The Tongue, the Lingometer, and the Role ofAccommodation in Occlusion

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A new diagnostic swallowing device (lingometer) and its huse to detect deforming tongue movements is described. A theory explaining the relationship of these movements to arch formation is also presented.

KEY WORDS: • LINGOMETER • MALOCCLUSION • TONGUE •

"We are just beginning to realize how common and varied are the vicious habits of the lips and tongue, how powerful and persistent they are in causing and maintaining malocclusion, how difficult they are to overcome, and how hopeless is success in treatment unless they are overcome."

— Edward H. Angle, M.D., D.D.S.: November, 1906

In this era of microchips, lasers and heart transplants, it may seem anachronistic over three quarters of a century after Angle made the statement above to still write about the relationships between the tongue and malocclusion. Perhaps this is because as orthodontists rather than speech pathologists, it has been easier to accept abnormality in skeletal development rather then abnormality in tongue function as a cause of malocclusion or as contributing to recurrence of a previously corrected malocclusion. Perhaps we have simply been baffled in dealing with such a virtually uncontrollable etiologic factor.

The diagnosis of adverse tongue behavior and its effect on the teeth can often cause frustration in our practices if good orthodontic results cannot be achieved or maintained even with the use of accepted myofunctional treatment procedures. This dilemma is examined by viewing the application of presently accepted research somewhat like a facet on a jewel, essentially the same, yet new and different.

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If one desires to move the maxilla anteriorly, the interdigitations of the sutures and the sutural ligament may oppose movement (NANDA AND HICKORY 1984); however, functional stresses may shape bone nevertheless.

WEINMAN AND SICHER (1955) wrote:

> "Generally it can be said that change of function in the young, growing skeleton leads to changes of shape and structure . . . it is as if the growing bone would grow into a new pattern, determined by the new mechanical forces."

This is Wolff's *Law of Transformation of Bone,* which is the theoretical basis for bone deformation due to tongue thrust.

Changing Theories

A short historical review of orthodontic literature reveals many different theoretical and clinical explanations for tongue thrust and its effects.

Habits and upper respiratory conditions have consistently been thought to be major contributors to tongue thrusting. A sucking habit could initiate an open bite which the tongue would maintain; or colds, allergics, tonsillitis, mouth breathing for various reasons, etc. could encourage a child to thrust the tongue during swallowing.

TEUSCHER (1940), RIX (1953), STRANG AND THOMPSON (1958) all attributed swallowing "perversions" to habits and/or an imbalance in the mechanism of nerve control. The latter claim these habits are nearly always seen in high-strung nervous children, but call this a secondary cause and admit they do not know the primary cause.

Some looked for the cause in skeletal growth deficiency. BALLARD (1959) suggests that lack of ramus growth and resultant high mandibular plane angles would make it difficult for the dorsum of the tongue to contact the hard palate, thus causing the patient to thrust the tongue forward in order to make an adequate swallowing seal. However, COHEN AND VIG (1976), in a study of 48 subjects based on longitudinal radiographic material, concluded that the tongue becomes *larger* in relation to the intermaxillary space and tends to descend during growth.

Others, beginning with STRAUB (1960), claim improper bottle feeding as the cause, since nipples with large holes force an infant to thrust the tongue to stop the excess flow. A spinoff from this research was the development of the *Nuk Sauger* functional preventive orthodontic program (BARRET 1961, ROCKY MOUNTAIN DENTAL PRODUCTS, CO. 1970). This includes a rubber nipple resembling the human nipple that is designed to simulate breast feeding, and a rubber exerciser of similar design.

In a departure from theories involving learned behavior, STOLZENBERG (1962), proposed that swallowing patterns were an inherited involuntary act which he tried to treat by hypnosis. He claims that in the trance state it is easier to acquire conditioned responses. More recently, SUBTELNY (1965) proposed that in the transitional stage at least, tongue thrust may really be an adaptation of the tongue to its environment, such as protruding where incisors are missing, or as an adjunct to thumb and finger sucking.

HANSON AND COHEN (1973), in a ciné study of 178 children over a four-year period, also say that it is possible that both form and function may contribute to the persistence of tongue thrusting as well as to the development of a malocclusion.

It should be recognized then, that among researchers there seems to be no real agreement as to the etiology of anterior tongue thrust.

The Role of Accommodation

As the oral cavity enlarges during childhood development, the neck elongates and the hyoid bone drops. The tongue moves back from the infantile to the mature position during this transitional period, which is usually completed by the second or third year (HANSON, BERNARD AND CASE 1970).

GRABER (1963) describes swallowing at this stage: "The lips close, and the incisors come together momentarily as the tip of the tongue lies behind the incisors during the swallowing act." He goes on to say that the functional force of the tongue is so great that it can hardly be ignored, either developmentally or orthodontically.

Much research has been directed toward determining tongue position in post-transitional swallowing patterns. ADRAN AND KEMP (1955), in a ciné radiographic study of 250 adults under thirty, state that when swallowing begins, the tongue tip is thrust forward against the upper anterior teeth. FLETCHER (1961) also observed tongue thrust patterns in a study of 1,615 school children, noting tongue thrust in 52.3% at age 6, 38.5% in the 8-13yr range, and 36.7% over 13yrs.

Researching from a different point of view as practicing orthodontists, BRAVER AND HOLT (1965) identified deforming and nondeforming tongue thrust, using as their criteria the resulting malocclusion, such as anterior and posterior open bites, Class II conditions, etc.

HEDGES AND MCLEAN (1965), in a ciné analysis of 22 children with excellent occlusions, found that in the majority of these cases the tongue contacted the maxillary incisors. They concluded that "The presence of tongue thrust pattern in that group was rather startling." What they considered a tongue thrust pattern was the forward movement of the anterior part of the tongue during the anterior alveolar phase of swallowing.

One of the broadest descriptions of normal swallowing is that described by SUBTELNY (1965):

1. The muscles of facial expression are not used during the act of swallowing.
2. The muscles of mastication bring the teeth and jaws together and hold them together during the act of deglutition.
3. The tongue remains within the confines of the dentoalveolar arches.

He then goes on to say that we should be careful not to accept even those descriptions "carte blanche."

It is apparent from the preceding reports (ADRAN AND KEMP 1955, GRABER 1963, CLEALL 1965, HEDGES AND MCLEAN 1965, AND SUBTELNY 1965) that swallowing with some forward movement of the tongue is a usual characteristic.

When the hard structures of some children react adversely to this normal tongue movement in accordance with Wolff's Law (WEINMAN AND SICHER 1955) by being more responsive, a malocclusion will be produced. If the tongue accommodates to the malocclusion during swallowing, the resultant tongue behavior may, in turn, cause further orthodontic problems if it is not corrected.

To illustrate with a hypothetical case, consider an individual with normal swallowing from infancy to the transitional state. At this time, however, in certain responsive children, perhaps due to sutural adaptations (NANDA AND HICKORY 1984), a maxillary protrusion is produced by the heretofore normal tongue pressure acting on the maxillary bone and teeth during swallowing.

If the tongue does not accommodate to the abnormal dental structures, no retraining is necessary after orthodontic correction.

However, if the child's tongue funtion accommodates to the protrusion by force-

fully flowing into it with every swallow, some very refractory additional problems will follow. The normal swallowing pattern will have been perverted to an "anterior tongue thrust," and this accommodation must be corrected if treatment and retention are to be successful, because the acquired tongue movement may persist even after orthodontic treatment has been completed.

The various responses to the normal forward motion of the tongue in swallowing may be tabulated as follows:

I. No hard tissue reaction to normal tongue pressures. Development follows a normal course.

II. Hard tissue reacts abnormally to normal tongue pressures, creating alterations in the relationships of teeth.

   A. Tongue does not accommodate to the abnormal dental relationships, so no retraining is necessary.

   B. Tongue accommodates to the teeth, resulting in abnormal tongue function and pressures.

   Such abnormal swallowing may cause relapse of an orthodontic correction.

Tongue Thrust Measurement

Many devices have been used in attempts to scientifically measure tongue movements. They have varied greatly in size, cost, efficiency and ingenuity.

A significant development in the early 1950's was cineradiography. RAMSEY AND WATSON (1955) demonstrated an early use of cinefluorographic analysis of the mechanism of swallowing. This made it possible to more accurately assess the forward thrust of the tongue by providing a solution to the problems of disruption caused by using lip retractors or fingers to observe swallowing. Movements could also be identified with respect to a precise time reference, thus adding to the effectiveness of this research tool.

STEVENS (1956) used a converted electrocardiograph to measure tongue pressure on the teeth; however, this apparatus was not very successful by today's standards. About the same time, WINDERS (1956) connected sensitive strain gauges to an oscillograph to record pressures from the lips, cheeks and tongue, and found no balance between the buccal and lingual sides of the teeth. During function there seemed to be more pressure exerted on the teeth by the tongue than by the buccal musculature and lips.

SUBTELNY (1964) did a cephalometric analysis of tongue movements by applying a contrast medium containing tantalum powder to the midline of the tongue tip. HEDGES (1965), in what was probably the most extensive cinefluorographic study to date, filmed tongue position with a rotating anode x-ray tube, videx cone adaptation, image intensifier, binocular mirror system, Auricon camera, head positioner and simultaneous sound tracks.

FISHMAN (1969) visualized tongue movement with occlusal radiographs and SUBTELNY (1970) further refined the ciné system by increasing speed to reduce radiation dosage. Films were analyzed on a special projector using a computer. He pointed out in this study the relation between form and function, centering on muscle patterns before and after change of form.

WILLIAMS AND KENT (1973), attempting to directly measure tongue force, used a calibrated coil spring attached to a disk resting on the lips, against which the tongue pushed. The measurements were amplified by an electrical device (Sanborn carrier), and seemed efficient in measuring tongue pressures before and after surgical procedures on the genioglossus

Fig. 1
A lingometer viewed from below, showing the alignment groove that engages the lower anterior teeth. The pin, which is horizontal when in use, is free to move through the acrylic pad that is held by the teeth. The tip of the pin protrudes between the lips, while the inside end is embedded in the button that rests against the tongue.

muscle. Tongue force over a six-month period showed a gradual increase which approached the original force.

The Lingometer

The gap between experimental laboratory and clinical practice is apparent when one considers the type of measuring equipment used by these researchers. In order to utilize the information gained through research, a more practical, cost effective, easily used, but still accurate instrument would be required for the orthodontist's office.

After much research and careful clinical studies, the lingometer was developed.

The lingometer (lin-gom-eter), shown in Fig. 1, is a practical, inexpensive and easily–used instrument that measures the degree of tongue accommodation to deviant oral growth. The self-aligning grooves are engaged by the lower teeth of the patient, who then swallows. The movement of the tongue is easily measured, and this information can be utilized as part of a more effective treatment plan.

Clinical Procedure

• The lingometer is inserted with the groove resting on the incisal edges of the lower anterior teeth.

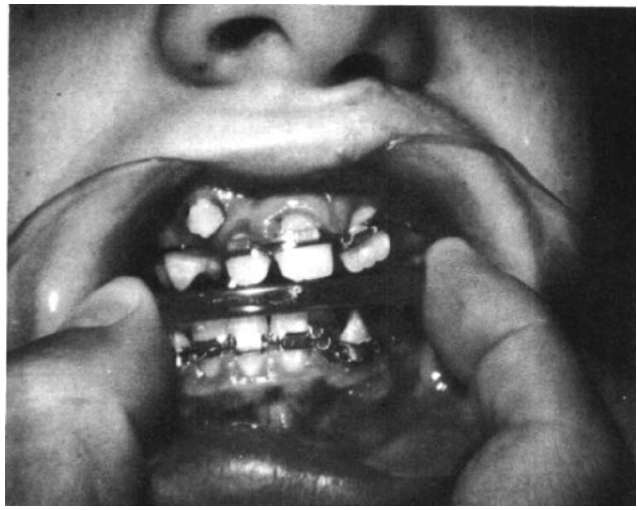

Fig. 2 A lingometer being positioned for a measurement

• The subject is instructed to close in their perception of normal occlusion, with the tongue resting lightly on the plastic disk. The wings of the device are held by the thumb and forefinger of the operator, with the last two fingers resting lightly on the larynx to detect the swallow (Fig. 2).

• The subject is then instructed to swallow. If there is a positive response, the disk will move the indicator shaft forward more than 1mm.

• This procedure is repeated to allow for tongue adjustment to an unfamiliar position. It may be necessary for the clinician to part the patient's lips slightly with the free hand to note movement of the shaft during the swallow.

The lingometer is a device for identifying an abnormal swallow by measuring the degree of tongue accommodation. This is a deviation from accepted theory that should be kept in mind in connection with the work that follows.

— Findings —

The lingometer has been clinically tested for over three years, examining 275 consecutive patients. Forty-seven of these were completed orthodontic cases, either in retention or ready for retainers.

All patients were seated upright in the dental chair and tested by the Author. If there was a twirling of the shaft, or forward movement did not exceed 1mm during testing, the reading was recorded as negative.

A patient with a positive response was retested to allow for tongue adjustment to an unfamiliar position (Table 1).

Since only the *movement* of the tip of the tongue and its relation to the lower anterior teeth are measured, the thickness of the part that is placed between the teeth does not affect the accuracy of the device. Tests with a thick lingometer were essentially identical to those with a thinner incisor pad (Fig. 3).

— Discussion —

Data in Table 1 indicates a marked increase in forward tongue pressure after seventeen years of age. This supports material collected by POSEN (1972), who has related an increase in maximum tongue force to age. For this reason, the lingometer has been most applicable in the six to seventeen age range. Below age six, difficulties in cooperation tend to affect the readings.

It is also seen that open bite cases are largely positive. ROGERS (1961), in examining fifty-six school children with open bites, reported that only one child did not demonstrate tongue thrust. The fact that there was not the 100% tongue thrust which one might expect to see in this type of malocclusion confirms the theory that this was probably a child in whom no tongue accommodation existed.

About half of the Class II cases in the sample showed positive lingometer readings. SUBTELNY (1964), in a study of forty-eight adolescents, found 48% with tongue thrust. These positive tongue accommodation cases indicated that the movement of the tongue had adapted to the protrusion. If the malocclusion had been corrected while the tongue still maintained accommodation to the pre-existing malocclusion, then the possibility for relapse would have been increased.

The fact that an anterior open bite was produced in some cases and a protrusion in others, was caused by the different position in which the tongue was carried forward during swallowing.

Of the twenty-eight sets of siblings examined, five sets of Class II malocclusions responded positively; that is, they demonstrated tongue accommodation. There was a group of sixteen sets with mixed responses; twelve positives in this group also had Class II malocclusion.

Tongue retraining has an important place in many orthodontic problems, and in the Author's office it is accomplished by a visiting speech pathologist. This particular program has been developed over a twelve-year period.

(JOSEPHSON 1960), in a request for a statement concerning his position in regard to current tongue thrust rehabilitation, replied:

> "Many of the tongue thrust rehabilitation programs have been based on the theory that some children swallow significantly different than others and that this

Table 1
Lingometer Response

	N Total	N ♀	N ♂	Positive ♀	Positive ♂
Patients	275	148	127	55	64
Siblings (sets)	28	31	27	12	13
Under 17	228	123	101	44	47
17 and Over	47	34	17	15	11
Class I	63	42	21	11	10
Class II	201	110	91	51	49
Class III	11	7	4	3	1
Open Bite	34	21	13	14	8
Finished	47	31	16	10	8
Relapsed	8	4	4	3	3

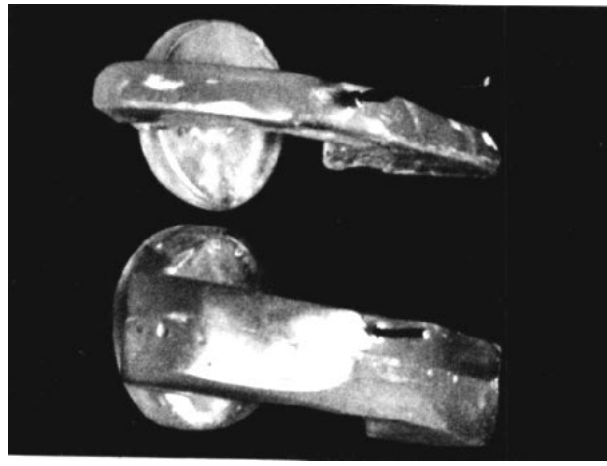

Fig. 3 Two lingometers viewed from the side, showing thick and thin versions. Thickness does not affect accuracy.

difference is the primary cause of certain types of orthodontic deviations. The basic research into deviant swallowing behavior appears to have been done in order to support this theory rather than to establish any clear-cut rationale. It was not until published studies from the Eastman Dispensary in Rochester, New York, that some questioning of the original Straub theory was initiated.

"In 1961, thought was given to the question: *Given that infant children generally swallow in a like manner, why then do some children whose teeth demonstrate certain abnormal positions appear to swallow differently than those whose bite may or may not be orthodontically sound?*

"Conclusions simply state that, as occlusion shifts, these individuals' tongue position during the swallowing process also shift to the new bite, resulting in both an increasingly abnormal swallow and additional orthodontic deviation. This specific behavior we have labeled "accommodation."

"Correction of a problem based on these conclusions is dependent on repositioning the tongue to its earlier placement and training the individual to involuntarily create a partial vacuum in the oral structure just prior to the act of swallowing. This causes a partial retraction of the tongue, rather than anterior movement, and prevents pressure on the lingual surfaces of incisors and cuspids. The process of change is behavioral in nature, and the entire program, including extended follow-up visits, lasts about eighteen months.

"A secondary source of change is by the use of the Nuk Sauger Secondary Exerciser. The individual is trained to sleep with the device in order to reposition the tongue when at rest. Ideally, the individual then is ready to accept orthodontic treatment and assist in the remediation process."

— Summary —

The assessment of swallowing function for each of our patients is a necessary though sometimes difficult

process. A different theoretical framework on the connection between abnormal tongue activity, tissue reaction and swallow patterns has been presented.

The lingometer has been developed to diagnose abnormal tongue force, based on this different theoretical framework. A positive response will indicate a need for a tongue retraining program in addition to orthodontic treatment, in order to minimize relapse by eliminating any unfavorable tongue accommodation.

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