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Research Article

Evaluation of Tongue Force on Mandibular Incisor in Various Malocclusions

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ABSTRACT

Objectives: To evaluate the tongue forces exerted on the mandibular incisors in various malocclusions and also compare it among genders.

Methods: The study was conducted on 512 subjects (340 females and 172 males). The subjects were divided into three groups according to the molar relation of the subjects. Molar relation and the tongue forces exerted on the mandibular incisor of the subjects were recorded using a diagnostic kit and a Flexi force resistive sensor respectively. Tongue Force at Rest (TFR), Tongue Force during Swallowing (TFS) and Maximum Tongue Force (MTF), were measured and statistically analyzed.

Results: MTF was a significantly more among males than females. A significant relationship while comparing TFR and TFS among the three groups was also found.

Conclusion: TFR and TFS were found to be influential in the malocclusion of an individual and also a stronger tongue musculature among males was concluded while comparing MTF.

Keywords: Tongue; Force; Malocclusion; Swallowing

INTRODUCTION

As believed by EH 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 and lips; extrinsic factors: external pressure due to habits and 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 [2], the trident factors affecting any habit or action are its intensity, duration or frequency. The duration of the force is more important than its intensity and frequency. Proffit et al. [3] 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.

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 device used to measure tongue force in our study is a small Force Sensitive Resistor (FSR) which has a 0.16" (4 mm) diameter for active sensing area (Figure 1). Two pins extend from the bottom of the sensor with 0.1" pitch making it board friendly. For

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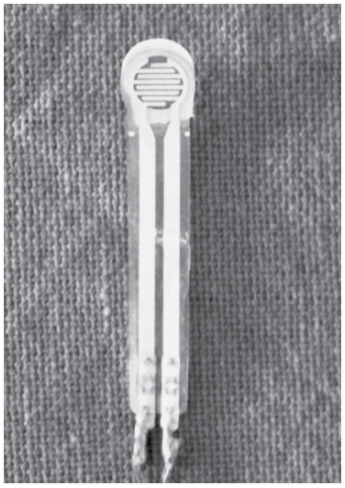

Figure 1: Flexi force resistive sensor of diameter 0.16".

the customized circuit, the sensor was connected with an Atmed Microcontroller (ATMEGA) which is an 8-bit microcontroller, an inbuilt Analog to Digital Converter (ADC) and a display. The voltage from the sensor is fed to the ADC pin of microcontroller and then converted and displayed onto the display screen. All the values obtained were standardized and were in millinewton (mN) unit.

512 subjects who came for any kind of orthodontic treatment to the hospital were selected for the study primarily falling under the inclusion criteria with no previous orthodontic treatment; with a full set of all permanent teeth present in the oral cavity and a DMFT score of less than 1. Subjects with any kind of systemic ailments were not considered for the study. The whole study protocol was certified and approved by the Institutional Research and Development Committee (IRDC) and Institutional Human Ethical Committee (IHEC) and completed in a period of one year from 1st January 2018 to 31st December 2018.

All the subjects were informed about the procedure with an informed consent duly signed. Diagnostic procedure to procure the molar relation of the individual was performed under sterile and aseptic conditions using a diagnostic kit. The molar relation was noted down considering the Angle's Classification as a guide for categorizing the total sample into three groups of Angle's Class I, II and III. The sensor Force Sensitive Resistor (FSR) part attached to the circuit was covered with a sterilized cellophane pouch separate for all samples. The covered sensor was fixed on a stainless steel cement spatula (bent at one end to adapt onto the lingual surface of the mandibular incisor). Then, the above component was placed in the oral cavity of the subject (specifically on the lingual surface of the most proclined mandibular incisor).

For procuring the readings related to the study the subject was then asked to close his/her mouth normally. The individual was then asked to place the tongue in its normal position i.e. at rest for a couple of seconds, and then he/she was asked to swallow intentionally. 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; TFR, TFS and MTF. The procedure mentioned above was repeated for a couple more time. An average value of all the three readings was noted down for the statistical analysis i.e. average TFR, TFS and MTF.

RESULTS

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

Table 1: Comparison of MTF, TFR and TFS among gender.

-	Gender	Statistic		Std. Error	"p" value
MTF	Female (N=340)	Mean	177.233	1.62705	0
		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	191.5	-	
		Variance	523.868	-	
		Std. Deviation	22.88816	-	
		Minimum	130.67	-	
		Maximum	303		
TFR	Female (N=340)	Mean	3.8004	0.19983	0.063
		Median	4	-	
		Variance	13.536	-	
		Std. Deviation	3.67917	-	
		Minimum	0	-	
		Maximum	18	-	
	Male (N=172)	Mean	3.1647	0.27245	
		Median	3.3333	-	
		Variance	12.767	-	
		Std. Deviation	3.57315	-	
		Minimum	0	-	
		Maximum	17.33	-	
TFS	Female (N=340)	Mean	11.7099	0.60536	0.06
		Median	12.3333	-	
		Variance	124.229	-	
		Std. Deviation	11.1458	-	
		Minimum	0	-	
		Maximum	82	-	
	Male (N=172)	Mean	9.7267	0.76826	
		Median	9.3333	-	
		Variance	101.517	-	
		Std. Deviation	10.07559	-	
		Minimum	0	-	
		Maximum	41.67	-	

the analysis was carried out on Statistical Package for the Social Sciences (SPSS) 18.0 version.

Among the total 512 subjects included in the study, 340 were females and 172 males. On comparing the average MTF among males and females, the mean value was found to be 193.4 and 177.2 respectively. A highly significant relation was found among the gender (p-value=0.00) with an increased value among males than females (Table 1). 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. The values put forward a highly significant relation (p-value of 0.00) among the groups in a very visible pattern with Class III having the maximum tongue force at rest followed by Class II and least force produced by Class I (Table 2). Mean values of the average TFS was found to be 6.6, 16.5 and 31.9 in all the three groups consequently. A significant relation (p-value=0.00) was found while comparing TFS among the groups (Table 3). The mean value of average MTF for all the three groups was found to be 185.1, 177.9 and 182.3 respectively. While comparing the MTF, the relation was non-significant (p-value=0.063) among the malocclusion (Table 4).

Table 2: Comparison of TFR among different malocclusion.

Malocclusion	Statistic		Std. Error	"p" value
Class I (N=324)	Mean	2.0741	0.13253	0
	Median	0.3333	-	
	Variance	5.691	-	
	Std. Deviation	2.3856	-	
	Minimum	0	-	
	Maximum	10.33	-	
Class II (N=163)	Mean	5.1943	0.25012	
	Median	5.6667	-	
	Variance	10.197	-	
	Minimum	0	-	
	Maximum	13	-	
	Std. Deviation	3.19332	-	
Class III (N=25)	Mean	12.56	0.50285	
	Median	12.3333	-	
	Variance	6.321	-	
	Std. Deviation	2.51426	-	
	Minimum	8.67	-	
	Maximum	18	-	

Table 3: Comparison of TFS among different malocclusion.

Malocclusion	Statistic		Std. Error	"p" value
Class I (N=324)	Mean	6.6451	0.41378	0
	Median	2.3333	-	
	Variance	55.473	-	
	Std. Deviation	7.44801	-	
	Minimum	0	-	
	Maximum	43.33	-	
Class II (N=163)	Mean	16.5174	0.85768	
	Median	18	-	
	Variance	119.904	-	
	Std. Deviation	10.95008	-	
	Minimum	0	-	
	Maximum	82	-	
Class III (N=25)	Mean	31.9867	0.83032	
	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
	Median	181.8333	-	
	Variance	988.45	-	
	Std. Deviation	31.43962	-	
	Minimum	112	-	
	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 [5], the perioral musculature and tongue principally determines the position of the teeth. On the other hand it was also pointed out that tongue pressure generally exceeds lip pressure [6-10]. Also various studies hypothesized that the lingual force exerted on the dentition was higher than the perioral musculature forces. Moreover authors acknowledged that muscle function, duration, speech and swallow can be a primary factor in causing and perpetuating a malocclusion [11-13]. Contradicting theories supported that there was no such influence of internal and external musculature on the positioning of the dentition [14-16]. Studies 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 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 [20,21]. Some 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. At rest, pressure from the tongue is slight but long lasting and, therefore, can move the teeth [7,22]. Amanda Valentim et al. [23], in their literature review stated that atypical swallowing can cause occlusion alterations. It was also hypothesized that duration of tongue is much more important than magnitude. Some also hypothesized contrary to the above results that there was no significant relation among different malocclusion [16,24].

The comparison of tongue force during swallowing among malocclusion in our study was found to be significant owing to the statement that tongue muscle can be one of the factors in causing and perpetuating malocclusion [11-13,25]. Also a pattern was indicated while the comparison was performed suggesting of increased swallowing force among Class III malocclusion groups. Studies contradicting the significance of swallowing were that of Winders7 and Luffingham [26]. The comparison of MTF among malocclusion was not significant suggesting that the magnitude or intensity does not influence primarily to malocclusion of an individual. Amanda Valentim [27] and Doto N [16] proposed the same. Contrary to it, some researchers found significance among different malocclusion while comparing the maximum tongue force exerted on the dentition [28-30].

Gender comparison of TFR and TFS showed a non-significant relationship. Dworkin [18] on the contrary found an increased tongue force at rest among men than women. Mortimore [31] and Jeong [30] found a significant difference of maximum tongue force exerted on dentition among gender (males=26 +/- 8 N; females=20 +/- 7 N). Similarly, 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 maximum force exerted by tongue depicts the strength of the tongue musculature and it can be concluded from our study that males have a stronger musculature. Resting pressure of tongue can be observed in a pattern i.e. Class III>Class I>Class II. So, it can be concluded that the resting force is influential in positioning the mandible with more force causing to Class III malocclusion. Swallowing pressure of tongue was also found in the similar pattern. Hence it is evident from the findings that more force exerted during swallowing affects the malocclusion of an individual.

CONFLICT OF INTEREST

No conflict of interest.

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