in a lingual direction so the patient is able to keep the lips closed without effort. With normal lip function thus restored the perioral musculature becomes stronger and the results of treatment will remain stable. To illustrate this type of therapy the following patient serves as an example.

The patient (Fig. 16), a female age twenty-five, had a bimaxillary dento-alveolar protrusion. The severe periodontal involvement and the mobility of the maxillary incisor teeth were aggravated by a tongue-thrusting habit during swallowing. The mouth was habitually open and the lips were in poor function. The maximum perioral force for this adult at the beginning of treatment was 100 grams with a maximum tongue force of 2200 grams. (The average lip force of an eighteen year old female is 251 grams). Treatment consisted of eliminating the tongue habit and uprighting the mandibular incisors through the removal of a mandibular incisor tooth. The protrusion of the maxillary arch was reduced by moving the incisor teeth in a lingual direction. When the case was placed in retention six months after the beginning of treatment, maximum perioral force had increased to 150 grams and the maximum tongue force was still 2200 grams. Ten months after treatment was begun, maximum lip force increased to 190 grams and maximum tongue force was 2225 grams. The mobility of the incisor teeth had decreased and marked improvement in the periodontal condition was noted (Fig. 17). The maxillary left lateral incisor was removed just prior to retention and was replaced by a fixed restoration. The patient's over-all improvement was due to elimination of the habit and reduction of the protrusion so that normal perioral function could take place.

Class II, Division 1 Malocclusions

In Table II maximum perioral forces for Class II, Division 1 malocclusions at various age levels may be noted. The range of maximum perioral force is 95 to 250 grams in an age range of seven and a half to sixteen years. It was observed that in those malocclusions which were less severe, i.e., where the overjet was only two to three millimeters, normal lip function was not greatly affected. The maximum perioral

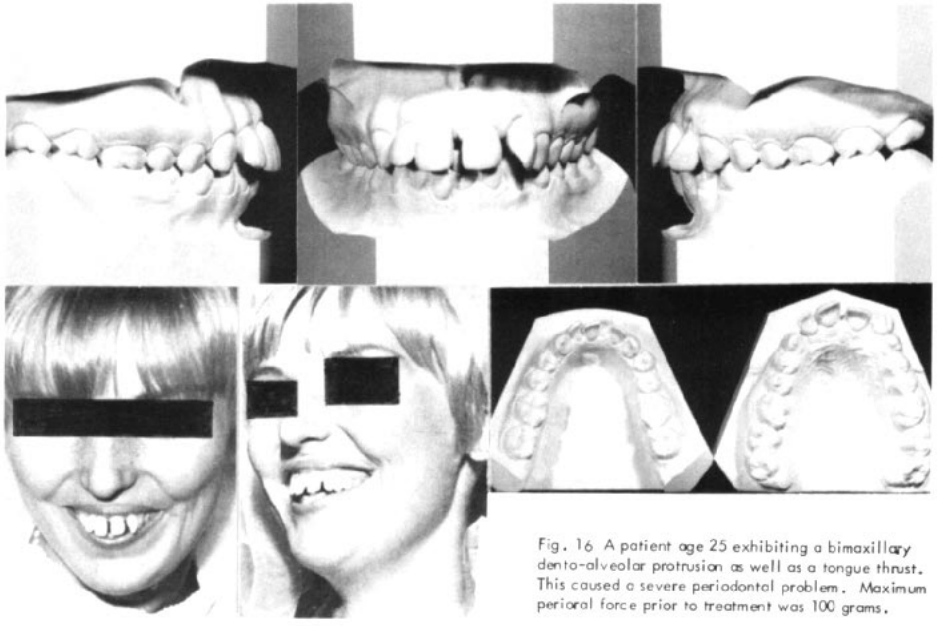


Fig. 16 A patient age 25 exhibiting a bimaxillary dento-alveolar protrusion as well as a tongue thrust. This caused a severe periodontal problem. Maximum perioral force prior to treatment was 100 grams.

Fig. 16

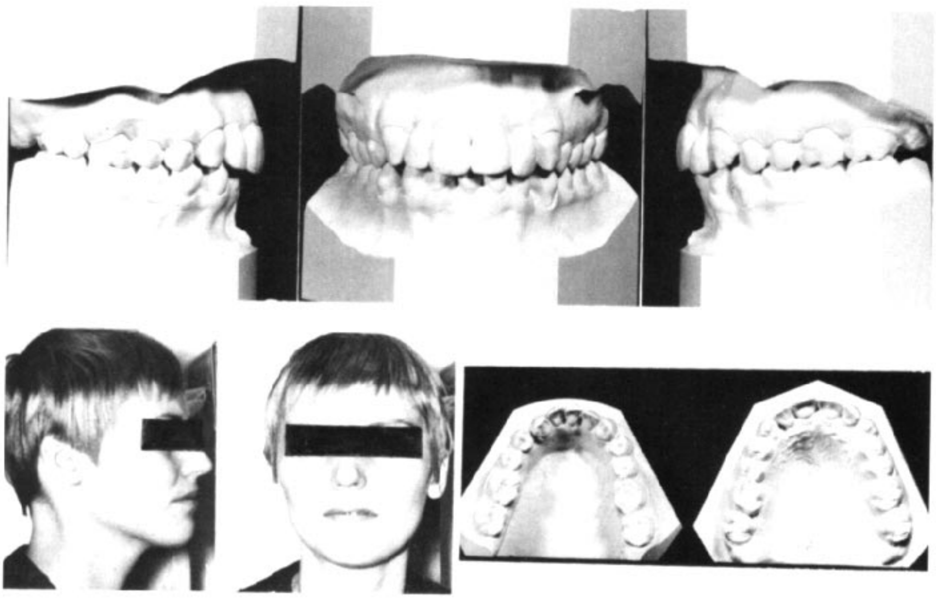


Fig. 17

force in these patients was similar to that of normal occlusion at the same age level. Where there was a severe protrusion of the maxillary incisors, however, normal lip function was curtailed and maximum perioral force was significantly lower than in those with normal occlusion. Those patients whose maximum perioral force was in the lower range (95-135 grams at ages 8½ to 12 years) exhibited a greater overjet and poor lip function. A few in this group exhibited a short, nonfunctional upper lip and a large overjet. An example of this type may be seen in Figure 14. His maximum perioral force was 100 grams at age eight and a half which is in the lower part of the normal range of 90-190 grams at the same age.

Clinical experience indicates that there is a difference in treatment response in these various types of Class II, Division 1. Those individuals whose maximum perioral force is in the lower range are more difficult to treat and respond less favorably to treatment than those whose maximum perioral force is in the higher range.

The concept of early interceptive treatment of Class II, Division 1 malocclusion is not new. Orthodontists are aware that malfunction of the perioral muscles, particularly in this class, will impede development of normal occlusion. As a result many clinicians will begin treatment during the mixed dentition period to develop good muscle balance as quickly as possible. Advocates of early interceptive therapy have made extensive use of cervical traction[44,45] to reduce the maxillary incisal protrusion. In addition to headgear mechanotherapy in the maxilla, the author has been routinely employing the vestibular appliance or lip bumper in the mandibular anchorage[41] or to regain space in the mandibular arch.[42] Its use in Class II, Division 1 malocclusions to restore, more quickly, normal lip function and improved facial esthetics has been invaluable. The rationale for its extensive use is to place the lower lip in a more anterior position, removing interference and contact with the lingual surfaces of the maxillary incisors, and away from the labial surfaces of the mandibular incisors.

Hypotonic and Hypertonic Lips

These adjectives are often used to describe the "tension" of the lips. Hypotonic is defined as "marked by abnormally low tension" and hypertonic as "showing an abnormally great tension." When one describes the lips as hypotonic, the general assumption is that there is a minimum of pressure brought to bear on the incisor teeth by the lips thereby implying that the dentition may be more protrusive. Conversely, when the term hypertonic is used, the assumption is that greater pressure is exerted on the incisor teeth suggesting that the dentition is less protrusive.

The method of determining the state of the perioral musculature and its evaluation may at best be described as subjective. The orthodontist may place his fingers in the mucobuccal fold attempting to stretch or "'palpate the thickness and character of the lips."[37] He will then state whether the lips are hypotonic or hypertonic. It is obvious that the interpretation of this method of perioral assessment is subject to great variations.

This study has indicated that there is a relationship between maximum perioral strength and the final position and angulation of the incisor teeth. It has also been demonstrated that high maximum perioral force is associated with hypertonicity. It is now possible with the method shown to more accurately describe the state of the perioral muscles. Thus, patients with bimaxillary alveolar protrusions, whose perioral function is poor and who show a low registration of maximum perioral force, may have lips justifiably described as hypotonic.

On the other hand, patients with certain Class I malocclusions and Class II, Division 2 malocclusions whose central incisors are inclined toward the lingual and whose maximum perioral strength is significantly greater than those with normal occlusion have lips in good function so that one would be justified in describing these individuals as hypertonic. How does one assess the tonicity of the lips in occlusions other than those just described? In studying maximum perioral force in individuals with normal occlusion a wide range of maximum perioral force was observed. For example, in Table I the range for females for maximum perioral force was 90-180 grams at age eight years. The clinical observation was made that patients in the lower range of maximum perioral force 90-120 grams showed a more protrusive incisor position, while in the higher range of 150-180 grams the incisors were in a more lingual position. One may therefore conclude that those patients from eight to nine years whose reading is in the lower range (90-120 grams) have lips described as *hypotonic*. Those in 120-150 grams range as "normal tonicity" and the remainder in the higher range (150-180 grams) would have their lips described as *hypertonic*. Thus one may note different degrees of hypo- and hypertonicity. For example, those in the hypertonic group may further be described as mildly hypertonic (150-165 grams), in the 166-180 gram range as hypertonic.

One may at this point question whether from an orthodontic point of view it would not be more informative to describe lips according to function rather than tonicity. There are certain malocclusions whose perioral muscle tonicity is difficult to assess.

For example, it is possible to have a patient who has a specific type of Class II, Division I malocclusion who might have a short, functionless upper lip which is hypotonic. The overjet is large so that the lower lip is in continuous contact with the lingual surfaces of the maxillary incisors. The mandibular incisors are inclined to the lingual because of a hyperactive mentalis muscle. Here two types of lips are present, an upper lip which is hypotonic and a lower lip which is hypertonic. Thus it may be more informative for the orthodontist to describe the lips of this patient as a Class II, Division 1 and having lips that are in *malfunction*. A patient who has a bimaxillary alveolar protrusion would be classified as having lips which are in *poor function* and individuals who are able to close their lips in repose without effort would be in *normal function*.

Summary and Conclusions

1. A significant relationship has been shown to exist between maximum strength and force of the lips and the final position and angulation which the maxillary and mandibular incisor teeth assume after eruption.

2. Maximum perioral force increases with age in both males and females with normal occlusion.

3. There is no significant difference in maximum lip force in males and females between the ages of eight to fourteen in those children with normal occlusion. After the age of fourteen the males exhibited a higher maximum perioral force.

4. There is no significant difference in maximum lip force at the same age level between those with untreated normal occlusions and those whose malocclusions have been treated.

5. Maximum tongue force increases with age in both groups, those with normal occlusion as well as in patients with malocclusions.

6. There is no significant difference in maximum tongue force at the same age levels between those of normal occlusion and patients with malocclusions.

7. The tendency for maximum lip

force to increase with age is not evident in children whose malocclusions are described as bimaxillary dento-alveolar protrusions.

8. Maximum perioral force in patients exhibiting Class II, Division 2 malocclusions is significantly higher than in any other group studied. Maximum tongue force in these cases is not significantly different from those individuals with normal occlusion at the same age.

9. From this study there is strong evidence that the role of the tongue in determining the final position and angulation of incisor teeth is minimal except in those patients where there is a perverted tongue position either during deglutition or at rest.

10. Early treatment of patients exhibiting Class II, Div. 2 tendencies is recommended.

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