

Tongue Thrusting, Tongue Pressure & Tongue Pressure Measuring Devices- A Review!!!

Pavankumar Singh¹, Anand Ambekar², Suresh Kangne³, Pravinkumar Marure⁴, Yatish Joshi⁵, Chaitanya Khanapure⁶.

¹Post graduate student, ²Professor, ³Professor & HOD, ⁴Reader, ⁵Lecturer
Dept of Orthodontics, MIDSR Dental College, Latur.

Abstract:

The tongue is a powerful muscular organ that exerts strong pressure at frequent intervals on the teeth during the daytime and nighttime. In tongue thrusting habits, the tongue is thrust between the upper and lower teeth in the jaw each time the patient swallows. It is clear that tongue function plays some role in the development of the dental arches. The distortions of the arches which accompany micro- or macroglossia, as well as the less dramatic but clinically significant effects as seen in oral habits such as tongue-thrusting, illustrate the possible effects. This article is to review various studies conducted on assessing tongue pressure using different pressure measuring devices in patients with or without tongue thrusting habit.

Key words: Early malocclusion treatment, early orthodontic treatment, interceptive orthodontics, preventive orthodontics.

Corresponding Author: Dr.Pavankumar R singh, Post graduate student, Dept of Orthodontics, MIDSR Dental College, Latur. Email id.: pavansingh6sept@gmail.com

INTRODUCTION

The tongue is a powerful muscular organ that exerts strong pressure at frequent intervals on the teeth during the daytime and nighttime. In tongue thrusting habits, the tongue is thrust between the upper and lower teeth in the jaw each time the patient swallows.¹

It is clear that tongue function plays some role in the development of the dental arches. The distortions of the arches which accompany micro- or macroglossia, as well as the less dramatic but clinically significant effects as seen in oral habits such as tongue-thrusting, illustrate the possible effects.²

Most dental professionals accept the theory of Tomes (1873), who asserted that opposing forces or pressure from the lips or cheeks on one side and the tongue on the other, determine the position of the teeth in the arch.³ The contribution of the forces of the lips, cheeks, and tongue are of particular interest to orthodontists in making correct treatment planning.

The technical skills and protocol that the orthodontist uses to assess these forces of tongue and perioral muscles may determine the ultimate success of orthodontic treatment.^{4,5}

Forces acting on the dentition are produced, principally, by perioral musculature and tongue. The forces play an important role in guiding teeth eruption and occlusion formation and maintaining dental arch shape and stability.^{6,7}

The dentition is supposed to be in a state of balance between forces from the outside, the lips and cheeks, and forces from the inside, the tongue. During the past decades, a lot of devices have been used to study these forces and some conclusions were made that the position of the teeth was influenced by the forces developed by the soft tissues surrounding them and that there existed a dynamic equilibrium between forces from lips and cheeks and those from tongue.

This dynamic balance would be different as oral functions change.^{6,7}

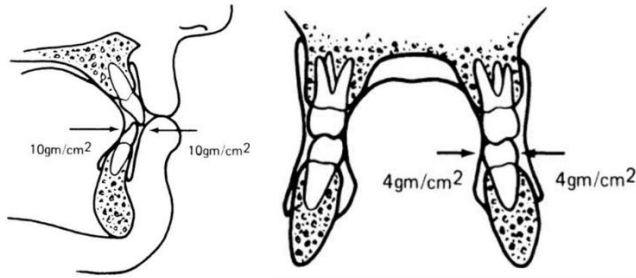


Figure 1: Equilibrium theory

Oral habits are repetitive behavior in the oral cavity which results result in loss of tooth structure and they include digit sucking, pacifier sucking, lip sucking and biting, nail-biting, bruxism, self-injurious habits, mouth breathing and tongue thrusting. These para functional habits are recognized as a major etiological factor for the development of dental malocclusion. Thumb sucking and tongue thrusting are the common ones. Abnormal tongue function, volume and posture have been long debated as a cause of malocclusion. Le foulon, in 1839 quoted “prevention is better than cure.” Understanding the etiology, effects and it management at an early stage may be very helpful to prevent future severe skeletal malocclusion.⁸

Figure 2: Open-bite in Tongue thrusting habit



To the extent that the form of dental arches is influenced by the musculature, resting pressures and resting posture of the tongue and lip seems more

important than pressure during swallowing or speech.⁷

It is very important for orthodontists to understand the effect of tongue function in the correction of malocclusion and stability after treatment. It has been reported that tongue thrust may be initiated during orthodontic treatment, especially when treatment creates temporary open spaces anteriorly or interferences with intercuspation or reduces tongue space. Cheng et al proposed that all tongue dysfunctions should be corrected if long-term stability of treatment results is desirable. Myofunctional therapy is can be indicated for correction of tongue thrust swallowing. It has been demonstrated that both myofunctional therapy and crib therapy in combination are successful in correction of tongue thrust swallowing.⁹



Figure 3: Different tongue thrusting habit breaking appliances

Equilibrium Theory, Muscle Pressures And Etiology:

The question of tongue lip pressure in the etiology of the malocclusion is basically a question of the validity of the “equilibrium theory” of the tooth position. Since the teeth remain in the stable position most of the time in most of people, and since tooth movement is observed when additional forces are

added to the system, it is apparent that there is an equilibrium which can be upset leading to proclination of teeth seen in tongue thrusting patients. However, it does not follow that teeth rest in the area of absolute balance between tongue and lip pressures. Therefore, it is more important to know the contributions of tongue and lips to the equilibrium. Direction, duration, magnitude of force are important variables which must be considered. According to findings of several investigators, even when the longer duration of lip pressures is taken into the account, the muscular activity of lips does not balance the functional activity of tongue. Time pressure integral come closer but do not balance.^{6,7,10}

Several authors suggest that resting pressure rather than pressure during the functional activity might be more likely to influence the position of teeth. Brader hypothesized that the radius of curvature of dental arch influences the stresses on teeth, and this factor added to the resting pressure would reveal the equilibrium statement.⁷

All the above relates to the horizontal position of the teeth in the arches, however vertical position of the teeth may be influenced by the functional activity. As the amount of force accompanying tooth eruption is few grams, vertically directed intermittent forces accompanying swallowing and other activity might influence the eruption of teeth and resulting in open bite.⁷

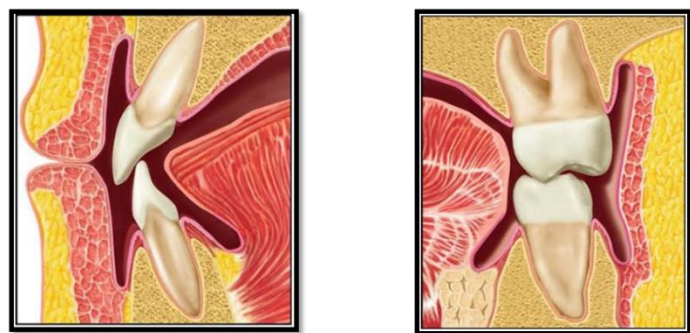


Figure 4: Neutral pressure zone of the teeth in anterior and posterior region of the arches.

PRIMARY FACTORS IN EQUILIBRIUM POSITION OF TEETH:-

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

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

SECONDARY FACTORS IN EQUILIBRIUM POSITION OF TEETH:-

1. Influences on postural relationship in the stomatognathic system
2. Secondary factors relating to eruption forces

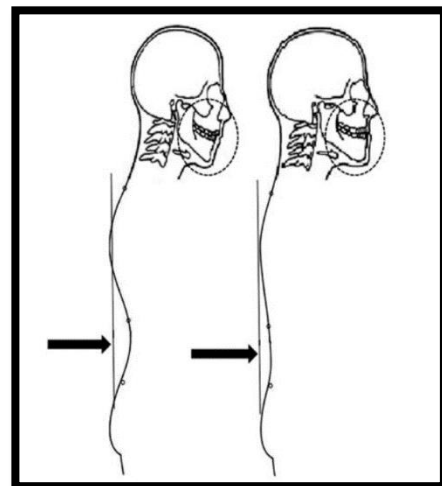


Figure 5: Patients with distal & vertical craniofacial patterns present higher than normal upper thoracic, lumbar lordotic and pelvic angle and vice versa.³⁵

VARIOUS METHODS EMPLOYED IN THE PAST STUDIES TO STUDY TONGUE ACTIVITY¹⁰: -

Electromyography-

Moyers investigated functional movements of the oro- facial musculature using the electromyograph. Since then, Tulley, Marx, and many others have contributed.

Measurement of intraoral pressures-

With the introduction of small transducers, intraoral pressures can be measured more accurately than with other methods previously described. Winders was probably the first in this field, and he has been followed by many other investigators who have confirmed that the tongue is probably more important than the surrounding musculature causing relapse of orthodontic treatment.

Cinefluoroscopy-

Ardran and Kemp, Cleall, Tulley, and others have shown that this technique has limitations in terms of speed and is only two dimensional. It does not lend itself to serial studies because, although the dosage is small using image intensifiers, it is difficult to persuade patients that it is clinically necessary.

Cephalometric head films.-

Peats and others have shown the possible differences between the relaxed and habitual postures of the tongue and this, in turn, has made some contribution to our knowledge. However, this technique is subject to variation.

Neurophysiologic experiments-

Bosma and his co-workers, Grossman, Berry, and Fawcus, have carried out various neurologic tests on the behavior of the tongue. So far, the use of stereognostic tests has indicated very considerable individual differences in lingual sensorimotor factors.

Serial cinephotography-

This is difficult to analyze scientifically, but, it does highlight the individual variations. Although cinephotography cannot display the intraoral movements of the tongue, work by Whillis and other film studies carried out by the Veterans Organization have shown tongue movements through surgical defects in the fact. This longitudinal approach has proved to be of great value.

DIFFERENT TYPES OF DEVICES USED IN STUDIES TO MEASURE TONGUE PRESSURE: -

1. Mouthpiece containing strain gauges
2. Mouthpiece containing load cells
3. Mouthpiece containing force sensing resistors
4. Pressure sensors attached on teeth or on palatal plates
5. Dynamometers
6. Bulbs filled with some fluid and connected to a pressure sensor
7. Myometer 160
8. Flexible resistive sensors

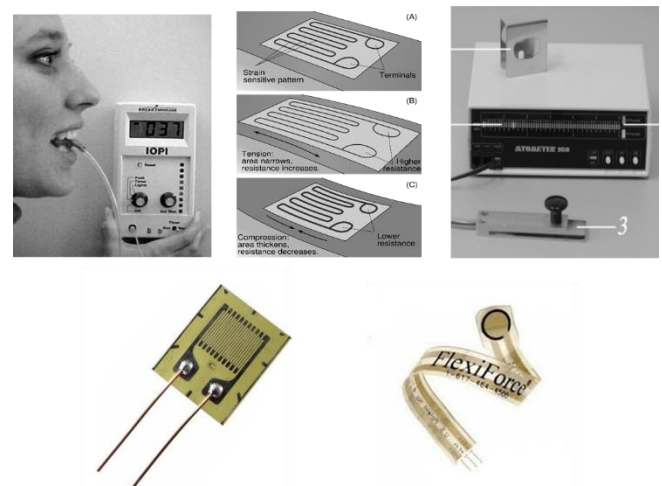


Figure 6: Different tongue pressure measuring devices

REVIEWS OF VARIOUS STUDIES CONDUCTED ON TONGUE PRESSURE:

Reference	Method	Sample	Results
Kydd (1956) ¹¹	Mouthpiece containing three strain gauges	One edentulous 30 years old man	Maximum force exerted anteriorly 23.13 N. Maximum force exerted laterally to the right: 11.56 N. Maximum force exerted laterally to the left: 10.23 N
Winders (1958) ⁴	A-19 strain gauges	25 subjects with different malocclusion	Swallowing pressure ranged from 0.581 psi to 10.138 psi
Kydd et al. (1963) ¹²	Mouthpiece containing two strain gauges	Subjects aged between 14 and 20 years old, with and without anterior open bite	Average pressure during swallowing was 27.95 kPa in subjects with anterior open bite and 12.06 kPa in normal subjects
Proffit et al. (1964) ¹³	Mouthpiece containing two strain gauges	19 men aged between 22 and 32 years old	Average of maximum pressure during saliva deglutition was 4 kPa on anterior teeth and 4.20 kPa on lateral teeth
Posen (1972) ³	Dynamometer	Subjects with normal occlusion	Maximum force: 6 N to 25 N.
McWilliams, Kent (1973) ¹⁴	Dynamometer	Seven subjects with tongue thrust and open bite	Maximum force: 4.83 (Measurements were recorded on a zero to ten scale)
Dworkin (1980) ¹⁵	Mouthpiece containing a strain gauge	67 men and 58 women aged between 20 and 72 years old	Maximum force exerted anteriorly: 32.9 N for men and 27.5 N for women. Maximum force exerted laterally to the right: 31.7 N for men and 28.7 N. Maximum force exerted laterally to the left: 29.3 N for men and 23.7 N for women

Frohlic et al. (1990) ¹⁶	A cannula, to provide water scape, connected to a pressure measuring system.	25 young adults with normal dental occlusion	Average pressures in rest position were - 0.17 kPa, -0.001 kPa, -0.03 kPa and 0.48 kPa, during chewing were 5.08 kPa, 9.41 kPa, 9.34 kPa e 14.33 kPa and during swallowing were 19.65 kPa, 32.65 kPa, 30.45 kPa e 27.56 kPa at upper incisor, lower incisor, upper molar and lower molar respectively.
Robinovitch et al. (1991) ¹⁷	Mouthpiece containing two strain gauges	One normal subject	Maximum force exerted laterally: 14.1 N Average force exerted laterally: 3.03 N
Scardella et al. (1993) ¹⁸	Mouthpiece containing a strain gauge	Five normal male subjects aged between 21 and 36 years old	Maximum force ranged between 9.50 N and 16.33 N, average maximum force was 12.67 N±1.25 N
Mortimore et al. (1999) ¹⁹	Mouthpiece containing load cell	86 women and 81 men aged between 42 and 62 years old	Maximum force for men: 26±8 N Maximum force for women: 20±7 N
Bu Sha et al. (2000) ²⁰	Bulbs filled with saline and connected to a pressure sensor	11 men between 19 and 41 years old	Maximum force: 28.0±2.0 N
Blumen et al. (2002) ²¹	Mouthpiece containing a strain gauge	Eight healthy men aged between 25 and 60 years old.	Maximum force: 5.44±1.52 N
Hayashi et al. (2002) ²²	Bulbs filled with air and connected to a pressure sensor	41 subjects between 24 and 85 years old	Average pressure: 27 kPa
Clark et al. (2003) ²³	Bulbs filled with air and connected to a pressure sensor	63 subjects aged 19 to 95 years old	Maximum pressure: 40 kPa Average pressure: 35 kPa
McAuliffe et al. (2005) ²⁴	Bulbs filled with air and	15 subjects between 20 and 31	Average pressure: 36.92 ± 6.44 kPa

	connected to a pressure sensor	years old	
Hori et al. (2006) ²⁵	Seven pressure sensors attached on a palatal plate	10 healthy subjects (8 men and 2 women) between 24 and 30 years old	Pressure during swallowing ranged between 0.8 and 17.1 kPa
Ball et al. (2006) ²⁶	Three Bulbs filled with air and connected to a pressure sensor	21 subjects (average age of 63,6 years old)	Pressure during swallowing: between 7,76 kPa and 20,56 kPa
O'Connor et al. (2007) ²⁷	A mouthpiece containing a round button connected to the force sensor by a cylindrical steel beam	12 male subjects with average age of 23 years old	Maximum force: 24.3 ± 6.7 N
Kieser et al. (2008) ²⁸	Eight pressure sensors attached on palatal plate	five adult volunteers	Pressure during swallowing of 10 mL of water ranged from 13.05 to 289.75 kPa
Utanohara et al. (2008) ²⁹	Bulbs filled with air and connected to a pressure sensor	843 subjects between 20 and 79 years old	Maximum pressure was 41.7±9.7 kPa between 20 and 29 years old; 41.9±9.9 kPa (30 to 39); 40.4±9.8 kPa (40 to 49); 40.7±9.8 kPa (50 to 59); 37.6±8.8 kPa (60 to 69); and 31.9±8.9 kPa (70 to 79)
Hori et al. (2009) ³⁰	Five pressure sensors attached to the palate	30 healthy subjects (20 men and 10 women) between 24 and 35 years old	Pressure during swallowing ranged between 1.0 and 14.5 kPa
Barroso et al. (2009) ³¹	A piston-cylinder assembly attached hydraulically to a pressure	10 subject aged between 14 and 80 years old	Average force: between 3.55 N and 13.24 N Maximum force: between 4.97 N and 19.96 N

	sensor		
Lambrechts et al. (2010) ⁵	The Myometer 160	107 subjects between 7 and 45 years old	Average pressure: 1.66 N
Tasalan et al. (2010) ¹	Diaphragm type transducer placed on palatal crib	13 tongue thrusting patients	Resting tongue pressure decreased from 21.09 ± 14.55 g/cm ² to 12.8 ± 2.41 g/cm ² and swallowing tongue pressure decreased from 216.43 ± 65.79 g/cm ² to 142.95 ± 29.2 g/cm ² at the end of 10th month
Valentim et al. (2014) ³²	Flexiforce resistive sensor placed on central incisor	28 subjects, aged 19–31 years	At rest- 0.00 ± 0.00 N, During swallowing- 0.31 ± 0.38 N
S Deshmukh et al. (2018) ³³	3 Flexiforce resistive sensor placed on palate	30 subjects with different growth pattern	Mean tongue pressure in average growth pattern cases was 49.48 Kpa, horizontal growth pattern was 51.47 Kpa, and vertical growth pattern was 35.36 Kpa.

OBSERVATIONS DEDUCED FROM THE ABOVE STUDIES:

Several researchers developed methods to quantify force/pressure exerted by the tongue, using different technologies. A trend of using strain gauges was observed in the first devices developed. Recently, the number of researches using bulbs and palatal plates with pressure sensors increased.

Some of the important results of the studies conducted on tongue pressure can be summarized as follow:

1. Maximum force exerted on the dentition by the tongue ranges from 37-240 g/cm² and 112 g/cm² on average.⁴
2. Tongue pressure during deglutition ranges from 41 to 709 g/cm².⁴
3. Mean tongue pressure was significantly more in the anteriomedial part of the hard palate than the posteromedial part.³⁴
4. Mean tongue pressure in horizontal growth pattern cases was significantly higher than average growth pattern and vertical growth pattern has lesser tongue pressure when compared with average growth pattern.³³
5. During the habitual position lip forces were greater than tongue forces. In function tongue exerts a much greater force on dentition than does the perioral musculature.⁴
6. Form of dental arches is more influenced by the musculature, resting posture and resting pressure of tongue and lips than pressure during swallowing or speech.¹⁰

7. Equilibrium theory: -
- Forces exerted upon the crown of the tooth by the surrounding soft tissue may be sufficient to cause tooth movement in the same manner as that produced by orthodontic appliance.⁶
 - Each element of the dentition may have more than one position of stable equilibrium within the system composed of the natural oral environment.⁶
 - Differential forces, even when they are of small magnitude if applied over a considerable period of time can cause important changes in the tooth position.⁶
8. Forces from occlusion probably also play a role in the vertical position of teeth by affecting eruption.⁷
9. Respiratory needs influence head, jaw and tongue posture and thereby alter the equilibrium.⁷
10. Anterior open-bite subjects i.e. tongue thrusting patients exerts both tongue and lip pressures for a longer duration.⁹
11. Crib appliance wear results in a disturbance in intraoral pressure equilibrium.¹
12. Males perioral and lingual forces is larger than females.⁵

The wide variation in maximum and average strength and pressure values found were related to the great diversity of devices. Methodological differences made it difficult to compare tongue force measured in different studies, as it depends on a number of factors such as the degree of protrusion, the direction of the movement, the distance between mandible and maxilla, the tongue region in contact with the sensor, the area in which the pressure is exerted. A lack of reproducibility in any of these parameters might lead to significant variation in the obtained results.

CONCLUSION:

This review will improve our knowledge about the tongue pressure and various instruments and

methods employed to measure tongue pressure in patients with or without tongue thrusting habit. It will also help in early detection of abnormal tongue pressure for treatment planning and retrain and reprogram the altered tongue pressure.

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