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Original Article

Post-Orthodontic Cephalometric Variations in Bimaxillary Protrusion Cases Managed by Premolar Extraction – A Retrospective Study

ND Alqahtani, R Alshammari[1], K Almoammar, N Almosa, A Almahdy, SF Albarakati[1]

Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, Riyadh, [1]Department of Preventive Dentistry, College of Dentistry, University of Hail, Hail, Saudi Arabia

Abstract

Background: Bimaxillary protrusion is a common dentofacial condition associated with proclination of maxillary and mandibular incisors in relation to the dental and cranial bases resulting in soft tissue procumbency. The present retrospective study aimed to investigate dental and soft tissue profile changes using cephalometric analysis to evaluate bimaxillary protrusion patients after extraction of the first four premolars and subsequent retraction of the anterior teeth. **Materials and Methods:** Pre-treatment and post-treatment cephalometric radiographs of 46 Saudi patients (16 males and 30 females), 18-30 years of age with bimaxillary protrusion, were selected based on inclusion criteria. Dental and soft tissue landmarks were traced using the Dolphin® imaging software and statistically analyzed with SPSS® 21 software. **Results:** The upper and lower incisors retroclined by a mean value of 9.6° and 9.65°, respectively, and an average distance of 4.1 mm. The level of maxillary incisor exposure was reduced by approximately 1.1 mm after treatment. A mean increase of 6.6° in the nasolabial angle was also observed. Multiple regression analysis showed that retraction of both upper and lower incisors by 1 mm would result in a 0.44 mm retraction of the upper and lower lips. **Conclusion:** A statistically significant increase in the nasolabial angle and upper lip length was found in relation to upper and lower incisor retraction and retroclination. A significant reduction was also evident in the post treatment upper incisor exposure, facial convexity angle and mentolabial sulcus depth.

Keywords: *Bimaxillary protrusion, cephalometric radiographs, soft tissue profiles*

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Introduction

Bimaxillary protrusion[1] is described as a condition with dental protraction, wherein the teeth are not perpendicular to the corresponding basal bone with anterior tipping of the incisors. In individuals with pure alveolar protraction, the teeth may or may not be in an upright position; however, a definite degree of prominence of the alveolar process is always associated with lip prominence. Esthetic concerns of the patients preferring orthodontic correction are often due to the protruding teeth and everted lips.[2] As the negative perceptions associated with bimaxillary protrusion in different cultures, it has been reported to be one of the main reasons behind patients seeking orthodontic management.[3,4]

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The primary objective of orthodontic management for bimaxillary protrusion of the teeth is to improve lip competency and reduce the convexity of the facial profile. Most often it is accomplished by removal of the maxillary and mandibular first premolars and subsequent retroclination of the anterior teeth to a more favorable position within the basal bone.[3,5,6] Previous prospective studies have compared soft tissue

Address for correspondence: Dr. ND Alqahtani, Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, P.O. Box 231903, Riyadh - 11321, Saudi Arabia.
E-mail: nasserdm@ksu.edu.sa

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procumbency in extraction and non-extraction cases and determined that study subjects with extraction of the maxillary and mandibular premolars presented with straighter faces and upright incisors in both arches.[7,8] Similarly, it has been reported that the extraction of the first maxillary and mandibular premolars flattens the facial form by 2–3 mm when compared with non-extraction orthodontic treatment.[9] From an orthodontic perspective, excessive lip prominence is an essential pretreatment profile feature that impacts the need for extraction.[10] Interestingly, Aldrees and Shamlan in their study found that bimaxillary protrusion is associated with an appreciable level of lip prominence as reported in Saudi cephalometric norms.[11]

The uniqueness of cephalometric findings in Saudi Arabian population and their differences with the global norms have been documented by several authors. In a clinical study based on Saudi population, Al-Jasser reported a reduced nasolabial angle and more anteriorly positioned upper and lower lips when compared to the Caucasian population.[12] Al Barakati reported that the enhanced bimaxillary lip prominence, elevated mentolabial sulcus, and a diminished vertical lip-chin ratio observed in Saudi adult patients are considerably at par with European and American cephalometric norms.[13] Moreover, Al Barakati and Bindayel observed that Saudi patients had more convex profiles with an enhanced H-angle and significant soft tissue prominence.[14]

Significant correlation between incisor and lip retraction in individuals with thin lips or a high lip strain, were reported based on a pre- and post-treatment cephalometric study by Oliver.[15] However, Rains and Nanda on evaluating similar soft tissue responses found a negligible correlation.[16] Additionally, Franklin and Hunter proved that a significant correlation existed between an increase in the nasolabial angle as a result of maxillary incisor retraction and also increased post-treatment lower facial dimension.[17] The differences in observed soft tissue responses might be attributable to individual variations in lip morphology, management protocol, gender and age of the study subject.[18,19]

The idea behind the present study was to substantiate and validate the effective dental and soft tissue post-orthodontic profile changes among Saudi individuals with bimaxillary protrusion. Therefore, the aim of the present study was to retrospectively evaluate these profile changes in patients managed with extraction of maxillary and mandibular first premolar teeth followed by retraction of anterior teeth, through comparative analysis of pre- and post-treatment cephalometric radiographs.

Materials and Methods

The present retrospective study was conducted using cephalometric radiographs of adult bimaxillary protrusion patients who underwent non-surgical extraction of maxillary and mandibular premolar teeth, and comprehensive orthodontic treatment. A power analysis (set at ≥80%) was utilized to determine a statistically acceptable sample size comparable to previously published data in the dental literature. Lateral cephalometric radiographs of patients with pleasing and harmonious facial profile determined by an ANB angle of 3° ± 2.3, SN-MP angle of 32° ± 5, Class I molar relationship with an inter-incisal angle of 110.4° ± 6, Overjet = 3 ± 1 mm, and Overbite = 1.4 ± 1 mm were included in the study. Based on the study protocol, cephalometric radiographs of subjects who underwent extraction of maxillary and mandibular first premolars, and treated with fixed orthodontic appliance for retraction of anterior teeth and correction of bimaxillary protrusion were only included. Cephalometric radiographs of individuals managed with functional appliances, orthognathic surgical procedures and individuals with congenitally missing teeth (exclusion of third molars) were excluded from the study.

Data were collected from pre- and post-orthodontic digital lateral cephalometric radiographs. Radiographic data acquisition was done using a Planmeca Proline XC CEPH X- Ray Unit (Planmeca OY, Helsinki, Finland) set at 80 kV with a total filtration 2.5 mm Al and 1500 VA, 50 Hz. All the radiographs were procured from a private clinic in Riyadh, Saudi Arabia, wherein the same orthodontist managed all the cases with a fixed edgewise (0.018" slot) mechanotherapy using maximum anchorage (Nance appliance) in the upper arch. The lateral cephalometric radiographs were taken according to the standard patient position protocols as determined by Burstone (1967).[20] Dolphin Imaging® 10.0 software (Dolphin Imaging and Management Solutions, Chatsworth, CA, United States) was utilized to analyze the digital lateral cephalometric radiographs. The probability for magnification was eliminated by calibrating the actual length of the ruler on the head positioner. A total of 23 linear measurements, five angular measurements, and two ratios were calculated for each subject. Lateral cephalometric measurements used in this study were based on a collection of commonly used linear and angular measurements from previous studies and selected from different analyses,

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namely, Burstone, Downs, Holdaway, Legan, Steiner, and Tweed analyses.

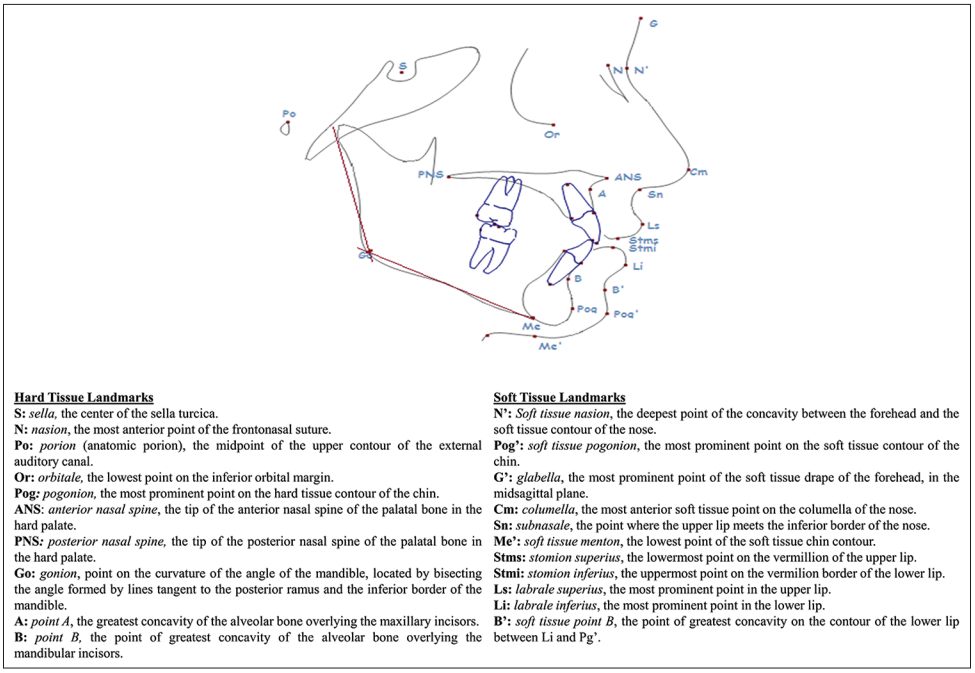
In order to evaluate intra examiner reliability, a pilot study operator traced 10 randomly selected radiographs twice within a period of 2 weeks to evaluate the degree of subjective error in measurement. The pilot study correlation values ranged from 77% to 99%, and were considered highly reliable. The lips and chin were the variables subjected to initial cephalometric analysis in accordance with cephalometric norms.[20] Soft tissue profile analysis for the lateral cephalometric radiographs was done using a customized analytic template obtained from a collection within the Dolphin analysis toolbar (Dolphin Imaging 10.0). Manual identification of the cephalometric points and landmarks was done on the digital images, and then soft tissue linear and angular variables were measured electronically.

Data were statistically analyzed using the SPSS PC+ version 21.0 for Windows; (IBM SPSS Statistics Version 21.0, IBM Corporation, Armonk, NY, USA). Descriptive statistics were used to describe the quantitative outcome variables. The mean values of the variables measured by the same investigator and identified landmarks were compared using paired t- tests to detect any significance in the difference. The strength of the relationship between the first and second readings was evaluated by a correlation of coefficient test. The results with high values were considered (a minimum value of $r = 0.75$) to have negligible error. The pre- and post-test mean values of quantitative variables were compared with the Student's paired *t*-test, with resulting differences being the variable of interest. Non-parametric statistical tests were used, as the data did not follow a normal distribution and were associated with high standard deviations. Wilcoxon's sign rank test was used when a higher standard deviation was observed in some of the variables. To quantify the correlation between the differences in the pre- and post-values of variables Spearman's rank correlation was used. To identify the predictors for some of the outcome variables of interest, multiple linear regression was used. The statistical significance of results was fixed at a *P* value below 5% ($\alpha = 0.05$) and 95% confidence interval.

Results

The cephalometric profile landmarks and planes of reference used in the present study are described in Figures 1 and 2, respectively. Similarly, cephalometric and soft tissue profile measurement and soft tissue angle measurements used in this study are detailed in Figures 3 and 4, respectively. The results of correlation between test and retest values for intra examiner reliability are shown in Table 1.

A significant difference in the pre- and post-orthodontic mean values of upper incisor retroclination and lower incisor retraction were evident when measured in relation to the cephalometric points. Retroclination of



Hard Tissue Landmarks

S: *sella,* the center of the sella turcica.
N: *nasion*, the most anterior point of the frontonasal suture.
Po: *porion* (anatomic porion), the midpoint of the upper contour of the external auditory canal.
Or: *orbitale,* the lowest point on the inferior orbital margin.
Pog: *pogonion,* the most prominent point on the hard tissue contour of the chin.
ANS: *anterior nasal spine*, the tip of the anterior nasal spine of the palatal bone in the hard palate.
PNS: *posterior nasal spine,* the tip of the posterior nasal spine of the palatal bone in the hard palate.
Go: *gonion*, point on the curvature of the angle of the mandible, located by bisecting the angle formed by lines tangent to the posterior ramus and the inferior border of the mandible.
A: *point A*, the greatest concavity of the alveolar bone overlying the maxillary incisors.
B: *point B,* the point of greatest concavity of the alveolar bone overlying the mandibular incisors.

Soft Tissue Landmarks

N': *Soft tissue nasion*, the deepest point of the concavity between the forehead and the soft tissue contour of the nose.
Pog': *soft tissue pogonion*, the most prominent point on the soft tissue contour of the chin.
G': *glabella*, the most prominent point of the soft tissue drape of the forehead, in the midsagittal plane.
Cm: *columella*, the most anterior soft tissue point on the columella of the nose.
Sn: *subnasale*, the point where the upper lip meets the inferior border of the nose.
Me': *soft tissue menton*, the lowest point of the soft tissue chin contour.
Stms: *stomion superius*, the lowermost point on the vermillion of the upper lip.
Stmi: *stomion inferius*, the uppermost point on the vermilion border of the lower lip.
Ls: *labrale superius*, the most prominent point in the upper lip.
Li: *labrale inferius*, the most prominent point in the lower lip.
B': *soft tissue point B*, the point of greatest concavity on the contour of the lower lip between Li and Pg'.

Figure 1: Cephalometric profile landmarks

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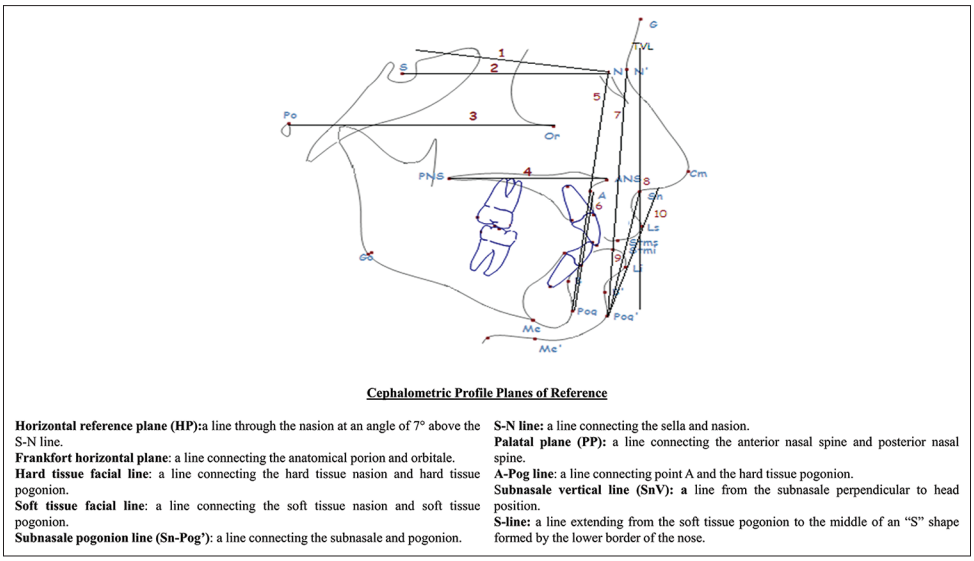

Cephalometric Profile Planes of Reference

Horizontal reference plane (HP):a line through the nasion at an angle of 7° above the S-N line.
Frankfort horizontal plane: a line connecting the anatomical porion and orbitale.
Hard tissue facial line: a line connecting the hard tissue nasion and hard tissue pogonion.
Soft tissue facial line: a line connecting the soft tissue nasion and soft tissue pogonion.
Subnasale pogonion line (Sn-Pog'): a line connecting the subnasale and pogonion.
S-N line: a line connecting the sella and nasion.
Palatal plane (PP): a line connecting the anterior nasal spine and posterior nasal spine.
A-Pog line: a line connecting point A and the hard tissue pogonion.
Subnasale vertical line (SnV): a line from the subnasale perpendicular to head position.
S-line: a line extending from the soft tissue pogonion to the middle of an "S" shape formed by the lower border of the nose.

Figure 2: Cephalometric profile planes of reference

Table 1: Correlation between test and retest values

Measurements	Correlation between test and retest values	*p*
Dental		
Upper incisor retroclination (UI-PP)	0.914	<0.001
Upper incisor retraction (UI-APog')	0.969	<0.001
Upper incisor retraction (UI-TVL)	0.941	<0.001
Lower incisor retroclination (LI-FMIA)	0.911	<0.001
Lower incisor retraction (LI-APog')	0.988	<0.001
Lower incisor retraction (LI-TVL)	0.913	<0.001
Maxillary incisor exposure	0.954	<0.001
Soft tissue		
Soft tissue facial angle	0.988	<0.001
Basic upper lip thickness	0.905	<0.001
Upper lip strain measurement	0.893	0.001
Facial convexity angle	0.988	<0.001
ST facial Ht (vertical height ratio)	0.771	0.034
Nasolabial angle	0.936	<0.001
Mentolabial sulcus depth	0.853	0.002
Interlabial gap	0.975	<0.001
Vertical lip-chin ratio	0.798	0.006
U lip length	0.793	0.006
Upper lip protrusion		
LL to Sn-Pog' line	0.975	<0.001
UL-SnV	0.988	<0.001
UL-S line	0.999	<0.001
L lip length	0.939	<0.001
Lower lip protrusion		
Li to Sn-Pog' line	0.991	<0.001
LL-SnV	0.954	<0.001
LL-S line	0.973	<0.001

UI- Upper incisor, PP-Palatal plane, A-Pog- Line connecting point A and hard tissue pogonion, TVL- True vertical line, FMIA- Frankfurt mandibular incisal angle, LI- Lower incisor, LL- Lower lip, Sn- subnasale, S- Sella

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Table 2: Evaluation of pre-treatment and post-treatment dental changes

Variables	Pre-treatment mean and Sd.	Post-treatment mean and Sd.	Mean difference	*p*	95% Confidence interval	
UI-PP (°)	122.4±4.7	109.6±5.1	9.6	<0.001*	4.5	14.7
UI-APog' (mm)	36.1±2.9	26.9±3.6	4.1	<0.001*	0.5	7.7
UI-TVL (mm)	3.58±2.1	0.83±2.3	3.8-9.65	<0.001*	2.30	4.19
LI-FMIA (°)	48.9±3.0	58.6±3.3	4.1	<0.001*	-10.7	-8.6
LI-APog' (mm)	35.7±5.0	26.3±5.8	3.6	<0.001*	-1.7	9.9
LI-TVL (mm)	-0.61±2.8	-3.24±2.2	1.1	<0.001*	0.8	6.42
Maxillary incisor exposure (mm)	4.2±2.1	3.1±1.7		<0.001*	0.59	1.64

**Statistically significant difference; UI- Upper Incisor, PP-Palatal plane, A-Pog- Line connecting point A and hard tissue pogonion, TVL- True vertical line, FMIA- Frankfurt mandibular incisal angle, LI- Lower incisor*

Table 3: Evaluation of pre-treatment and post-treatment soft tissue changes

Variables	Pre-treatment mean and Sd.	Post-treatment mean and Sd.	Mean difference	*p*	95% confidence interval	
Soft tissue facial angle (°)	89.0±4.4	88.8±3.9	0.05	0.96	1.1	1.2
Facial convexity angle (°)	20.3±14.3	19.0±15.0	1.3	<0.001*	0.63	1.9
Vertical height ratio (%)	3.0±13.1	3.2±14.2	-0.2	0.12#	---	--
Nasolabial angle (°)	98.1±17.3	104.7±18.4	-6.6	<0.001*	-8.8	-4.4
Mentolabial sulcus depth (mm)	5.3±1.9	4.4±1.6	0.9	0.005*	0.30	1.6
Vertical lip-chin ratio (%)	48.2±5.1	48.8±5.8	-0.6	0.41	-1.8	0.77
Basic upper lip thickness (mm)	19.9±3.6	20.3±3.6	-0.4	0.50	-1.5	0.74
Upper lip thickness (mm)	12.1±2.1	12.2±1.9	-0.1	0.80	-0.46	0.60
U lip length (mm)	21.0±1.7	22.1±1.9	-1.1	<0.001*	-1.5	-0.67
L lip length (mm)	23.0±3.3	23.5±3.5	-0.5	0.015*	-0.8	-0.09
UL protrusion (Ls to Sn-Pog' line) (mm)	12.5±1.6	8.4±1.7	4.1	<0.001*	3.6	4.6
UL protrusion (LL-SnV) (mm)	5.3±1.9	3.4±1.9	1.9	<0.001*	1.5	2.3
UL protrusion (LL-S line) (mm)	2.5±1.7	0.50±1.8	2.0	<0.001*	1.6	2.3
LL protrusion (Li to Sn-Pog' line) (mm)	8.9±2.0	4.7±1.4	4.2	<0.001*	3.6	4.7
LL protrusion (LL-SnV) (mm)	2.9±2.6	1.3±2.3	1.6	<0.001*#	-1	4.2
LL protrusion (LL-S line) (mm)	4.2±1.7	1.5±1.8	2.7	<0.001*	2.4	3.1
Interlabial gap (mm)	5.6±7.0	3.0±1.4	2.6	<0.001*#	-4.4	9.6

**Statistically significant difference, #Wilcoxon sign rank test; UI- Upper Incisor, PP-Palatal plane, LL- Lower lip, Sn-Pog- a line connecting the subnasale and soft tissue pogonion, SnV): a line passing through the subnasale perpendicular to the natural head position, S-line- a line extending from the soft tissue pogonion to the middle of an "S" shape formed by the lower border of the nose*

Table 4: Correlations of lower lip changes with dental and soft tissue variables

Variables	LI-FMA (r)	LI-APog' line (r)
LL retraction to Sn-Pog' line	-0.341*	0.697**

**Statistically significant positive correlation, ** High statistically significant correlation; LL- Lower lip, Sn-Pog- a line connecting the subnasale and soft tissue pogonion*

the upper incisors were evident by a mean angle of 9.6° in relation to the palatal plane and they had been retracted by a mean distance of 4.1 and 3.8 mm in relation to the A-Pog' line and true vertical line (TVL), respectively. The lower incisors had been retroclined by a mean angle of 9.65° in relation to the FMIA angle and were retracted by a mean distance of 4.1 and 3.6 mm in relation to the A-Pog' line and TVL, respectively [Table 2].

Moreover, statistically significant difference ($P < 0.05$) in the mean values of the soft tissue profile parameters such as the facial convexity angle, nasolabial angle, mentolabial sulcus depth, and upper lip length were also evident. While the amount of facial convexity was reduced by a mean angle of 1.3°, the nasolabial angle increased by a mean of 6.6°, and the mentolabial sulcus depth decreased by a mean of 0.9 mm. Wilcoxon sign rank test showed a significant ($P < 0.05$) reduction in lower lip protrusion in relation to SnV by a mean value of 1.6 mm and a further reduction in the mean

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Table 5: Predictors of upper and lower lip changes

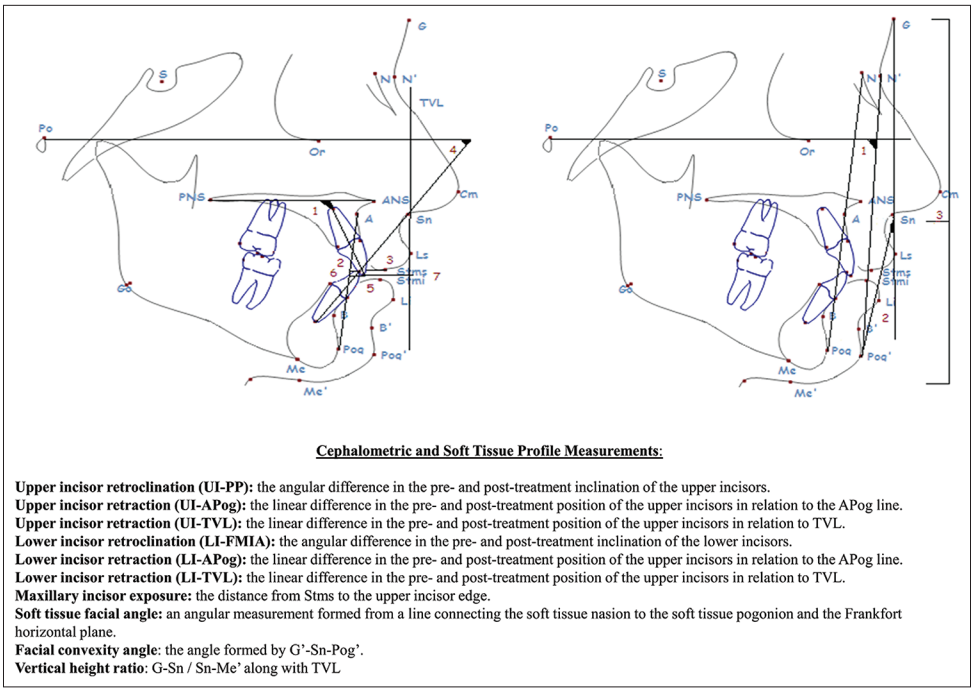
Dependent	Independent	*r*	*p*	r^2
Change of basic upper lip thickness	Lower incisor retraction	0.175	0.042*	42%
	Initial basic upper lip thickness	0.447	0.004**	
Change of upper lip thickness	Initial upper lip thickness	0.416	0.001**	28%
Change of UL-SnV	Upper incisor retraction	0.147	0.009**	21%
Change of LL-SnV	Upper incisor retraction	0.204	0.006**	25%

**Statistically significant positivee correlation, ** High statistically significant correlation; UL- Upper lip, LL- Lower lip, SnV- A line passing through the subnasale perpendicular to the natural head position*

Table 6: Predictors of other soft tissue changes

Dependent	Independent	*r*	*p*	r^2
Change of soft tissue facial angle	Lower incisor retraction	0.526	0.013*	22%
Change of facial convexity angle	UL to Sn-Pog' line	0.900	0.008**	42%
	Change of UL to S-line	1.364	0.001**	
Change of mentolabial sulcus depth	Lower incisor retroclination	-0.230,	0.001**	60%
	Initial mentolabial sulcus depth	0.809	<0.0001**	
Change of interlabial gap	Initial upper lip thickness	0.395	0.018*	21%

**Statistically significant positive correlation, ** High statistically significant correlation; UL- Upper lip, Sn-Pog- a line connecting the subnasale and soft tissue Pogonion, S-line: a line extending from the soft tissue pogonion to the middle of an "S" shape formed by the lower border of the nose*



Cephalometric and Soft Tissue Profile Measurements:

Upper incisor retroclination (UI-PP): the angular difference in the pre- and post-treatment inclination of the upper incisors.
Upper incisor retraction (UI-APog): the linear difference in the pre- and post-treatment position of the upper incisors in relation to the APog line.
Upper incisor retraction (UI-TVL): the linear difference in the pre- and post-treatment position of the upper incisors in relation to TVL.
Lower incisor retroclination (LI-FMIA): the angular difference in the pre- and post-treatment inclination of the lower incisors.
Lower incisor retraction (LI-APog): the linear difference in the pre- and post-treatment position of the upper incisors in relation to the APog line.
Lower incisor retraction (LI-TVL): the linear difference in the pre- and post-treatment position of the upper incisors in relation to TVL.
Maxillary incisor exposure: the distance from Stms to the upper incisor edge.
Soft tissue facial angle: an angular measurement formed from a line connecting the soft tissue nasion to the soft tissue pogonion and the Frankfort horizontal plane.
Facial convexity angle: the angle formed by G'-Sn-Pog'.
Vertical height ratio: G-Sn / Sn-Me' along with TVL

Figure 3: Cephalometric and soft tissue profile measurements

interlabial distance (2.6 mm) was also observed. There was no significant difference between the pre- and post-treatment values of other soft tissue variables (soft tissue facial angle, vertical height ratio, vertical lip-chin ratio, basic upper lip thickness, upper lip thickness, and lower lip length) [Table 3].

Pearson's coefficient of correlation (*r*) was calculated to assess the degree of correlation among different variables. Retraction of the lower lip in relation to the Sn-Pog' line exhibited a highly positive correlation with LI-APog' line [Table 4]. Linear regression was used to find the most important probable predictors (independent variables) that could lead to statistically significant changes in dependent variables. A change in initial upper lip thickness could be 42% predicted by lower incisor retroclination and initial basic upper lip thickness. Consequently, retraction of the lower incisors by a distance of

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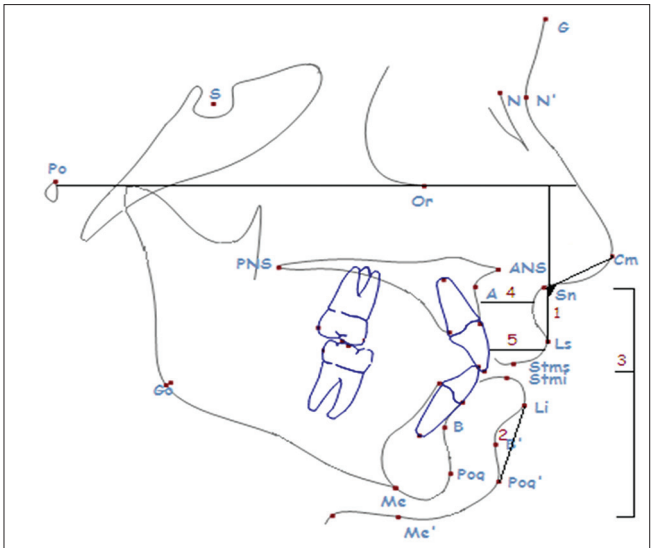

Soft Tissue Angle Measurements

Nasolabial angle: the angle formed by Cm-Sn-Ls.
Mentolabial sulcus depth: the distance from B' to Li-Pog'.
Vertical lip-chin ratio: Sn-Stms / Stmi-Me' along TVL.
Basic upper lip thickness (UL-A point): the distance from a point about 3 mm below point A to the drape of the upper lip.
Upper lip thickness (UL-vermilion): the distance from the labial surface of the upper incisors to the vermilion border of the upper lip.

Figure 4: Soft tissue angle measurements

1 mm would increase the basic upper lip thickness by 0.175 mm. In addition, each 1 mm of lower incisor retraction would increase the soft tissue facial angle by 0.52° [Tables 5 and 6].

Discussion

The present retrospective study evaluated the variations in dental and soft tissue facial form following orthodontic management of patients with bimaxillary protrusion, treated through extraction of maxillary and mandibular first premolars and followed by retroclination of the anterior teeth.[19,21-23]

Results from this study indicate appreciable changes in the dental position and inclination of the upper and lower incisors (9.6° and 9.65°) between pre- and post-treatment records. Moreover, using the TVL as a reference the increase in mean upper and lower incisor retroclination were 3.8 and 3.6 mm, respectively. In agreement with our results, Jacobs[24] reported a 4-to-10 mm horizontal change in the maxillary incisor position among Class II, Division I malocclusion patients, managed with maxillary and mandibular first premolar extraction.[24] However, Saelens and De Smit[25] reported findings which were comparatively lower than the present study. In their study, the reduction in incisor inclination following first premolar extraction and Begg appliance therapy was 1.4° (upper) and 3.5° (lower), and incisor retraction was 2.1 mm (upper) and 0.6 mm (lower).[25] Interestingly, Bills *et al*.[26] reported higher angular incisor retroclination (upper: 12.7°/lower; 5.6°) and retraction (upper: 5.2 mm/lower: 3.2 mm) under similar circumstances. The differences observed in the afore-mentioned study[26] could be attributable to the racial group of the sample and the different reference lines used to assess incisor inclination. Instead of the TVL, they utilized a vertical plane which was drawn perpendicular to an imaginary horizontal line constructed 7° below the SN plane and passing through S-point.[26] This altered vertical plane has also been reportedly used in two other studies.[27,28]

Kachiwala *et al*.[27] reported upper and lower incisor retraction of 5.9 and 3.9 mm, respectively, following first premolar extraction in a sample comprising Indian women. Based on a study in Iranian females treated with fixed orthodontic appliances and first premolar extraction for Class I or Class II malocclusion, Sodagar *et al*.[28] reported incisor retraction of 4.5 mm (upper) and 1.9 mm (lower). Although the present study sample included males and females, it should be highlighted that variability in mean values of incisor retroclination and retraction could be due to ethnic differences in dental protrusion, variations in the reference planes and the types of orthodontic appliance and anchorage used. Furthermore, statistically significant correlation was observed in the present study between lower incisor retraction and retroclination, and lower lip retraction (r = 0.697 and r = −0.341, respectively), as observed in previous studies.[19,29,30] This could be justified by the fact that the lower incisor is considered as the supporting unit for the lower lip, and any movement in the lower incisor would consequently affect the lower lip to a certain degree. Similarly, Khan and Fida[30] also reported significant correlation between the upper and lower incisors' position and the upper and lower lips (r = 0.53 and r = 0.051, respectively) following retraction and retroclination of the incisors.[30]

The Prediction of soft tissue profile changes following orthodontic retraction of incisors determined from a population of bimaxillary protrusion cases showed that upper incisor retraction accounted for approximately 62% of upper lip retraction.[27] It was further surmised that the presence of other confounding factors may account for the remaining 38%.[27] Studies on three-dimensional soft tissue evaluations have concluded that lip response follows a nonlinear relationship with incisor retraction.[15,21,27] Additionally, retraction of the upper lip coincides with reduction in upper incisor exposure, as evidenced from the present study,

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wherein a highly significant change in upper incisor exposure (1.1 mm) was observed following retraction. In contrast, Konstantonis[31] reported insignificant differences related to upper incisor exposure following upper lip retraction.[31] Similarly, insignificant changes in the upper incisor exposure and interlabial gap, following upper incisor retraction, were also reported by Khan and Fida.[30] Although their study was based on a small sample size (n = 17), they suggested that even minimal interlabial gap reduction will bring about a great esthetic improvement, especially in patients with thin or short lips.[30] Moreover, the present study showed that the mentolabial sulcus depth became shallower when compared to pre-treatment values and this change was significant by a mean value of 0.9 mm. This also resulted in a significant increase in the mentolabial angle and subsequent improvement in the facial profile angle by mean values of 7.5° and 12.2°, respectively, as suggested in previous studies.[18,27]

The results of this study indicated no significant difference in terms of change in upper lip thickness in response to upper incisor retroclination. However, there was negative correlation between the mean values of upper incisor exposure and upper lip thickness (r = −0.43). Based on a similar study, Drobocky and Smith[32] reported significant correlation between upper incisor retraction and upper lip thickness. In addition, they observed that 3 mm of upper incisor retraction would increase upper lip thickness by 1 mm.[32] On the contrary, Oliver[15] reported no correlation between incisor retraction and lip movement, especially in subjects with thick lips. Interestingly, the results of the present study suggest that incisor retroclination in combination with initial basic upper lip thickness are reliable predictors for change in the upper lip thickness, in up to 42.2% of patients. While every 1° of incisor retroclination resulted in a 0.17 mm increase in basic upper lip thickness, a 1-mm increase in initial basic upper lip thickness will reduced this change by 0.45 mm. Although not observed in the present research, studies in the literature have also reported significant reduction in lower lip thickness[33] and significant increase in lower lip length up to 3.4 mm,[34] following first premolar extraction and incisor retraction. Accordingly, lower lip changes are reportedly associated with a higher percentage of predictability, in contrast to upper lip changes owing to the complex functional musculoskeletal anatomy of the nasomaxillary complex.[30,33,34]

Although the present study comprehensively evaluated dental and soft tissue lateral cephalometric changes in patients with bimaxillary protrusion and treated by first premolar extraction, the outcomes were limited by the small number of male subjects included in the study sample. Moreover, the presence of various cephalometric analyses and lack of standardization in the research methods, as reported in the literature, make it difficult to compare the present study results to those of other studies.

Conclusion

Results of the present study indicate a statistically significant increase in nasolabial angle and upper lip length in relation to upper and lower incisor retraction and retroclination in individuals with bimaxillary protrusion and treated with extraction of maxillary and mandibular first premolars. In addition, post-orthodontic retraction of anterior teeth resulted in a statistically significant decrease in upper incisor exposure, facial convexity angle, mentolabial sulcus depth, and upper and lower lip protrusion. Multiple regression analysis showed that retraction of both upper and lower incisors by 1 mm would result in a 0.44-mm retraction of the upper and lower lips. Future researches in this field with a focus towards standardization of cephalometric analysis will be beneficial in increasing the accuracy of the comparisons.

Ethical compliance

The research proposal was approved by, the Institutional Ethics Committee, CDRC. No. FR.0439, IRB. No. E-18-3029.

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Conflicts of interest

There are no conflicts of interest.

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