Original Article

Lip morphology changes after first premolar extractions in patients with bimaxillary protrusion in North Indian population – A pilot study

ABSTRACT

Introduction: As we witness the soft-tissue paradigm, treating the face becomes more important than just treating the hard tissue variables. Therefore, it becomes crucial to quantify the soft-tissue response to changes in the hard tissue following orthodontic treatment.

Purpose of the Study: To determine lip morphology changes after first premolar extractions in patients with bimaxillary protrusion as ratios of hard and soft-tissue changes.

Materials and Methods: The sample consisted of pretreatment and posttreatment lateral cephalograms of 15 subjects with Class I bimaxillary protrusion who had undergone orthodontic treatment with four first premolars extraction and retraction of upper and lower incisors. Pre- and post-treatment lateral cephalograms were traced and superimposed by using SN-7° plane. Sixteen linear measurements were made. Statistical analysis was performed to analyze the co-relation between the hard and soft tissue change by Pearson's correlation. Stepwise multiple regression were made to determine factors that related with lip changes.

Results: Significant changes after treatment were found both in dental and lip analysis. The equations of upper and lower lip changes in sagittal and vertical dimensions were derived.

Conclusion: Stepwise multiple regression analysis revealed that a 1 mm retraction of the maxillary incisor cervical point would produce a 0.59 mm retraction of upper lip and 1 mm retraction of the mandibular incisor cervical point would produce 0.89 mm retraction of the lower lip. The predictability of this study may be helpful for the clinician in predicting the amount of change in profile of the patient post treatment, thus aiding in planning the treatment.

Keywords: Class I bimaxillary protrusion, incisor retraction, lip morphology, lip retraction

INTRODUCTION

Bimaxillary protrusion is a commonly seen malocclusion in Asian population.[1] It refers to a protrusive dentoalveolar relation of maxillary and mandibular dental arches that produce a convex facial profile and an increased procumbency of lips, making facial esthetics, a primary concern for these patients. The concept of esthetics is not just restricted to tooth alignment but also the facial profile. Orthodontic treatment not only produces changes in dental component but also indirectly alters the soft-tissue profile of the

patient. Therefore, the treatment in bimaxillary protrusion cases is directed toward extraction of upper and lower first premolars with subsequent retraction of upper and lower

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incisors.[1] As soft tissue follows the hard tissue, quantifying the lip morphology becomes as important as planning the treatment, attributing to the fact that predicting the amount of lip retrusion in patients with bimaxillary protrusion can be used as a tool for the clinician to anticipate the amount of expected change in the profile of the patient. In case the predicted outcome cannot solve the problem, other treatment modalities can be considered.

There is a general consensus in the literature that incisor retraction is correlated to soft-tissue changes, and therefore has the potential to alter facial aesthetics.[2-4] There have been myriad studies in the past about the upper and lower lip changes after incisor retraction in different populations.[5-9] Data from previous studies show different values for different ethnicities.[10-13] A study evaluating the lip changes with the changes of the maxillary and the mandibular incisor positions in Japanese adults revealed a 1 mm retraction and a 1 mm intrusion of the maxillary incisor cervical point produced a 0.22 mm retraction of the upper lip and a 1 mm retraction of the mandibular incisor tip produced 0.76 mm retraction of the lower lip.[10] However, another study on African American females attained a ratio of 1.75:1 and 1.2:1 between mandibular incisor retraction and retraction of lower lip, and between maxillary incisor retraction and upper lip change respectively.[11] Kusnoto and Kusnoto[13] performed similar study in adult Indonesians treated for bimaxillary protrusion and found that for every millimeter of mandibular incisor retraction, upper lip retracted by 0.4 mm and lower lip by 0.6 mm. For Caucasians, the ratios of maxillary incisor retraction to upper lip retraction are from 2.24:1 to 2.93:1 and for mandibular incisor retraction to lower lip retraction from 1.11:1 to 1.23:1.[14-16] Owing to the variations in the results of similar studies performed on different ethnicities, Sundareswaran and Vijayan[17] performed a study on Dravidian ethnicity and attained a ratio of 1:2.01 for upper lip to upper incisor retraction and 1:1 for lower lip to lower incisor retraction. Moreover, the thickness of the lip is said to be a governing factor affecting the lip morphology post treatment. While some studies have shown a correlation between lip thickness and upper lip response to incisor retraction,[18] others show no significant correlation.[19] Therefore, the present study aimed to establish the relationship between the amount of incisor retraction and the lip changes, as well as to study these changes as related to the initial soft-tissue variables namely lip thickness and the lip strain.

MATERIALS AND METHODS

The study was designed as a retrospective cross-sectional study. Records of bimaxillary protrusion cases which were debonded in the year 2019 in the Department of Orthodontics and Dentofacial Orthopaedics, Baba Jaswant Singh Dental College, Hospital and Research Institute, Ludhiana, were included in the study.

Inclusion criteria
1. Adults (minimum 18 years of age at the start of the treatment)
2. Pretreatment Class I molar relationship, upper and lower incisor protrusion (U1 to NA >4 mm, L1 to NB >4 mm)
3. Cases with orthodontic treatment consisting of the extraction of four premolars with subsequent retraction of anterior teeth
4. Pre- and post-treatment cephalometric radiographs of adequate diagnostic quality.

The sample size for the study was collected using the formula – $N = (Z_{\alpha/2})^2 \, 2s^2/d^2$

$N = (1.96)^2 \, 2 \times 2.4^2/1^2 = 44.25 \cong 44$

The present study was conducted as a pilot study for a larger sample study. Twenty-one cases were identified from the record room. After evaluation of inclusion criteria and completeness of records, 15 cases were selected for the study. The study was performed on the pre and post treatment cephalograms. All the cephalograms were traced with fine 3H pencil, and each parameter was measured with the same ruler and protractor. Before tracing, all cephalograms were checked to ensure that the radiographs were taken when subjects were relaxed, in maximum intercuspation and lip in repose. All the cephalograms were taken from the same cephalostat (Orthphos XG 3D, Dentsply, Sirona, Germany), under same exposure parameters (77 kV, 15 mA, 9.4 s) and the percentage of magnification for pre- and post-cephalograms were constant.

The reference lines for cephalometric analysis were S-true horizontal and S-true vertical. S-true horizontal was constructed from 7 tangent with SN plane and S-true vertical was the line perpendicular with S true horizontal [Figure 1].[20] The variables mentioned in Table 1 were traced to indicate the position of hard and soft tissue landmarks related to the horizontal [Figure 2a] and the vertical reference lines [Figure 2b].[20] The analysis used for the study was derived from a previous study by Yasutomi *et al.*[10]

The amount of lip fall was calculated as a ratio of linear movement of upper and lower incisors with the linear movement of the upper and lower lip, respectively.

The data were further analyzed for any co-relation of the changes in lip morphology with the pretreatment variables, i.e., the lip thickness and the lip strain. Classes based on lip
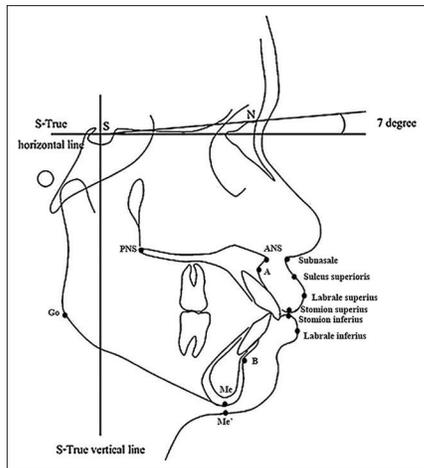
Figure 1: Reference points for the study[20]

Figure 2: (a) Horizontal measurements of dental and lip changes in Table 1.[20] (b) Vertical measurements of dental and lip changes in Table 1[20]

Table 1: Parameters that were used to show relationship of dental and lip changes

Parameters	Definitions
H-tU1 (mm)	Distance from upper incisor edge perpendicular to S-true vertical line
H-cU1 (mm)	Distance from cervical of upper incisor perpendicular to S-true vertical line
H-tL1 (mm)	Distance from lower incisor edge perpendicular to S-true vertical line
H-cL1 (mm)	Distance from cervical of lower incisor perpendicular to S-true vertical line
V-tU1 (mm)	Distance from upper incisor edge perpendicular to S-true horizontal line
V-cU1 (mm)	Distance from cervical of upper incisor perpendicular to S-true horizontal line
V-tL1 (mm)	Distance from lower incisor edge perpendicular to S-true horizontal line
V-cL1 (mm)	Distance from cervical of lower incisor perpendicular to S-true horizontal line
H-U-lip (mm)	Distance from most anterior of upper lip perpendicular to S-true vertical line
H-L-lip (mm)	Distance from most anterior of lower lip perpendicular to S-true vertical line
V-U-lip (mm)	Distance from most inferior of upper lip perpendicular to S-true horizontal line
V-L-lip (mm)	Distance from most superior of lower lip perpendicular to S-true horizontal line
H-subnasale (mm)	Distance from subnasale perpendicular to S-true vertical line
H-sulcus superioris (mm)	Distance from sulcus superioris perpendicular to S-true vertical line
Basic upper lip thickness (mm)	Distance from a point 2 mm below point A to soft tissue contour of upper lip
Thickness at the vermilion border (mm)	Distance from the most labial point on upper incisor to soft tissue contour of upper lip

H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower, t: Incisal edge, c: Cervical point

thickness [Table 2] and lip strain were based on Holdaway's values.[16] Similarly lip strain (difference of basic upper lip thickness and thickness at vermilion border)[16] of more than 2 mm was considered to be a criteria for strained lips.
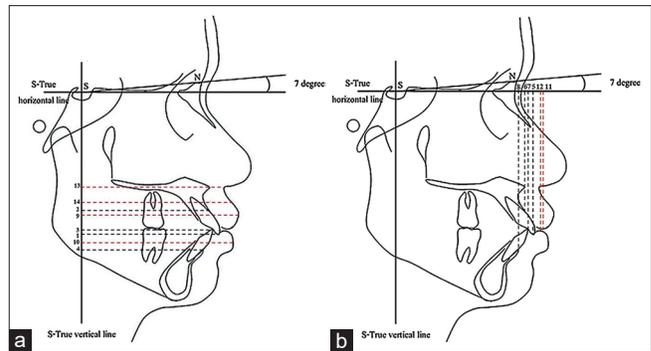
Statistical analysis of the data

The data were evaluated for statistical significance using Statistical Package for Social Sciences (version 23.0, IBM Corp, Armonk, NY, USA) and $P < 0.05$ was considered as the level of significance. Pearson's correlation coefficients were calculated to assess the association between the hard and soft tissue measurements. Stepwise multiple regression analysis was used to determine the best combination of variables that predict lip changes after incisor retraction during orthodontic treatment, at a significance level of $P < 0.05$. ANOVA test was employed to check for any significance of difference in the lip changes in three groups based on lip thickness and two groups based on lip strain.

RESULTS

The means and standard deviations of the pre- and post-treatment measurements and the changes between them are shown in Table 3.

Table 4 shows the correlations between the changes in the soft tissue with the hard tissue and with the pretreatment soft-tissue variables in the horizontal and vertical planes.

Horizontal lip changes

Pearson's correlation showed significant positive correlations between the horizontal changes in upper lip position and the horizontal changes of maxillary incisor cervical position ($R = 0.59$), horizontal changes of mandibular incisor cervical position ($R = 0.58$). There were significant positive correlations between the horizontal changes of lower lip position and those of maxillary incisor tip position ($R = 0.59$), maxillary incisor cervical position ($R = 0.89$), mandibular incisor tip position ($R = 0.53$), and mandibular incisor cervical point ($R = 0.80$). None of the other single hard or soft tissue variables produced good correlations or predicable regression models.

Vertical lip changes

Pearson's correlation indicated a significant positive correlation between the vertical change of upper lip position

Table 2: Classes based on lip thickness

Grade	Class	Range (mm)
1	Thin lips	<14
2	Normal lips	14-16
3	Thick lips	>16

Table 3: Means and standard deviations of pre- and post-treatment variables and the changes between them

Variables	Pretreatment		Posttreatment		Changes	
	Mean	SD	Mean	SD	Mean	SD
H tU1	70.36	5.29	64.76	6.11	5.60	4.02
H cU1	69.15	3.89	65.59	4.27	3.65	3.23
H tL1	65.47	5.58	60.75	6.17	4.76	3.41
H cL1	62.77	5.44	58.77	6.19	4.00	3.11
V-tU1	69.73	4.06	69.13	5.67	3.09	2.85
V-cU1	58.71	4.03	58.73	4.13	3.08	2.23
V-tL1	66.33	5.10	65.80	5.48	2.25	1.82
V-cL1	73.30	5.06	72.67	5.46	2.78	2.34
H-U-lip	81.39	3.69	78.51	5.59	4.00	2.63
H-L-lip	77.01	5.36	74.76	6.42	3.22	3.29
V-U-lip	67.57	3.43	66.67	4.55	1.85	1.21
V-L-lip	69.13	3.67	68.60	4.40	2.29	1.23
H-subnasale	79.97	5.11	78.45	4.27	4.01	3.89
H-sulcus superioris	78.35	5.08	76.75	4.21	3.72	3.49

H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower, t: Incisal edge, c: Cervical point, SD: Standard deviation

Table 4: Pearson correlation analysis between lip and hard tissue changes

	Correlations					
	Pearson correlation					
	ΔH-U Lip	ΔH-L Lip	Δ V-Ulip	ΔV-L lip	ΔSn	Δsls
ΔH-t U1	0.451	0.590*	0.024	00.087	−0.039	0.085
ΔH-cU1	0.597*	0.893**	0.025	0.192	0.298	0.404
ΔH-t L1	0.465	0.535*	0.019	0.130	0.060	0.207
ΔH-cL1	0.584*	0.800**	0.033	0.180	0.305	0.401
Δ V-tU1	0.065	−0.016	0.444	0.523*	−0.101	−0.112
Δ V-cU1	0.320	0.353	0.115	−0.164	0.101	0.050
Δ V-tL1	0.337	0.423	0.504	0.363	0.183	0.150
Δ V-cL1	0.249	0.118	0.524*	−0.074	0.194	0.077
Lip thickness	−0.215	−0.282	−0.182	0.196	−0.070	−0.120
Lip strain	−0.043	0.168	−0.082	0.142	−0.150	−0.112

**Correlation is significant at the 0.01 level (two-tailed), *Correlation is significant at the 0.05 level (two-tailed). H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower, t: Incisal edge, c: Cervical point

and those of mandibular incisor cervical point ($R = 0.52$). There was also a significant positive correlation between the vertical change of lower lip position and the vertical changes of the maxillary incisor tip position ($R = 0.52$).

Stepwise multiple regression analysis [Table 5] revealed that every 1 mm of maxillary incisor retraction at cervical point would produce 0.59 mm backward movement of the upper lip and every 1 mm of mandibular incisor retraction at cervical point would produce 0.89 mm backward movement of the lower lip.

The mean values of the changes in dental and the soft-tissue parameters in both the horizontal and vertical dimensions were seen in the following three groups based on the lip thickness [Table 6] and two groups based on lip strain [Table 7].

The mean soft-tissue changes (Δ H-U Lip, ΔH-L Lip, ΔSn, Δ V-U lip, Δ V-L lip), in the thin lips category were higher than the mean from the total sample [Table 6]. For the thick lips category the mean soft-tissue changes (Δ H-U Lip, ΔH-L Lip, Δ V-U lip, Δ V-L lip, Δ sls), were lower than the mean from the total sample [Table 6].

The mean soft-tissue changes in ΔH-U Lip was more in the unstrained lips compared to the strained lips [Table 7]. ANOVA tests [Tables 8 and 9] show that all these changes were statistically significant ($P < 0.05$).

DISCUSSION

The present study focused on the effects of the dental changes on the soft-tissue profile variables. The ratio of the amount of retraction of the incisors to lip retrusion is a key factor for the prediction of the soft-tissue profile following orthodontic treatment. This ratio has been evaluated in subjects with different morphological, gender, and racial backgrounds using various reference points on the lateral cephalograms. In our study, the ratios of incisor retractions and upper and lower lip retractions came out to be 1:0.59 and 1:0.89, respectively. These ratios are in concordance with previous studies made by Suntornlohanakul *et al.*,[20] Diels *et al.*[21] and Caplan and Shivapuja.[11] Another study from Kusnoto and Kusnoto[13] in Indonesians presented the ratios of incisor

Table 5: Stepwise multiple regression models for the horizontal measurements of the hard and soft tissue variables

Dependent variables	R	R²	Standard error of estimation	Prediction equations			
				Constant	1st	2nd	P
H-U lip	0.597	0.357	2.19	2.25	0.487 (ΔH c U1)	-	0.019
H-L lip	0.89	0.71	1.53	−0.92	0.908 (ΔH c L1)	-	0.000

H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower, c: Cervical point

Table 6: Mean and standard deviation of changes in soft tissue variables in three groups of different lip thickness

	Descriptive statistics							
	Lip thickness							
	Thin lips		Normal lips		Thick lips		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ΔH-U Lip	4.92	2.53	3.39	2.85	3.40	2.83	4.00	2.63
ΔH- L Lip	3.95	3.78	3.04	3.38	1.65	1.63	3.22	3.29
ΔSn	4.03	2.35	4.17	5.27	3.40	4.10	4.01	3.89
ΔV-U lip	2.08	1.77	1.76	0.80	1.50	0.57	1.85	1.21
ΔV-L lip	2.00	1.18	2.31	1.38	3.05	1.06	2.29	1.23
Δsls	3.62	2.27	4.13	4.72	2.60	2.69	3.72	3.49

H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower, SD: Standard deviation

Table 7: Mean and standard deviation of changes in soft tissue variables in two groups of different lip strain

	Descriptive statistics			
	Lip strain			
	Ustrained lips		Strained lips	
	Mean	SD	Mean	SD
ΔH- U Lip	4.350	4.5962	3.946	2.5102
ΔH-L Lip	0.950	0.9192	3.569	3.3986
ΔSn	1.400	1.9799	4.415	4.0043
ΔV-Ulip	1.050	0.6364	1.977	1.2411
ΔV- Llip	0.750	0.0707	2.523	1.1432
Δsls	1.150	0.4950	4.115	3.5928

H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower, SD: Standard deviation

Table 8: Tests of between-subjects effects (for groups based on lip thickness)

Dependent variable	Mean square	F	Significant
ΔH- ULip	82.801	11.212	0.001
ΔH- LLip	54.624	4.584	0.023
ΔSn	80.844	4.594	0.023
ΔV- U lip	17.385	10.565	0.001
ΔV- L lip	26.699	16.452	0.000
Δsls	70.439	5.072	0.017

H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower

Table 9: Tests of between-subjects effects (for groups based on lip strain)

Dependent variable	Mean square	F	Significant
ΔH-U Lip	120.141	16.145	0.000
ΔH-L Lip	83.709	7.803	0.006
ΔSn	128.682	8.520	0.004
ΔV Ulip	26.506	18.243	0.000
ΔV L lip	41.941	34.755	0.000
Δsls	111.409	9.335	0.003

H: Horizontal measurement, V: Vertical measurement, U: Upper, L: Lower

retractions and upper and lower lip retractions as 1:0.4 and 1:0.6, respectively. This study was also done in subjects with bimaxillary skeletal prognathism. These ratios are slightly lesser than the ratios obtained in our present study. This

can be attributed to ethnic differences. Several studies in the past have discussed the ratios for Caucasians. The ratios of maxillary incisor retraction to upper lip retraction ranged from 2.24:1 to 2.93:1 and for mandibular incisor retraction to lower lip retraction from 1.11:1 to 1.23:1.[14-16] The ratio of mandibular incisor retraction to lower lip retraction (1:0.89) from our study stands close to this range, however, the ratio of maxillary incisor retraction to upper lip retraction is slightly more in our study. This may be attributed to the fact that our sample consisted of more subjects with thin lips.

The changes of upper and lower lips correlated with the changes of upper and lower incisors mainly occurred in the sagittal direction.

Changes as related to lip thickness

Previous studies[19-20,22] have shown the relation between lip thickness and the amount of lip retrusion after incisor retraction. In a study by Oliver,[18] patients with thin lips had significant correlation between osseous and soft-tissue changes, whereas no significant correlation was found in persons with thick lips between osseous and soft-tissue changes. Our study presented significant correlation between the hard and soft tissue changes for all the subjects, however the mean soft-tissue changes (Δ H-U Lip, ΔH-L Lip, Δ Sn, Δ V-U lip, Δ V-L lip), in the thin lips category were even higher than the mean from the total sample. Thus, it can be used to anticipate the relative amount of lip retraction after extraction, and thus, the expected change in the profile of the patient.

Changes as related to lip strain

Holdaway's studies[23] have shown that retraction of the maxillary lip does not follow tooth retraction until the factor of lip strain has been eliminated. Similar results were seen in our study as the mean soft-tissue changes in ΔH-U Lip was more in the unstrained lips compared to the strained lips.

CONCLUSION

There were significant changes of upper and lower lips as related to upper and lower incisor retractions.

The ratios and multiple regression equations were as followed:
- Upper incisors retraction: Upper lip retraction = 1:0.59
- Lower incisors retraction: Lower lip retraction = 1:0.89
- ΔH-U-lip = 0.487 (Δ HcUI)
- ΔH-L-lip = 0.908 (Δ HcLI).

Despite, there being a standard treatment protocol of four first premolar extractions for bimaxillary protrusion cases,

satisfied treated patients in not a very consistent finding. This stresses upon the fact that predicting the soft-tissue changes before treatment can help the clinician provide other treatment options to the patients with this malocclusion. Thus, the present study proves to be useful in this context.

Limitations of the study

The ratios obtained in the study for the lip retraction corresponding to the incisor retraction cannot be universally applied. The study has been performed on a smaller sample size and an extensive study is required to extrapolate these ratios as the standard for the North Indian population.

Future scope of the study

This study is a pilot study for a bigger project, i.e., on a larger sample size. Owing to the fact that the ethnic and racial differences affect the post treatment behavior of soft tissue, the study on our North Indian population to predict the response peculiar to our population is justified.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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