Labial and Palatal Pressure Changes in Extraction Cases Before and After Maxillary Incisor Retraction: A Quasi-Experimental Study

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ABSTRACT

Objective: To evaluate the changes in lip and tongue pressure before and after incisor retraction in patients undergoing orthodontic treatment with premolar extraction and incisor retraction.

Study Design: A Quasi-experimental study

Place and Duration of the Study: Orthodontic Department at Dow University of Health Sciences, Pakistan, from January 2018 to November 2019.

Methodology: The study included 64 patients who were divided into two groups, (32 patients of class I and 32 patients of class II malocclusion). The lip and tongue pressures were recorded before and after incisor retraction with the help of Flexiforce sensor. The collected data were statistically analysed using the SPSS V-24 software. Shapiro-Wilk test was used to test the normality of data. The mean difference between lip and tongue pressure before and after incisor retraction was analyzed by Wilcoxon Signed Ranks Test. The difference in soft tissue pressures between class I and class II treatment groups was carried out using the Mann Whitney test.

Results: The mean pressure on the labial surface of incisors was significantly reduced after premolar extraction and incisor retraction ($p \leq 0.001$). On the other hand tongue pressure on the palatal side of incisors was enhanced after incisor retraction ($p=0.008$) Comparing the differences between Angle's class I and class II malocclusion in mean pressure changes before and after incisor retraction revealed that the difference was not statistically significant on labial ($p=0.58$) or palatal side ($p=0.28$) of maxillary incisors.

Conclusion: Reduced lip pressure and increased tongue pressure were observed after incisor retraction, whereas no significant change was seen in between the class I and class II cases. This signifies that orthodontic extraction affects the pressure changes on incisors and teeth do not remain in balance equilibrium at rest.

Key Words: *Lip pressure, Tongue pressure, Orthodontic treatment, Flexiforce resistive sensor, Extraction, neutral zone.*

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INTRODUCTION

The success of orthodontic treatment depends upon one major variable which is the retention of the final position of the teeth after treatment.[1] The focus of the treatment is to arrange the teeth in the most aesthetic and optimally functional position.

Many factors are needed for the maintenance of teeth in a particular position that includes number of the teeth moved, characteristics of occlusion, patient's age, time period for the treatment, arch size, type of malocclusion and oral habits.[2] Any pressure applied on the bone can cause changes in the oral cavity environment that may cause changes in the position of the teeth in order to restore harmony.[3]

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Widely accepted theory among dental professions accepts that the forces created by the tongue, lips and cheeks are responsible for arranging the teeth in the neutral equilibrium position.[4]

The location and position of the soft tissues in the oral cavity determine the pressure and forces it creates.[4] Oral habits of the patient are also responsible for the forces generated *i.e.* environmental factors do play their part. Oral habits such as thumb suckling are one of the causes for the malalignment of the teeth.[5] When a patient sucks the thumb, the erupting teeth against the pressure exerted by the thumb apart from soft tissue pressure can cause the disorderly position of the teeth.

Following the balance theory, the position of the teeth is in equilibrium under two opposing force that negates each other, tongue pressure from the inside and cheek and lip pressure from the outside, movement of teeth is possible if the forces from either side become unbalanced over a certain period.[6,7]

The rationale of this study was to determine whether lip and tongue pressures on labial and palatal surface of maxillary incisor teeth adapt themselves to the new position or not, because if the teeth are not in a balanced position from labial and lingual forces the chances of relapse become high. Hence,

the primary objective of this study was to evaluate the chances of lip and tongue pressure on maxillary incisors before and after incisor retraction using Flexi force sensor. The secondary objective was to measure the difference in lip and tongue pressure on incisors between class I and class II malocclusion groups.

METHODOLOGY

A prospective quasi-experimental study was conducted at the Orthodontic Department of Dow University of Health Sciences, after approval from the Institutional Review Board (IRB-1007/-DUHS/Approval/2018/21) with the mean age of the subjects ranging between 15 to 34 years. The sample size was calculated using the means and SD of tongue and lip pressure at habitual rest position of 0.2 ± 0.2 N,[8] keeping the power of study and CI at 99%. A sample of 28 patients was calculated for each group. Due to patient attrition and the rate of loss to follow-up, 15% extra of the sample size was taken, therefore a total of 32 patients were recruited in each group. The total sample comprised of 64 patients *i.e*. 32 in class I and 32 in class II malocclusion groups.

The sample included in this study were subjects undergoing orthodontic treatment with extraction plan of right and left maxillary premolars followed by canine and incisor retraction, having a mean age of 25 ± 5 years with arch length discrepancy of 3 to 5 mm. *Subjects specific for Angle's* Class I group had bilateral molar, canine, and incisors in class I relationship, ANB 2°–4°, overjet 2 to 4 mm and overbite 1–4 mm. *Subjects specific for Angle's* Class II group had full cusp class II molar relationship, canine in class II relationship, Incisors in class II div 1 relationship, ANB 5°–7°, overjet 4 – 7 mm and overbite 1 – 4 mm. First and second molars were ligated together as anchorage unit with transpalatal arch for reinforced anchorage. Subjects were excluded on the basis of having severe crowding, previous glossectomies, parafunctional habits, paralysis or paresis of lips or tongue, current speech or language therapy, nasal obstruction at the time of evaluation, cognitive impairment, temporomandibular joint dysfunction, craniomandibular anomalies, malformed or missing permanent teeth, systemic muscle or joint disorders, craniofacial syndromes, excessive hypodivergent or hyperdivergent patients that required orthognathic surgical treatment, or previous orthodontic treatment.

The Data collection was carried out at two separate intervals using flexi force sensor purchased from Tekscan (Tekscan, Inc.307 West First Street South Boston, MA 02127-1309, USA).[8] The device consisted of thin and flexible piezoresistive force sensor with a thickness of 0.203 mm (0.008 in.), length of 191 mm (7.5 in.)* (optional trimmed lengths: 152 mm (6 in.), 102 mm (4 in.), 51 mm (2 in.), width 14 mm (0.55 in.), sensing area of 9.53 mm (0.375 in.) diameter, connector 3-pin Male Square Pin (center pin is inactive), substrate polyester (ex: Mylar) Pin Spacing of 2.54 mm (0.1 in.). The sensors were used on the right and left labial and palatal side of all four maxillary incisors and were attached to the tooth surface by denture adhesive paste which is normally used for complete denture adhesion. The thickness of flexiforce sensor was 0.2 mm and it was covered by polythene sleeve which was 0.1mm thick on both sides making it 0.4 mm, and 0.1 mm thickness was taken by the adhesive gel, so the overall thickness was less than 1 mm. Sensors were then connected to an amplifier circuit acquisition board system NI USB 6008 (national instrument, Austin, TX, USA) and a computer. Sample rate was 70 Hz and the data was shown in force, time, history graphs and numerical value of sensors with the help of LabVIEW (National Instrument, Austin, TX, USA).

At the first interval lip and tongue pressure on both the labial and palatal surfaces at rest were recorded on all maxillary incisors after canine retraction had been completed. The final reading was taken on the buccal and palatal side of all four maxillary incisors, after incisor retraction was completed.

Each patient was instructed to relax for 30 seconds after which reading was noted as the time of relaxed perioral muscles.[8] A second attempt was made after a rest phase of one minute. Five readings were taken by the same examiner and mean values for each patient were made. The maximum total sampling time for one patient was 10 minutes. All readings were taken with the patient in natural head position.

The collected data were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) Version 24 software. Shapiro-Wilk test was used to test the normality of data which showed that the data was not normally distributed hence nonparametric tests were applied. Mean and standard deviations were used to express all quantitative variables. The mean difference between lip and tongue pressure before and after incisor retraction was analysed by Wilcoxon Signed Ranks Test. Difference in soft tissue pressures between class I and class II treatment groups were carried out using Mann Whitney test. The level of significance was set at less than 0.05.

RESULTS

The descriptive statistics for the mean pressures recorded on all the four maxillary incisors are given in Table I.

According to the statistical analysis in Table II, the mean pressure applied by the lip on the labial surface of incisors was significantly reduced after premolar extraction and incisor retraction ($p \leq 0.001$). On the other hand, tongue pressure on the palatal side of incisors was significantly enhanced after premolar extraction and incisor retraction ($p=0.008$). It should however be noted that the change was considerably more on the central incisors than on the lateral incisors.

The mean pressures on labial and palatal surfaces of maxillary incisors in class I and class II malocclusion were compared in Table III. Comparing the mean pressure differences between Angle's Class I and Class II malocclusion before and after incisor retraction reveals that the difference in both classes was not statistically significant on the labial side ($p=0.58$) or palatal side ($p= 0.28$) of maxillary incisors, respectively Table IV.

Table I: Mean labial and palatal pressures on individual maxillary incisors in Newton (N).

Tooth	Labial		Palatal	
	Before (Means± SD)	After (Means± SD)	Before (Means± SD)	After (Means± SD)
Right maxillary central incisor	0.0203±0.0191	0.0033±0.0089	0.0000 ±0.0000	0.0057 ±0.0016
Left maxillary central incisor	0.0228 ±0.0234	0.0041 ±0.0121	0.0005 ±0.0037	0.0170 ±0.0095
Right maxillary lateral incisor	0.0142 ±0.0005	0.0044 ±0.0013	0.0005 ±0.00375	0.0013 ±0.0054
Left maxillary lateral incisor	0.0116 ±0.0181	0.0022 ±0.0074	0.0000 ±0.0000	0.0017 ±0.0095

Number of patients =64, Descriptive Statistics

Table II: Mean difference in pressure, before and after incisor retraction on labial and palatal side of maxillary incisors in Newton (N).

Pressure site	IQR	Z score	50th median		p-value
			Before	After	
Lip pressure on labial surface of all four incisors	0.05	-8.474	0.0100	0.0000	<0.001
Tongue pressure on palatal surface of all four incisors	0.07	-2.656	0.0000	0.0000	0.008

Number of patients = 64 Wilcoxon Signed Ranks Test. p-value ≤0.05.

Table III: Mean pressure on maxillary incisors in Angles class I and class II malocclusion in Newton (N).

Tooth	Class I				Class II			
	Labial		Palatal		Labial		Palatal	
	Before	After	Before	After	Before	After	Before	After
Right central incisor	0.0230 ±0.0182	0.0030 ±0.0088	0.0000 ±0.0000	0.0015 ±0.0056	0.0174 ±0,0198	0.0035 ±0.0091	0.0000 ±0.0000	0.0016 ±0.0058
Left central incisor	0.0282 ±0.0270	0.0048 ±0.0146	0.0009 ±0.0052	0.0009 ±0.0052	0.0171 ±0.0175	0.0032 ±0.0091	0.0000 ±0.0000	0.0026 ±0.0126
Right lateral incisor	0.0103 ±0.0192	0.0024 ±0.0075	0.0009 ±0.0053	0.0012 ±0.0054	0.0184 ±0.0218	0.0065 ±0.0114	0.0000 ±0.0000	0.0013 ±0.0056
Left lateral Incisor	0.0091 ±0.0133	0.0012 ±0.0054	0.0000 ±0.0000	0.0003 ±0.0017	0.0142 ±0.0220	0.0032 ±0.0091	0.0000 ±0.0000	0.0019 ±0.0075

N=64 (class I, n=32, class II, n=32), Descriptive Statistics,

Table IV: Mean change in pressures between Class I and Class II malocclusion in Newton (N).

Tooth surface	Difference between class I and class II		Median	p-value
	Z score	IQR for the difference		
Labial	-0.549	0.015	0.0125±0.02	0.583
Palatal	-1.07	0.001	-0.0012 ±0.00	0.285

N=64 p-value ≤0.05 Mann Whitney test

DISCUSSION

The position of the teeth in the oral cavity is majorly influenced by the soft tissue which includes the cheeks, tongue and lips in addition to the muscle and other perioral structures. Any morphological change or parafunctional habits can affect the resultant pressure applied on the teeth, hence, selection of patients with any abnormal habits such as thumb sucking and mouth breathing is very critical because the state of the occlusion of the patient is not only affected by genetics but also by environmental factors.[9-11]

This study focused on measuring the labial and palatal resting pressures, however many studies pointed out that soft tissue pressure during swallowing is much higher than during rest, but these intermittent forces play a minor role in the positioning of the teeth as the position of teeth is more affected by the consistency of force than the amount of force itself.[12]

The study focused on eliminating confounding variables and keeping the natural head position as a baseline in order to keep the pressure constant for each patient. Nevertheless, one of the authors presented that the perioral pressure on the maxillary incisor is higher in class II malocclusion than class I malocclusion.[13]

Previous researchers declared that the lip pressure on the upper incisors is lowest in class II div 2 malocclusion while highest in class II div 1 malocclusion.[14] However, the lower lip did not show a significant difference in both the malocclusions.[15] Subsequently, another study also reported that subjects with class II div 2 had greater lower labial tonicity but less lip pressure in comparison to subjects with class II div 1 which suggests that pressure exerted by lips depends on the incisal position and not the labial tone.[16] Many studies displayed change in the lower lip pressure as they stated that the lower lip pressure is responsible for the upper incisor position in class II div 2 cases. They believed that the lower lip plays an equal role in affecting the position of the upper incisors. Therefore, they demonstrated the

difference of the applied pressure through measuring the lower lip pressure and vertical lip pressure on the upper incisors by the lower lip.[17] However, this study only measured the changes in the upper lip pressure and tongue pressure to evaluate the independent effect of the upper lip pressure on the incisors.

According to this study the lips do not apply any force (0 Newton) at the rest position; however, it was observed that subjects with class I malocclusion showed slightly increased force than class II malocclusion but the difference was statistically negligible because muscles adapt to changed environment due to histogenesis.[18] Di Fazio *et al.* also evaluated the lip pressures at rest and swallowing at incisal edge in class I and class II subjects. His results are in concordance with our study with no difference in pressure between the two skeletal classes.[19] Researchers testified that the lip pressure against upper incisors in the rest position has a direct relation with overjet, increased pressure in subjects with greater overjet than in those with normal overjet.[20]

Furthermore, when evaluating the tongue pressure on incisors before and after retraction, authors did not find significant change between the malocclusion groups, whereas increased pressure was observed after retraction in the total sample. On the contrary literature review shows a significant difference in tongue pressure at rest and on swallowing. The difference in results might be due to the differences in sample size and method of assessment.[21]

Besides it has been evaluated that tongue thrust action is related to generalise spacing between teeth. Therefore, it can be deduced that before planning any such treatment the habitual tongue thrusting condition should be resolved, this offers better long-term stability and retention of the position of the teeth after the treatment. For such patients initially myofunctional therapy is required in order to avoid relapse of the treatment along with the crib therapy.[22,23]

There should be a standardised method for the measurement of lip and tongue pressure so that the readings can be compared. There is no single method or device on which everyone agrees to be the gold standard for lip and tongue pressure measurement.[19,24,25] Many devices and methods were used to evaluate lip and tongue pressure. This includes gauges attached on the tooth surface, mouthpiece with load cells, force sensing resistors, pressure sensors, dynamometers, bulbs filled with fluid, transducers and other instruments used for measuring intraoral pressure from lip and tongue. Flexiforce resistive sensor was used to measure lip and tongue forces in this study because it is the latest device used for this type of measurement and its measurement can easily be seen on laptop screen with the help of its software Any minute changes fluctuate on screen as the level of pressure changes.[19]

The current study was done on a small sample and was a single-centre study hence the results cannot be generalised to the population. Besides, the authors did not evaluate the effect of lower lip pressure on incisor retraction as the lip rests on the upper incisors.

CONCLUSION

The labial pressure was reduced, whereas the lingual pressure was significantly increased after incisor retraction. There was no significant change in lip and tongue pressures after incisor retraction in Angle's class I and class II malocclusion. Most of the teeth showed different magnitudes of forces on labial and palatal sides *i.e.*, teeth do not remain in balanced equilibrium at rest and there may be other forces or factors acting on teeth to keep them in the same position.

ETHICAL APPROVAL:
This study was performed after ethical approval from the institutional review board of the Dow University of Health Sciences (IRB-1007/DUHS/Approval/2018/21).

PATIENTS' CONSENT:
The consent form was signed by every patient before data collection.

COMPETING INTEREST:
The authors declared no competing interest.

AUTHORS' CONTRIBUTION:
BZ: Designed, directed and coordinated the study, created the study plan, analysed the data and did article writing.
BA: Literature review, statistical analysis of data, article writing and proofreading.
Bothe the authors have approved the final version of the manuscript to be published.

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