ISSN: 2573-8224
Research Article
Journal of Oral & Dental Health

Evaluation of Tongue Force on Mandibular Incisor in Various Malocclusions

Parijat Chakraborty[1]*, Pratik Chandra[2], Ragni Tandon[3], Aftab Azam[4] and Ramji Rastogi[5]

[1]*Post Graduate Student, Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow, India*

[2]*Assistant Professor, Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow, India*

[3]*Professor, Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow, India*

[4]*Professor, Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow, India*

[5]*Private Practice, Ayodhya, India*

***Corresponding author**
Parijat Chakraborty, Post Graduate Student, Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow, India

Submitted: 17 May 2020; **Accepted**: 08 Jun 2020; **Published**: 27 Jun 2020

Abstract
Objectives: *The aim of the study is to evaluate the tongue force on the mandibular incisors in various malocclusions and among genders.*

Material and Methods: *512 subjects (340 females and 172 males) within the age group of 18-28years were selected for the study. The subjects were divided into three groups according the molar relation of the subjects. Molar relation and the tongue force exerted on the mandibular incisor of the subjects were recorded using a diagnostic kit and a Flexiforce resistive sensor respectively. Tongue force at rest (TFR), during swallowing (TFS) and maximum tongue force (MTF) were measured.*

Results: *There was a significant increase in MTF among males than females. A significant relation among the groups when TFR and TFS were compared was also found.*

Conclusion: *TFR and TFS were found to be influential in causing malocclusion and also a stronger tongue musculature among males than females was concluded while comparing MTF.*

Introduction
As believed by E H Angle, the environment of the dentition was a major cause of malocclusion, and it was possible to produce a stable ideal occlusion without extraction of teeth because the environment could be modified by the orthodontists. Just like orthodontics applies pressure to teeth, thus will the tongue. Primary factors in equilibrium include intrinsic factors: by tongue & lips; extrinsic factors: external pressure due to Habits & Appliances; forces from dental occlusion and forces from periodontal membrane: Eruptive forces. Of the primary factors involved in the dental equilibrium, it appears that resting pressure of tongue, lips and eruption forces have the proper force and time characteristics to relate to tooth position [1].

According to Graber and Swain, the trident factors affecting any habit or action are its Intensity, Duration or Frequency [2]. The duration of the force is more important than its intensity and frequency. Proffit, et al. was among the first researchers who measured force levels of the tongue against the maxillary incisors and palate during normal swallowing and concluded that the resting position was more significant than the swallowing position [3].

Many researchers introduced devices to measure force/pressure put by the tongue in oral cavity. Various categories like, Mouthpiece with gauge; Mouthpiece containing load cells; Mouthpiece containing force sensing resistors; Pressure sensors connected on teeth or on palatal plates; Dynamometers; Bulbs filled with some fluid and connected to a pressure sensing element and Intra Oral Performance Instrument (IOPI) and other technologies were used to quantify tongue force [4].

Hence, the aim of the study is to evaluate the tongue forces on mandibular incisor teeth in different malocclusions using a sensor and also to find out whether there is any significant relation between the force of tongue and malocclusion.

Materials and Methods
The appliance used to measure tongue force in our study is a small force sensitive resistor (FSR). It has a 0.16" (4 mm) diameter active sensing area (Figure 1). Two pins extend from the bottom of the sensor with 0.1" pitch making it board friendly. In the customized circuit, we used Atmed microcontroller (ATMEGA) which is an 8-bit microcontroller. This microcontroller has an inbuilt analog to digital converter (ADC). The voltage from the sensor is fed to the ADC pin of microcontroller. All the values are obtained in milinewton (mN) unit.

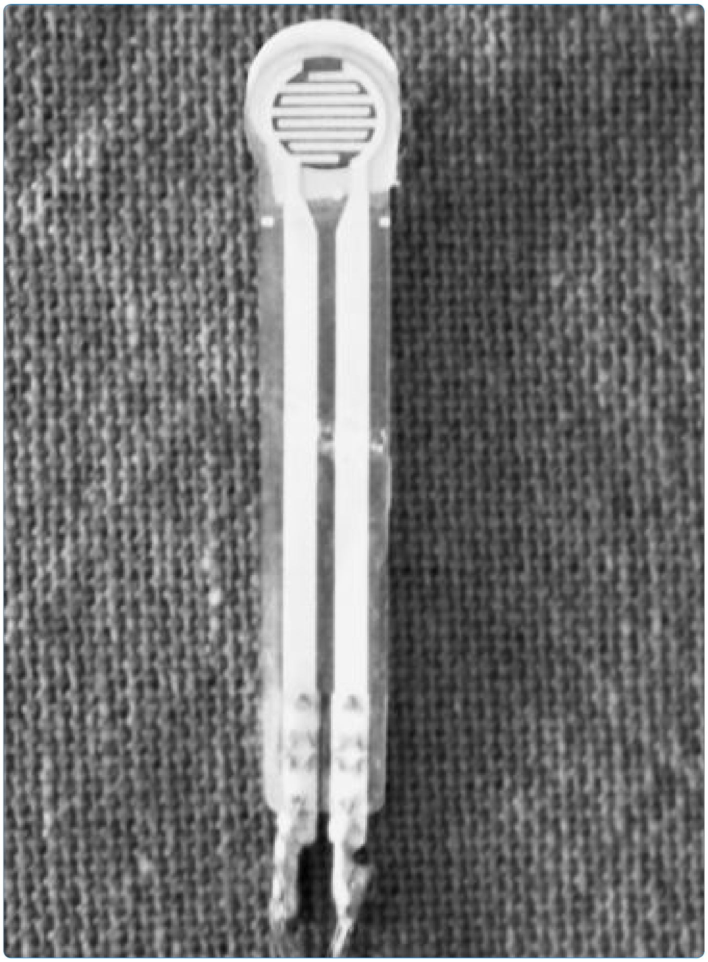

Figure 1: Flexiforce Resistive Sensor of diameter 0.16"

512 subjects were selected for the study falling under the inclusion criteria with no previous orthodontic treatment with a set of all permanent teeth present in the oral cavity. Subjects with any kind of systemic ailments were not considered for the study. The study protocol was approved by the Institutional Research and Development Committee (IRDC) and Institutional Human Ethical Committee (IHEC) of Saraswati Dental College & Hospital, India.

All the subjects were informed about the procedure with an informed consent. Diagnostic procedure to procure the molar relation of the individual was done under sterile and aseptic conditions using a diagnostic kit. The Angle's Classification was taken as a guide for categorizing into three groups of Angle's Class I, II and III. The sensor (FSR) attached to the circuit was covered with a sterilized cellophane pouch, subsequently fixing it using an adhesive with a customized instrument which was bent at a specific angle so as to easily adapt onto the lingual surface of the mandibular incisor of the individual. Then, the above component was placed in the oral cavity of the subject specifically on the lingual surface of the most proclined mandibular incisor. The subject was then asked to close his/her mouth normally and the circuit was attached to a power source. To obtain the tongue force, the individual was asked to place the tongue to its normal position i.e. at rest for a couple of seconds, and then he/she was asked to swallow without disturbing the component knowingly/unknowingly from its place in the oral cavity. Subsequently, subject was asked to exert maximum tongue force on the sensor placed lingual to the incisor for 2 seconds, the values obtained on the display of the circuit were recorded under the following headings; at rest (TFR), during swallowing (TFS) and maximum tongue force (MTF). The procedure mentioned above was repeated for a couple more time, for getting an average value of all the three readings i.e. average TFR, TFS and MTF.

Statistical Analysis

The data obtained was noted down which further helped in preparing the mater chart for the statistical analysis. The results were presented in frequencies, percentages and mean ± SD, minimum and maximum along with range. One Way ANOVA test was used for comparison. The p-value < 0.05 was considered significant. All the analysis was carried out on SPSS 18.0 version (Chicago, Inc., USA).

Results

Among the total 512 subjects included in the study, 340 were females and 172 males (Table 1). On comparing the average MTF among males and females, the mean value was found to be 193.4 and 177.2 respectively. There was a highly significant relation found among the gender (p value = 0.00) with an increased value among males than females. But it was not same when the same comparison was done with the other variables i.e. TFR and TFS (statistically non-significant) (Table 1).

Table 1: Comparison of MTF, TFR and TFS among Gender

	Gender	Statistic		Std. Error	"p" value
MTF	Female (N =340)	Mean	177.2330	1.62705	0.00
		Median	174.6667		
		Variance	897.432		
		Std. Deviation	29.95718		
		Minimum	99.67		
		Maximum	533.33		
	Male (N =172)	Mean	193.4477	1.74521	
		Median	191.5000		
		Variance	523.868		
		Std. Deviation	22.88816		
		Minimum	130.67		
		Maximum	303.00		
TFR	Female (N =340)	Mean	3.8004	.19983	0.063
		Median	4.0000		
		Variance	13.536		
		Std. Deviation	3.67917		
		Minimum	.00		
		Maximum	18.00		
	Male (N= 172)	Mean	3.1647	.27245	
		Median	3.3333		
		Variance	12.767		
		Std. Deviation	3.57315		
		Minimum	.00		
		Maximum	17.33		

TFS	Female (N= 340)	Mean	11.7099	.60536	0.060
		Median	12.3333		
		Variance	124.229		
		Std. Deviation	11.14580		
		Minimum	.00		
		Maximum	82.00		
	Male (N =172)	Mean	9.7267	.76826	
		Median	9.3333		
		Variance	101.517		
		Std. Deviation	10.07559		
		Minimum	.00		
		Maximum	41.67		

The statistical analysis revealed a mean value of average TFR as 2.0, 5.1 and 12.5 in Class I, II and III respectively with a standard deviation of 2.3, 3.1 and 2.5 in all three groups accordingly. The minimum values of the above variable was found to be 0 in both group I and II and 8.67 in Group III and maximum values were 10.3, 13, 18 accordingly. The values put forward a highly significant relation among the groups (p value of 0.00) (Table 2).

Table 2: Comparison of TFR among different malocclusion

Malocclusion	Statistic		Std. Error	"p" value
Class I (N = 324)	Mean	2.0741	.13253	0.00
	Median	.3333		
	Variance	5.691		
	Std. Deviation	2.38560		
	Minimum	.00		
	Maximum	10.33		
Class II (N = 163)	Mean	5.1943	.25012	
	Median	5.6667		
	Variance	10.197		
	Minimum	.00		
	Maximum	13.00		
	Std. Deviation	3.19332		
Class III (N = 25)	Mean	12.5600	.50285	
	Median	12.3333		
	Variance	6.321		
	Std. Deviation	2.51426		
	Minimum	8.67		
	Maximum	18.00		

Mean values of the average TFS was found to be 6.6, 16.5 and 31.9 with a standard deviation of 7.4, 10.9 and 4.1 in all the three groups consequently. The minimum value in group I and II was 0 and 22.3 in group III whereas 43.3, 82 and 41.6 were the maximum values in the groups respectively. A significant relation was found while comparing TFS among the groups (p value = 0.00) (Table 3). The mean value of average MTF for all the three groups was found to be 185.1, 177.9 and 182.3 with a standard deviation of 31.4, 22.3 and 26.6 respectively. While comparing the MTF, the relation was non-significant (p value = 0.063) among the malocclusion (Table 4).

Table 3: Comparison of TFS among different malocclusion

Malocclusion	Statistic		Std. Error	"p" value
Class I (N = 324)	Mean	6.6451	.41378	0.00
	Median	2.3333		
	Variance	55.473		
	Std. Deviation	7.44801		
	Minimum	.00		
	Maximum	43.33		
Class II (N = 163)	Mean	16.5174	.85768	
	Median	18.0000		
	Variance	119.904		
	Std. Deviation	10.95008		
	Minimum	.00		
	Maximum	82.00		
Class III (N = 25)	Mean	31.9867	.83032	
	Median	31.6667		
	Variance	17.236		
	Std. Deviation	4.15162		
	Minimum	22.33		
	Maximum	41.67		

Table 4: Comparison of MTF among different malocclusion

Malocclusion	Statistic		Std. Error	"p" value
Class I (N = 324)	Mean	185.0854	1.74665	0.063
	Median	181.8333		
	Variance	988.450		
	Std. Deviation	31.43962		
	Minimum	112.00		
	Maximum	533.33		
Class II (N= 163)	Mean	177.8998	1.75271	
	Median	175.3333		
	Variance	500.734		
	Std. Deviation	22.37709		
	Minimum	102.67		
	Maximum	238.67		
Class III (N= 25)	Mean	182.3733	5.33747	
	Median	181.6667		
	Variance	712.216		
	Std. Deviation	26.68737		
	Minimum	99.67		
	Maximum	240.33		

Discussion

According to the Theory of Tomes, the perioral musculature and tongue principally determines the position of the teeth [5]. In 1926, Friel pointed out that tongue pressure generally exceeds lip pressure which was later confirmed by Winders and Kydd [6-8]. Proffit, Ruan and Takada also concluded in their studies that the lingual force exerted on the dentition was higher than the perioral musculature forces [1,9,10]. Other authors acknowledged that muscle function, duration, speech and swallow can be a primary factor in causing and perpetuating a malocclusion (Hanson & Cohen, Garliner and Cheng) [11-13]. Contradicting to this theory, Subtenly, Hopkins and Doto N concluded that there was no such influence of internal and external musculature on the positioning of the dentition [14-16]. In accordance to these literatures we decided to measure the tongue force rather than other orofacial forces exerted on the teeth.

Studies performed by Tulley, Dworkin and Trawitzki verified that the force experienced by the anterior tooth during the habitual position and during swallowing adapted well to different types of occlusion than the posterior teeth [17-19]. According to the equilibrium theory by Proffit, Weinstein, Jung, et al. the effect of force produced by the tongue depends on the duration of the specific pressure because only sustained pressure by the tongue against the teeth would have an effect on the anterior dentition [1,20,21]. Keeping in mind the above, we measured the tongue force exerted on the mandibular incisor teeth specifically.

Proffit, Thüer, Winders suggested that light forces exerted by the lips, cheeks, and tongue at rest are more important than intermittent forces, such as forces exerted during speech and mastication Inappropriate positioning of the tongue is a major cause of occurrence of poor oral occlusion relapse [1,7,22,]. At rest, pressure from the tongue is slight but long lasting and, therefore, can move the teeth. Amanda Valentim, et al. in their literature reviewed that atypical swallowing can cause occlusion alterations [23]. It was also hypothesized that duration of tongue is much more important than magnitude. Swallowing occurs 203–1,008 times each day in healthy adults (Melsen) [24]. Therefore, as a frequently performed action, tongue force during swallowing and tongue during rest along with maximum tongue force exerted on the mandibular incisor teeth was observed in various individuals in our study.

Authors like Posen and Tulley conducted studies to find a relation between the force exerted by the lingual and perioral musculature on the dentition and the type of malocclusion present in the individual [17,25]. Similarly in our study the tongue force at rest among different groups was measured and observed the comparison to be significant with tongue force increasing among the groups. Lambrechts, Lowe A also found tongue force at rest to be significant among Angle's malocclusion [26,27]. Some also hypothesized contrary to our results that there was no significant relation among different malocclusion are Doto N, Ahlgren [16,28].

The comparison of tongue force during swallowing among malocclusion in our study was also found to be significant. Contradicting to the above Luffingham, Winders [7,29]. Supporting of our result were the studies of Shiono, Knösel and Cheng [13,30,31].

The comparison of MTF among malocclusion was not significant. Amanda Valentim, Doto N proposed the same [16,32]. But some researchers found significance among different malocclusion while comparing the maximum tongue force exerted on the dentition (Posen, Ruan, Yamaguchi and Jeong) [25,33-35].

According to our study the comparison of TFR among gender showed a non-significant relationship. Similar non-significant difference were seen in the studies conducted by Ruan, et al., Frohlic, et al., Proffit, Jung [1,21,33,36]. According to Frohlic, et al. the average tongue pressure at rest was -0.001 kPa at lower incisors, Thüer, McNulty found tongue pressure at rest to be negative in contrary to the results [22,36,37].

On comparing TFS among gender in our study, a non-significant relationship was found ($p = 0.06$). Similarly, according to Amanda Valentim tongue pressure and lip pressure during swallowing was of equal magnitude with no significant difference among gender [23]. Dworkin found an increased force among men than women (men 32.9 N and women 27.5 N) [18]. Mortimore, Jeong found a significant difference of maximum tongue force exerted on dentition among gender (males = 26 +/- 8 N; females = 20 +/- 7 N) [35,38]. In our study we found a significant relationship ($p = 0.00$) of maximum tongue force among gender with a mean force value of 193.4 in males and 177.2 in females.

Conclusion

The values from the study conducted revealed

- There was an influence of tongue position at rest on the malocclusion but
- There was no definite difference when compared among males and females.
- As discussed earlier that atypical swallowing or a frequent performed action can influence the malocclusion, it was evident from the former values that more force exerted during swallow affected malocclusion.
- This pattern of maximum tongue force showed that males have a stronger tongue musculature than females but the malocclusion was not influenced by the maximum tongue force.

References

1. Proffit WR (1978) Equilibrium theory revisited: Factors influencing position of the teeth. Angle Orthod 48: 175-186.
2. Graber TM, Swain BF (1975) Current orthodontic concepts and techniques. W.B. Saunders Company; 2nd edition.
3. Proffit WR (1975) Muscle pressures and tooth position: North American whites and Australian aborigines. Angle Orthod 45: 1-11.
4. Furlan RMMM, Valentim AF, Motta AR, Barroso MFS, da Costa CG, et al. (2011) Devices to Measure Tongue Force-A Critical Analysis.
5. Tomes CS (1873) The bearing of the development of the jaws on irregularities. Dental Cosmos 15: 292-296.
6. Friel ES (1926) An investigation into the relation of function and form. British Dental J 47: 353-379.
7. Winders RV (1958) Forces exerted on the dentition by the perioral and lingual musculature during swallowing. Am J Ortho 28: 226-235.
8. Kydd William L (1957) Maximum forces exerted on the dentition by the perioral and lingual musculature. The Journal of the American Dental Association 55: 646-650.
9. Wen-hua Ruan, Min-dong Chen, Zhi-yuan Gu, Yuan Lu, Ji-mei Su, et al. (2005) Muscular Forces Exerted on the Normal Deciduous Dentition. The Angle Orthodontist 75: 785-790.
10. Jun-ichi Takada, Takashi Ono, Shigeki Takahashi, Ei-ichi Honda, Tohru Kurabayashi (2008) Changes in Horizontal Jaw Position and Intraoral Pressure. The Angle Orthodontist 78: 254-261.

11. Hanson ML, Cohen MS (1973) Effects of form and function on swallowing and the developing dentition. American Journal of Orthodontics 64: 63-82.

12. Garliner D (1976) Myofunctional therapy. General dentistry 24: 30-40.

13. Chia-Fen Cheng, Chien-Lun Peng, Hung-Yi Chiou, Chi-Yang Tsai (2002) Dentofacial morphology and tongue function during swallowing. American Journal of Orthodontics and Dentofacial Orthopedics 122: 491-499.

14. Subtenly Daniel, Subtenly Joanne (1962) Malocclusion, speech, and deglutition. Am J Ortho 48: 685-697.

15. Hopkins GB, McEwen JD (1957) Speech and the orthodontists. Dent Pract 7: 313-326.

16. Doto N, Yamada K (2015) The relationship between maximum lip closing force and tongue pressure according to lateral craniofacial morphology. Orthodontic Waves 74: 69-75.

17. Tullev WJ (1956) Adverse muscle forces – their diagnostic significance. American Journal of Orthodontics 56: 801-814.

18. Dworkin JP (1980) Tongue strength measurement in patients with amyotrophic lateral sclerosis: qualitative vs quantitative procedures. Archives of Physical Medicine Rehabilitation 61: 424-444.

19. Trawitzki LV, Borges CG, Giglio LD, Silva JB (2011) Tongue strength of healthy young adults. Journal of Oral Rehabilitation 38: 482-486.

20. Weinstein S, Haack DC, Morris LY, Snyder BB, Attaway HE (1963) On an equilibrium theory of tooth position. The Angle Orthodontist 33: 1-26.

21. Min-Ho Jung, Won-Sik Yang, Dong-Seok Nahm (2010) Maximum closing force of mentolabial muscles and type of malocclusion. The Angle Orthodontist 80: 72-79.

22. Thüer U, Sieber R, Ingervall B (1999) Cheek and tongue pressures in the molar areas and the atmospheric pressure in the palatal vault in young adults. Eur J Orthod 21: 299-309.

23. Valentim AF, Furlan RM, Perilo TV, Berbert MC, Motta AR, et al. (2014) Evaluation of the force applied by the tongue and lip on the maxillary central incisor tooth. In CoDAS 26: 235-240.

24. Melsen B, Attina L, Santuari M, Attina A (1987) Relationship between swallowing pattern, mode of respiration and development of malocclusion. The Angle Orthodontist 57: 113-120.

25. Posen AL (1972) The influence of maximum perioral and tongue force on the incisor teeth. Angle Orthod 42: 285-309.

26. Helen Lambrechts, Evelyne De Baets, Steffen Fieuws, Guy Willems (2010) Lip and tongue pressure in orthodontic patients. European Journal of Orthodontics 32: 466-471.

27. Lowe AA, Takada K, Yamagata Y, Sakuda M (1985) Dentoskeletal and tongue soft-tissue correlates: a cephalometric analysis of rest position. American journal of orthodontics 88: 333-341.

28. Ahlgren J, Ingervall B, Thilander B (1973) Muscle activity in normal and post normal occlusion. Am J Orthod 64: 445-456.

29. Luffingham JK (1969) Lip Cheek Pressure exerted upon teeth in three adult groups with different occlusions 14: 337-350.

30. Shiono Y, Morikawa K, Maki K (2015) Comparative clinical study evaluating lip- closure forces in association with tongue pressure in children. Pediatric Dental Journal 25: 19-25.

31 Knösel M, Nüser C, Jung K, Helms HJ, Engelke W, et al. (2016) Interaction between deglutition, tongue posture, and malocclusion: A comparison of intraoral compartment formation in subjects with neutral occlusion or different types of malocclusion. The Angle Orthodontist 86: 697-705.

32. Valentim AF, Furlan RM, Perilo TV, Motta AR, Casas EB (2016) Relationship between perception of tongue position and measures of tongue force on the teeth. CoDAS 28: 546-550.

33. Ruan WH, Su J M, Ye XW (2007) Pressure from the lips and the tongue in children with class III malocclusion. J Zhejiang Univ Sci B 8: 296-301.

34. Yamaguchi, Hideharu, Kenji Sueishi (2003) "Malocclusion associated with abnormal posture." The Bulletin of Tokyo Dental College 44: 43-54.

35. Jeong DM, Shin YJ, Lee NR, Lim HK, Choung HW, et al. (2017) Maximal strength and endurance scores of the tongue, lip, and cheek in healthy, normal Koreans. Journal of the Korean Association of Oral and Maxillofacial Surgeons 43: 221-228.

36. Frohlich K, Thuer U, Ingervall B (1990) Pressure from tongue on the tooth in young adults. The Angle Orthodontist 61: 17-24.

37. McNulty EC, Lear CS, Moorrees CF (1968) Variability in lip adaptation to changes in incisor position. Journal of Dental Research 47: 537-547.

38. Mortimore LL, Fiddes P, Stephens S, Douglas NJ (1999) Tongue protrusion force and fatigability in male and female subject. European Respiratory Journal 14: 191-195.