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Upper Lip Pressure Variations During Orthodontic Treatment.

[1]Dr. Gayathri, Post Graduate Student Department of Orthodontics, Tamilnadu Dental College and Hospital, chennai, Tamilnadu, India.

[2]Dr. G.Vimala, Professor and HOD Department of Orthodontics, Tamilnadu Dental College and Hospital, chennai, Tamilnadu, India.

[3]Dr. A.Prema, Post Graduate Student Department of Orthodontics, Tamilnadu Dental College and Hospital, chennai, Tamilnadu, India.

[4]Dr. Abdul Shameer, Post Graduate Student Department of Orthodontics, Tamilnadu Dental College and Hospital, chennai, Tamilnadu, India.

Corresponding Author: Dr. A.Prema, Post Graduate Student Department of Orthodontics, Tamilnadu Dental College and Hospital, chennai, Tamilnadu, India.

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Abstract

Introduction: The contribution of the forces of the lips, cheeks, and tongue are of particular interest to orthodontists in correct treatment planning.The objectives of this prospective clinical study are to quantify the variation of pressure exerted by the upper lip on the upper teeth during the retraction phase of fixed orthodontic treatment .The null hypothesis is that there is no difference in the lip pressure after incisors retraction during corrective orthodontic treatment.

Methods: 30 patients, age group of 16-20 yrs undergoing orthodontic treatment were included in the study. They were divided in to 2 groups as Angle's Class I malocclusion and Class II div 1 malocclusion groups.The lip pressure changes was recorded using lip pressure tester at six time intervals during the study period. Repeated measure ANOVA is applied to compare mean values between time points and groups. Linear regression analysis was done to find out the ratio between lip pressure and maxillary incisor changes during retraction.

Result: The lip pressure after alignment and leveling stage was 24.53 gm/cm^2 in class I and 25.62 gm/cm^2 in class II div 1. The lip pressure decreased with retraction of incisors in both groups. For every millimeter of maxillary incisor retraction, 3.066 g/cm^2 lip pressure reduced in class I subjects and 3.248 g/cm^2 in class II division 1 subjects.

Conclusion: The null hypothesis is rejected. The lip pressure decreases with retraction of incisors during orthodontic treatment..

Keywords: Lip Pressure,Orthodontic Space Closure, Malocclusion.

Introduction

Malocclusion of teeth is due to interplay of genetic and environmental factors. The forces from the lips, cheeks and tongue forms the most important environmental factors in the etiology of malocclusion[1]. Of all the forces, those from the tissues in passive resting state are believed to be more important than forces exerted on teeth during various functions such as speech and

swallowing[2]. Therefore, light forces exerted by the lips, cheeks, and tongue at rest are more important than functional forces. The influence of the forces exerted by the perioral musculature on the position of the teeth has been the object of many scientific studies. Many studies been conducted to evaluate the incisor position and upper lip pressure in normal occlusion and malocclusion patients. Amanda[3] had done a pilot study measuring the tongue and lip force against the maxillary central incisor using the force resisting sensor. Ruan[4] and Ogushi[5] measured the muscle forces exerted on facial surface of teeth in normal occlusion. Kilic et al[6] studied the associations between muscle activity in the upper lip and the inclinations of the incisors, overjet and overbite. Lambrechts[7] conducted a study to determine differences in lip and tongue pressure as a function of gender, age, Angle classification, characteristics of occlusion, and oral habits. There are also studies to evaluate the soft tissue changes (upper and lower lip response) following orthodontic treatment [8,9].

However there is no clarity about lip pressure variations in fixed orthodontic treatment during retraction stage of maxillary anterior teeth, in studies reported so far. The contribution of the forces of the lips, cheeks, and tongue are of particular interest to orthodontists in correct treatment planning. The technical skills and protocol that the orthodontist uses to assess these forces may determine the ultimate success of orthodontic treatment. Hence the objective of the present study is to quantify the changes in the upper lip pressure when the anterior teeth are retracted and to find the ratio between the changes in lip pressure to every millimeter of retraction.The null hypothesis to be tested is that there is no difference in the lip pressure after incisors retraction during corrective orthodontic treatment.

Materials And Methods

Ethical approval for the present study was obtained from the institutional ethics committee (Ref no: R. C. No:0420/DE/2016). Outpatients undergoing orthodontic treatment at Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College and Hospital, were screened for this cross sectional study by random sampling method.

A. Study Population and Characteristics

30 individuals (14 females and 16 males), who fulfilled the selection criteria were included in this study. The inclusion criteria are:1.Systemically healthy individuals with full complement of teeth. 2.Age group : 16 to 20 years 3.Either sex. 4. Angle's class I and class II div.1 molar relationship 5. Class I Skeletal base 6. Average growth pattern 7. Overjet 6-7 mm 8. Mild to moderate crowding (1-6mm of discrepancy) 9. Acute nasolabial angle (85-95degrees) 10. Patients with incompetent lips only due to dental protrusion 11.Normal lip length 12. Patients with no pernicious oral habits, like Tongue thrusting, lip biting etc. 13.Patients willing for voluntary participation and have signed informed consent.

The study group was categorized according to the malocclusion and sex:

Group A1- Angle's Class I malocclusion, male (n=8)

Group A2- Angle's Class I malocclusion, female (n=7)

Group B1- Angle's Class II div 1 malocclusion, male (n=8)

Group B2- Angle's Class II div 1 malocclusion, female (n=7).

The procedure involved in the study was explained and written consent was also obtained from all subjects before beginning the study. The required pretreatment records was taken for all individuals included in the study. Diagnosis and treatment plan were established for all the patients. Extraction of the first premolars was done in the

maxillary arch. Orthodontic treatment was started with preadjusted Edgewise orthodontic appliance using 0.022 inch MBT prescription brackets. Banding of the first and second molars in both upper and lower arches was done. The sequence of archwires are the same for all subjects which includes: 0.016 Ni-Ti, 0.016 x 0.022 Ni-Ti, 0.016 x 0.022 SS ,0.017 x 0.025 Ni-Ti, 0.017 x 0.025 SS, 0.019 x 0.025 Ni-Ti, 0.019 x 0.025 SS. Consolidation of arches using ligature wires was done after completing the alignment and leveling stage of orthodontic treatment and en masse retraction of maxillary anteriors using NITI closed coil springs in 0.019 x 0.025 SS. The lip pressure for the study group was recorded at the following time intervals:

T0- at the end of leveling and alignment and before retraction of anterior teeth

T1- **T5-** at the end of every month of retraction of maxillary anterior teeth.

B. Measurement of Lip Pressure

The lip pressure was measured using the lip pressure tester consists of Flexiforce Sensor Model A301 (Tekscan) and Data analog to Digital converter (Fig: 1). Flexi Force sensors (Fig: 2) use technology based on resistivity. The application of a force in a sensitive area elicits a change in resistance of a sensing element inversely proportional to the applied force. The sensors were encapsulated and their movements were restricted to prevent errors in the generated force signal. The signal conditioning is made using operational amplifiers for signal linearization and conversion of electrical resistance into electrical voltage. Once the signal goes through the amplification system, the device starts measuring the resistance and amplifies those signals and digitally displays in terms of pressure (g/cm^2) and force (N).

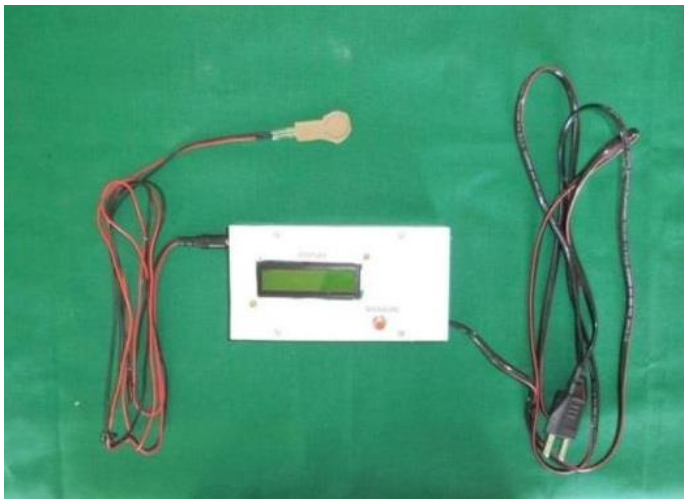

Fig 1:Lip Pressure tester (Flexiforce Sensor and Data analog to Digital converter) Model A301 (Tekscan)

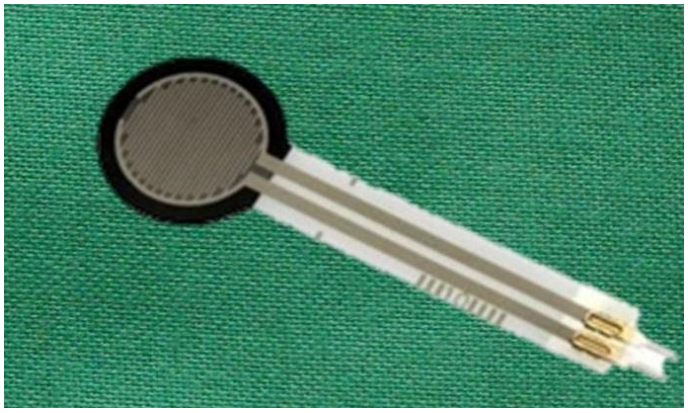

Fig 2: Flexiforce Sensor

When recording the lip pressure, the orthodontic wires were removed and oral cavity was cleaned properly and dried. All the study subjects were made to sit upright with their head in the natural head position and with their lips relaxed before initiating the measurement of lip pressure. The flexiforce sensors were covered by a disposable cover which will be changed for every subject and disposed safely after use. The flexiforce resistive sensor was positioned on the midline between the maxillary incisors over the central incisor brackets with a thin layer of soft wax preferably orthodontic wax for stabilization and the subjects were asked to gently close the lips without straining them and remain as such for one minute. The device displays readings every 10 seconds in a minute. (i.e) 6 set of readings in one minute and gives the average

value of all the six readings in both pressure and force units which is included in the analysis.

C. Statistical analysis

The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests results reveal that variables follow Normal distribution. Therefore to analyse the data, parametric methods are applied. To compare the mean values between groups independent samples t-test is applied. To compare mean values between time points and groups, repeated measures ANOVA (General Linear Model) is applied. To compare proportions between groups Chi-Square test is applied. Linear regression analysis was done to find out the ratio between lip pressure variations and maxillary incisor change in inclination. SPSS version 22.0 is used to analyse the data. Significance level is fixed as 5% ($\alpha = 0.05$).

Results

Independent sample T-Test done to compare the mean age between study groups shows that there is no significant difference in the lip pressure between the mean age of class I and Class-II div.1 groups. Chi-Square test used to compare proportions of genders between class I and Class-II div.1 groups confirms there is no significant difference in lip pressure variations in proportions of gender between the study groups. The lip pressure after alignment and leveling stage (T0) was 24.53 gm/cm2 in class I and 25.62 gm/cm2 in class II division 1. To compare mean lip pressure between groups, Independent samples T-Test was done (Table: 1)The results show the mean lip pressure gradually reduces from T0-T5 (Fig:3), but significant difference between mean lip pressure are seen only at base line data (T0). Independent samples T-Test to compare mean percentage change between groups was done at each time point (T1 – T5). This was calculated by the formula Percentage change between groups = (T0-time point/T0) ×100.Mean percentage change from T0 at different time points (T1-T5) show significant differences in lip pressure between class I and class II groups (Fig :4).

Variables	Group	Mean	Std.Dev	t-Value	p-Value
Lip pressure -TO	Class -I	24.5307	0.91743	3.832	0.001
	Class-II div.I	25.628	0.62335		
Lip pressure -Tl	Class -I	20.3253	1.19452	0.369	0.715
	Class-II div.1	20.1633	1.21032		
Lip pressure -T2	Class -I	17.964	1.2869	1.041	0.307
	Class-TI div.1	17.5087	1.10065		
Lip pressure -T3	Class -I	14.862	0.89787	1.076	0.291
	Class-II div.1	14.442	1.21623		
Lip pressure -T4	Class -I	12.0393	1.2111	1.052	0.302
	Class-II div.1	11.6213	0.94876		
Lip pressure -T5	Class -I	8.6627	0.79516	0.101	0.921
	Class-II div.1	8.628	1.07348		

Table 1: Independent samples T-Test to compare mean lip pressure between groups

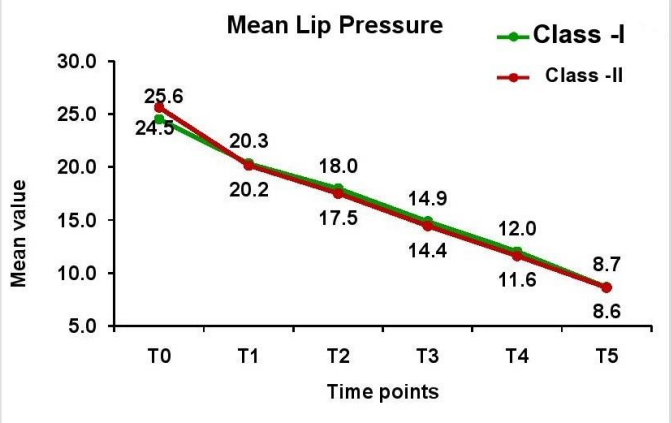

Fig. 3: Comparison of mean lip pressure between groups

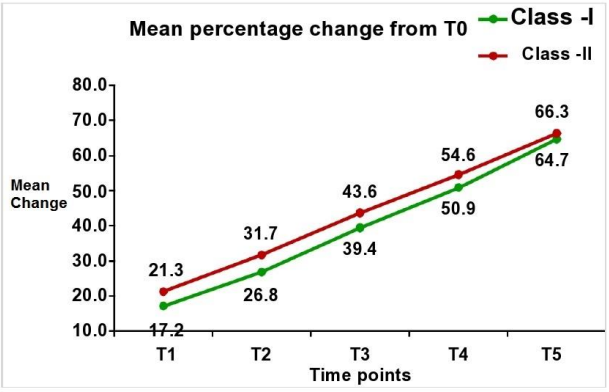

Fig.4: Mean percentage change in lip pressure between groups

The results show that the subjects with class II malocclusion have greater lip pressure than class I, even though lip pressure reduces gradually in both the groups. To compare mean lip pressure values between groups and time points simultaneously, repeated measures ANOVA (General Linear Model) was applied. The results of repeated measures ANOVA indicate that there is a significant difference in mean lip pressure between the time points(Table: 2). The mean lip pressure at different time points (T1 –T5) is statistically significant from the base line (T0) mean lip pressure. It is observed that there is a significant interaction effect in mean lip pressure between groups (class I & Class-II div.1) and time points (T1 –T5). There is no significant effect between groups.

Linear regression analysis was done to measure the ratio between maxillary incisor retraction and upper lip variations. Prediction power or percentage of variability was done between class I and Class-II div.1. This result shows that for every millimetre of maxillary incisor retraction, 3.066 g/cm2 pressure reduced in the upper lip in class I subjects and 3.248 g/cm2 pressure reduced in the upper lip in Class-II div.1 subjects during retraction phase. The regression coefficient shows that the ratio between lip pressure and change in inclination of maxillary anterior teeth is greater in Class-II div.1 (3.248) than in class I (3.066) (Table:3).

Source	Time points	Type III Sum of Squares	df	Mean Square	F-Value	P-Value
Time points	T1 vs. T0	701.317	1	701.317	744.256	<0.001
	T2 vs. T0	1617.589	1	1617.589	1357.875	<0.001
	T3 vs. T0	3261.878	1	3261.878	2987.956	<0.001
	T4 vs. T0	5266.080	1	5266.080	3280.674	<0.001
	T5 vs. T0	8102.291	1	8102.291	8315.390	<0.001
Time points Group	T1 vs. T0	11.894	1	11.894	12623	0.001
	T2 vs. T0	18.081	1	18.081	15.178	0.001
	T3 vs. T0	17.267	1	17.267	15.658	<0.001
	T4 vs. T0	17.222	1	17.222	10.729	0.003
	T5 vs. T0	9.611	1	9.611	9.863	0.004
Error	T1 vs. T0	26.385	28	.942		
	T2 vs. T0	33.385	28	1.191		
	T3 vs. T0	30.877	28	1.103		
	T4 vs. T0	44.945	28	1.605		
	T5 vs. T0	27.282	28	.974		

Table 2: Tests of Within-Subjects Contrasts.

Group	Model		Regression Coefficients		t-Value	P-Value.	95.0% Confidence Interval for B	
			B	Std. Error			Lower Bound	Upper Bound
Class -I	1	(Constant)	27.127					
		Change in teeth	-3.066	.068	-45.124	.000	-3.201	-2.931
Class-II div.I	1	(Constant)	27.701					
		Change in teeth	-3.248	.077	-42.274	.000	-3.401	-3.096

Table 3: Regression Coefficients

Fitted regression equation is

Class-I : Lip pressure = 27.127 – 3.066 Change in teeth

Class-II div.1: Lip pressure = 27.701 – 3.248 Change in teeth

Discussion

The lips, cheeks, and tongue are the most important environmental determinants of tooth position. The forces from the tongue have consistently been found to be greater than those from the lips[10]. However the teeth are in an equilibrium position because the forces are equal on them over time from all directions, regardless of the strength of the muscle that is applying the force. Tooth movement occurs whenever a force is greater or lasts longer than its countering force[11]. The forces from the tissues (lips, cheeks, and tongue) in the passive resting state exerts more pressure on the teeth when compared to forces exerted on the teeth during various functions such as speech and swallowing and mastication. Studies proved that at rest, the lip exerts a larger force than the tongue on the maxillary right central incisor tooth[3]. Hence the objective of this study is to measure the upper lip force level in the passive relaxed position on the maxillary anterior teeth before and during retraction.Many devices of different shapes and thickness have been designed to measure lip pressure. The thickness of the transducer has an influence on the pressure measurements[12]. Ho et al[13] showed that the labial pressure exponentially

increases when tissue displacement is greater than 1.5 mm.The flexiforce sensor employed for this study is unique in that it is thin(0.203mm) eliminating the unwanted tissue displacement, flexible, customizable and small sized ideal for prototyping and integration . This device has the following advantage of better linearity, measurement of higher loads and stable output with respect to load area. The head position of the patients is also considered as an important factor in lip pressure measurements on teeth. According to Ingervall & Thuer[14] lip pressures increase with extension and decreases with flexion of head compared to pressures in natural head position. So, considering their findings, the lip pressure was recorded in natural head position in the present study.The result of the present study shows no significant difference in lip pressure between age and gender. The subjects with class II malocclusion have greater lip pressure than class I,the lip pressure evaluated after alignment and leveling stage (T0) was 24.53 gm/cm2 in class I and 25.62 gm/cm2 in class II division 1. This is in accordance to the study by Domizia Di Fazio et al [15] concluded that in healthy patients, upper lip pressure does not change at rest and during swallowing, upper lip pressure was 24.33 g/cm2 in Class I and 24.61 g/cm2 in Class II and lip pressure was higher in adults than in young subjects.According to the present study the lip pressure reduces gradually in both the groups during retraction. However the ratio between lip pressure variation and change in inclination of maxillary anterior teeth is greater in class II division 1 than in class I. For every millimeter of maxillary incisor retraction, 3.066 g/cm2 lip pressure reduced in class I subjects and 3.248 g/cm2 lip pressure reduced in class II division 1 subjects. Therefore the ratio of maxillary incisor retraction to upper lip retraction was 3.066:1 in subjects with Class I malocclusion and 3.248:1 in subjects with class II div I malocclusion. This is due to the fact lip strain is relieved during the orthodontic treatment by retraction of upper incisors, upper lip will start following upper incisors more closely[16]. Previous reports shows that the ratio of maxillary incisor retraction to upper lip retraction was 1.85:1 in class I cases, while retraction in Class II division 1 cases was 2.22:1[17] and for every 1 mm incisor retraction, the upper lip retracted approximately 0.5 mm in bimaxillary extraction cases[18].Ramos et al [19] evaluated the upper lip changes correlated to maxillary incisor retraction by superimposing Bjork type metal implants in the maxilla in pre and post treatment cephalograms and concluded that retraction of the upper lip accompanied maxillary incisor retraction at a mean ratio of 1:0.75 for patients with pretreatment lip seal and1:0.70 for those with pretreatment lip incompetence. Oliver found that patients with thin lips or a high lip strain displayed a significant correlation between incisor retraction and lip retraction, whereas patients with thick lips or low lip strain displayed no correlation[20]. Hence the thickness of the lips may also play a role in determining the lip pressure on the maxillary anterior teeth, therefore further studies recommended relating lip thickness to lip pressure. The research could also be extended to find out the changes in the lip pressure changes during all stages of fixed orthodontic treatment including post retention phase.

Conclusion

The null hypothesis is rejected. The lip pressure decreases with retraction of incisors during orthodontic treatment..

Ethical Statement: Ethical approval for the present study was obtained from the institutional ethics committee Tamilnadu Goverment Dental College and Hospital, chennai. (Ref no: R. C. No:0420/DE/2016).

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