Original Article

Dental and Soft Tissue Changes Following Extraction of Second Premolars in Females with Bimaxillary Protrusion: A Retrospective Study

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Abstract

Background: Bimaxillary protrusion is a condition wherein esthetic concerns are the main reason behind seeking orthodontic treatment. **Aim:** The aim of this retrospective cephalometric study was to evaluate the soft tissue profile and dental changes among female Saudi bimaxillary protrusion patients treated with extraction of all second premolars followed by retraction of the anterior teeth. **Subjects and Methods:** Pre and posttreatment cephalometric radiographs of adult female patients (ages 18–30 years) who underwent orthodontic therapy for Class I bimaxillary protrusion were obtained. Data were analyzed with SPSS® software. A paired *t*-test and Pearson's correlation coefficients were conducted with the statistical significance set at 95% (P value < 0.05). **Results:** At posttreatment, there was an overall decrease in the mean values among the majority of the soft tissue and dental cephalometric angles and linear measurements. Among soft tissue variables, there was a marginal increase in the upper lip length by 1.49 mm ($P < 0.001$), and the nasolabial angle increased markedly by 7.64° ($P < 0.001$). Similarly, a marked increase in retroclination by 5.95° ($P < 0.001$) was observed among the dental variables. Conversely, no significant changes were noted in the lower incisors. Pearson's correlation analysis revealed a significant correlation between all the different dental variables. Within the soft tissue variables, there was a significant positive correlation between changes in the upper lip protrusion, lower lip protrusion, upper lip thickness, and the distance from the upper and lower lips to the S-line.

Keywords: *Bimaxillary protrusion, cephalometric analysis, incisor retraction, orthodontic therapy, second premolar extraction, soft tissue profile*

Background

Bimaxillary protrusion is a common clinical condition wherein esthetic concerns of the individual are the main reason behind seeking orthodontic treatment.[1] The protrusion of the upper and lower incisors, along with an evident lip incompetency that characterizes bimaxillary dentoalveolar protrusion, warrants comprehensive orthodontic treatment planning and intervention, which, in most cases, involves the extraction of teeth.[2] Contemporary orthodontic treatment protocols have necessitated a comprehensive approach toward improvements in soft tissue profile in addition to correction of occlusal discrepancies.[3] The pleasing esthetics achieved at the end of orthodontic management for an individual with bimaxillary dentoalveolar protrusion often validates the comprehensive treatment approach.[4] However, optimum facial balance and a pleasing soft tissue profile are not achievable without proper knowledge of the postorthodontic soft tissue profile changes.[5] This justifies the need for a scientific evidence base pertaining to the profound soft tissue profile changes that occur as

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a result of currently operational orthodontic treatment protocols.[6]

The management of bimaxillary protrusion with extraction of the four premolars followed by retraction of the maxillary and mandibular incisors has been reported to improve facial profile deliver results.[7] Most commonly, the first four premolars are extracted and proclined incisors are subsequently retracted in order to reduce lip procumbency and enhance the facial profile.[8] In recent research, the lip profile changes among extraction and nonextraction cases were attributed to the inherent morphology of the soft tissues.[9] According to Saelens and De Smit (1998), when nonextraction treatment is performed without the use of extra-oral traction, it is assumed that the alignment of the teeth results in proclination of the anterior teeth, as well as of the facial profile of the patient.[10] However, Mascarenhas *et al*. (2015) reported that the choice of orthodontic treatment with dental extraction is a very important decision and needs to be subjectively modified according to each patient's treatment requirements. The decision of which tooth/teeth to extract is quite difficult,[11] and clinicians should establish this based on the tooth/teeth that, if extracted, will have the least effect on the patient's profile.[12] Moreover, the decision to extract teeth should be made not only based on the amount of dental crowding but also upon the expected influence on the patient's soft tissue facial profile.[10]

According to a study by Hans *et al*. (2006), the teeth most commonly extracted for orthodontic treatment are the premolars.[13] Their location between the anterior and posterior segments of the mouth makes them a convenient option for extraction.[14] Premolars are normally removed to create space to resolve dental crowding or to treat patients with bimaxillary protrusion.[15] Schoppe (1964) analyzed cases treated by second premolar extractions and concluded that more controlled mesial movement of the molars could be achieved while maintaining them in a good inclination.[16] Steadman (1964), while discussing Schoppe's study, observed that extraction of the second premolars made space closure easier and allowed the teeth to remain synchronized with the growth of the soft tissues and the profile.[17] In some clinical cases wherein first premolar extraction is warranted, a decision to extract the second premolars is also considered due to poor structure of the latter and to preserve the healthy first premolar.

Despite the extensive current evidence on changes post first premolar extraction in multiple ethnic groups, there is a paucity of studies that investigate the postorthodontic soft tissue profile and dental changes after the extraction of maxillary and mandibular second premolars among the Saudi female population. Therefore, the present retrospective study was conceptualized to evaluate, using cephalometric assessment, the soft tissue profile and dental changes among female Saudi bimaxillary protrusion patients treated with extraction of all second premolars followed by retraction of the anterior teeth.

Material and Methods

This study evaluated the pre and posttreatment soft tissue profile and dental changes using lateral cephalometric records obtained from a sample of adult female patients with bimaxillary dentoalveolar protrusion. The sampling frame for the study included patients who underwent orthodontic treatment in a private practice setting in Riyadh, Saudi Arabia, between April 2018 and February 2019. Based on an assumed statistical power of 80%, for this clinical trial and confidence level of 95%, determining a chance of 5% ending up with $P < 0.05$,[18] the sample size was estimated as 30 patients.

The samples were included in the study based on the following inclusion criteria:

- Adult female patients in the age range of 18 to 30
- Angle Class I molar relationship with pretreatment interincisal angle less than 118°[19]
- Patients with mild-to-moderate crowding and minimal discrepancy of incisor position and facial profile who were comprehensively planned for treatment with preferable orthodontic extraction of the four second premolars and subsequent retraction of the anterior teeth with reciprocal anchorage mechanics[20]
- Availability of lateral cephalometric radiographs with adequate diagnostic quality.

Patients were excluded if they had undergone functional appliance therapy or surgical orthodontic treatment, had congenitally missing teeth (excluding third molars), or if they had a medical history of pharyngeal pathology and/or nasal obstruction, snoring, obstructive sleep apnea, adenoidectomy, and tonsillectomy.

All lateral cephalometric radiographs were obtained using a Planmeca Proline XC CEPH X-Ray Unit (Planmeca OY, Helsinki, Finland) set at 80 kV with a total filtration of 2.5 mm Al and 1500 VA and 50 Hz. The radiographs had been obtained as part of the patients' routine records for orthodontic treatment and were taken by the same dental radiology technician with the patients maintaining a natural head position, with the teeth in occlusion and lips relaxed as suggested originally by Burstone (1967).[21]

Treatment mechanics

All subjects were treated by the same clinician. The average treatment duration was 20 months. All patients received full-fixed appliances using 0.022" slot brackets with Roth prescription. Reciprocal anchorage mechanics were applied during orthodontic space closure post second premolar extraction.

Cephalometric analysis

Cephalometric analysis was done using Dolphin Imaging® Software, Version 10.0 (Dolphin Imaging and Management Solutions, Chatsworth, California, USA). The magnification probability was eliminated through calibration of the actual length of the ruler on the head positioner with concomitant identification of the ends of the rulers and the anatomical landmarks. The soft tissue profile and dental landmarks were identified based on previously reported studies and as described in Figures 1 and 2.[22,23]

Further, the anterior cranial base anatomy was used to superimpose pre and posttreatment cephalometric radiographs and quantify the changes in each variable.[24] In order to increase the validity of the measurements, the true vertical line was used as the vertical reference line during superimposition. Identification of cephalometric landmarks on the digital images was carried out manually by the same examiner, followed by the soft tissue and dental linear and angular variable measurements, using different analyses. To ensure intraexaminer reliability, 10 randomly selected cephalometric radiographs were traced and measured by the same investigator. The identification of the cephalometric landmarks and measurement of the variables were carried out in two different sessions separated by a period of two weeks.

Statistical analysis

The mean values of the variables were compared with a paired *t*-test to detect any significant errors. The data was analyzed using the Statistical Package for the Social Sciences (version 21.0 for Windows; SPSS, Chicago, Ill). Descriptive statistics were calculated for each variable of interest. The change from the pre and posttreatment cephalograms was assessed using a paired *t*-test. Pearson's correlation coefficients were also calculated for all the variables of interest. Any *P* value less than 0.05 (5%) was considered statistically significant, and a *P* value less than 0.01 (1%) was considered highly significant.

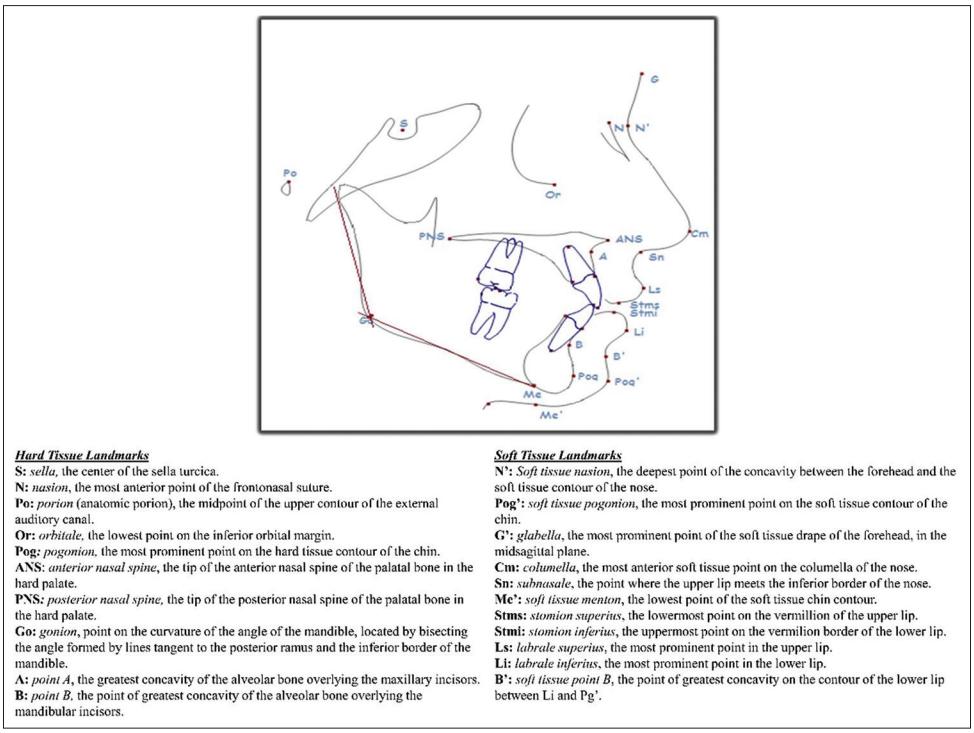
Results

All the cephalometric linear and angular measurements were recorded based on the reference planes and landmarks described in Figures 1 and 2. Similarly, the different soft tissue profile and dental cephalometric measurements are enunciated in Figures 3, 4, and 5. The pre and posttreatment descriptive statistics for the variables of interest are tabulated in Table 1 (Soft tissue cephalometric measurements) and Table 2 (Dental cephalometric measurements). All the variables followed a normal distribution pattern except for soft tissue facial height ratio and interlabial gap. These were analyzed using nonparametric tests. Results of the paired samples *t*-test and Wilcoxon sign rank nonparametric test between the pretreatment and posttreatment variables are shown in Tables 1 and 2.

The paired samples *t*-test and Wilcoxon sign rank nonparametric test between the pretreatment and posttreatment variables revealed a statistically significant change for all measurements except the soft tissue facial angle (0.59°, $P = 0.297$), upper lip thickness at A point (1.83 mm, $P = 0.065$), soft tissue facial height ratio (0.01%, $P = 0.564$), and vertical lip-chin ratio (0.68%, $P = 0.3980$). In addition, the change in facial convexity angle (5.32°, $P = 0.045$) was not highly statistically significant [Tables 1 and 2].

Following the extraction of the second premolars and fixed orthodontic appliance therapy for bimaxillary protrusion, there was an overall decrease in the mean values among the majority of the soft tissue and dental cephalometric angles and linear measurements. Among soft tissue cephalometric variables, there was a marginal increase in the upper lip length posttreatment by 1.49 mm ($P < 0.001$), and the nasolabial angle increased markedly by 7.64° ($P < 0.001$). Similarly, a marked increase in the lower incisor retroclination by 5.95° ($P < 0.001$) was observed among the dental cephalometric variables. There was no change in the dental variables pertaining to the lower incisors.

Pearson's correlation between the different cephalometric variables, which showed statistically significant changes posttreatment, is detailed in Table 3. There was a statistically significant correlation between all the different dental variables [Table 3]. Further, it was observed that the change in upper incisor retraction had a significant positive correlation with the upper lip length, lower lip length, and lower lip protrusion. Similarly, the changes in lower incisor retraction and lower lip to mandibular plane angle had a significant positive correlation with the upper lip length. Interestingly, there was a significant negative correlation between the upper lip length and lower lip protrusion,



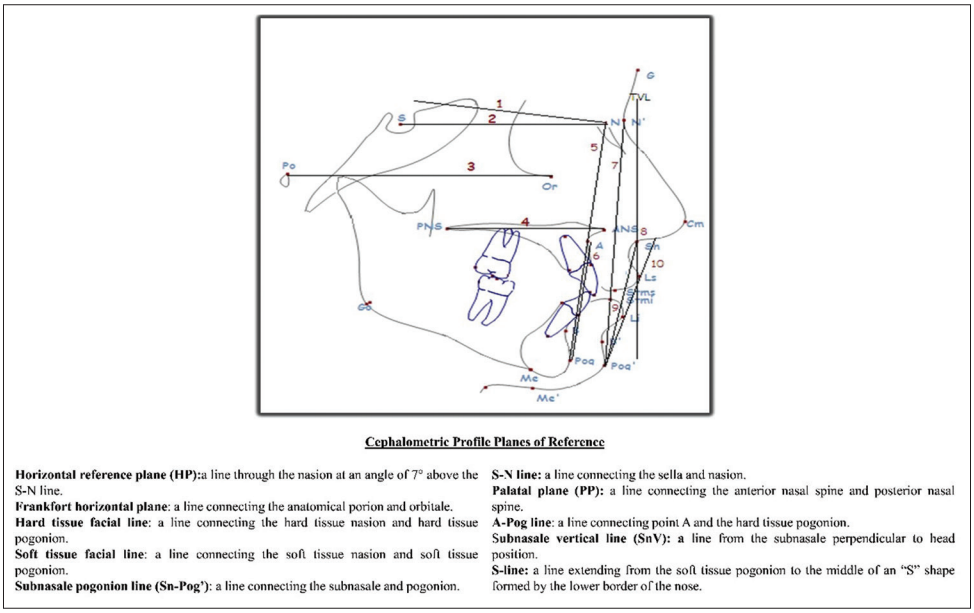
Hard Tissue Landmarks

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: Lateral cephalometric tracing showing the different hard and soft tissue cephalometric landmarks



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: Lateral cephalometric tracing showing the cephalometric profile planes of reference

when compared to a change in the lower incisor retroclination. In addition, changes in the lower incisor to the angle formed between the long axis of the lower incisors and line drawn from nasion to pogonion (NB angle) showed a significant positive correlation with the lower lip protrusion and the distance from the lower lip to the S-line [Table 3].

Within the soft tissue variables, there was a significant positive correlation between changes in the upper lip protrusion, lower lip protrusion, upper lip thickness, and the distances from the upper and lower lip to the S-line. While the facial convexity angle showed a significant positive correlation with changes in the lower lip protrusion, the nasolabial angle was

Table 1: Mean, standard deviation, mean difference between pretreatment and posttreatment values, and paired *t*-test significance among the soft tissue-related cephalometric measurements (variables)

Variable	Description	Pretreatment		Posttreatment		Mean difference	*P*
		Mean	S.D.	Mean	S.D.		
Upper Lip Length (Sn-StSup) (mm)	Upper lip length (Sn-StSup) (mm)	19.29	2.29	20.78	2.55	-1.49	<0.001*
Lower Lip Length (StInf-B') (mm)	Lower lip length (StInf-B') (mm)	25.26	3.60	22.32	3.29	2.94	<0.001*
Upper lip anterior (ULA-Sn) (mm)	Upper lip anterior (ULA-Sn) (mm)	4.30	1.86	2.51	1.97	1.79	<0.001*
Upper Lip-S Line (mm)	Upper lip to S-Line (mm)	1.93	1.81	0.02	1.87	1.91	<0.001*
Lower Lip Protrusion (mm)	Lower lip protrusion (mm)	3.09	3.21	1.40	2.90	1.70	<0.001*
Lower Lip - S Line (mm)	Lower lip to S-Line (mm)	4.40	2.53	1.78	2.37	2.63	<0.001*
UL Protrusion (UL-SnPg') (mm)	Upper lip protrusion (UL-SnPg') (mm)	5.53	1.54	3.76	1.71	1.78	<0.001*
LL Protrusion (LL-SnPg') (mm)	Lower lip protrusion (LL-SnPg') (mm)	6.35	2.37	4.04	2.26	2.31	<0.001*
S.T. Facial Angle (FH-N'Pg') (°)	Soft tissue facial angle (FH-N'Pg') (°)	87.73	4.21	87.14	4.90	0.59	0.297
U-Lip Thickness at A Point (mm)	Basic upper lip thickness (UL-A point) (mm)	13.74	1.40	13.11	1.83	0.62	0.065
U-Lip Thickness at Ver Border (mm)	Upper lip thickness (UL-vermilion) (mm)	12.32	1.82	11.22	1.65	1.09	<0.001*
Facial Convexity (G'-Sn-Po') (°)	Facial convexity angle (G'-Sn-Po') (°)	161.02	4.81	161.98	5.32	-0.96	0.045*
Soft Tissue Face Ht (G'Sn: SnMe')(%)	Soft tissue facial height ratio (G'Sn: SnMe') (%)	1.01	0.09	1.01	0.09	0.01	0.564#
Nasolabial Angle (Col-Sn-UL) (°)	Nasolabial angle (Col-Sn-UL) (°)	104.66	9.40	112.30	9.95	-7.64	<0.001*
Si-(LiPog')	Mentolabial sulcus depth (mm)	-3.71	1.16	-3.12	1.37	-0.59	0.012*
Stm-I (mm)	Lower lip length (mm)	4.22	2.23	2.71	1.59	1.51	<0.001*
Interlabial Gap (mm)	Interlabial gap (mm)	5.56	3.47	1.64	1.91	3.92	<0.001#*
Sn-Stomion/Stomion-Me (%)	Vertical lip-chin ratio (%)	49.62	4.60	48.94	5.34	0.68	0.398

S.D=Standard deviation; #Wilcoxon sign rank test; *Statistically significant difference

Table 2: Mean, standard deviation, mean difference between pretreatment and posttreatment values, and paired *t*-test significance among the dental-related cephalometric measurements (variables)

Variable	Description	Pretreatment		Posttreatment		Mean difference	*P*
		Mean	S.D.	Mean	S.D.		
UI -Palatal Plane (°)	Upper incisor retroclination (UI-PP) (°)	118.47	3.74	109.81	5.28	8.66	<0.001*
UI Protrusion (U1-APo) (mm)	Upper incisor retraction (UI-APog) (mm)	10.17	1.63	6.20	1.95	3.97	<0.001*
LI to A-Po (°)	Lower incisor retraction (LI-APog) (°)	31.10	4.62	25.32	3.93	5.78	<0.001*
FMIA (LI-FH) (°)	Lower incisor retroclination (LI-FMIA) (°)	47.79	5.44	53.74	6.69	-5.95	<0.001*
LI-APOG	Lower incisor retraction (LI-A Pog) (mm)	6.23	2.07	3.09	1.95	3.13	<0.001*
LI-MP	Lower incisor to Mandibular plane (°)	98.22	7.44	90.41	5.92	7.81	<0.001*
LI-NB	Lower incisor to NB plane (mm)	8.85	1.65	6.10	1.90	2.75	<0.001*

S.D=Standard deviation; *Statistically significant difference

significantly negatively correlated with changes in the lower lip length, upper lip protrusion, lower lip protrusion, upper lip thickness, facial convexity angle, and interlabial gap. The only significant positive correlation observed with changes in the nasolabial angle was with the mentolabial sulcus depth. Although changes in the interlabial gap showed a significant positive correlation with the upper lip length and upper lip thickness, they were significantly negatively correlated with changes in the upper lip length, lower

Table 3: Pearson's correlation of cephalometric variables which showed statistically significant difference between the mean pretreatment and posttreatment values (*n*=29)

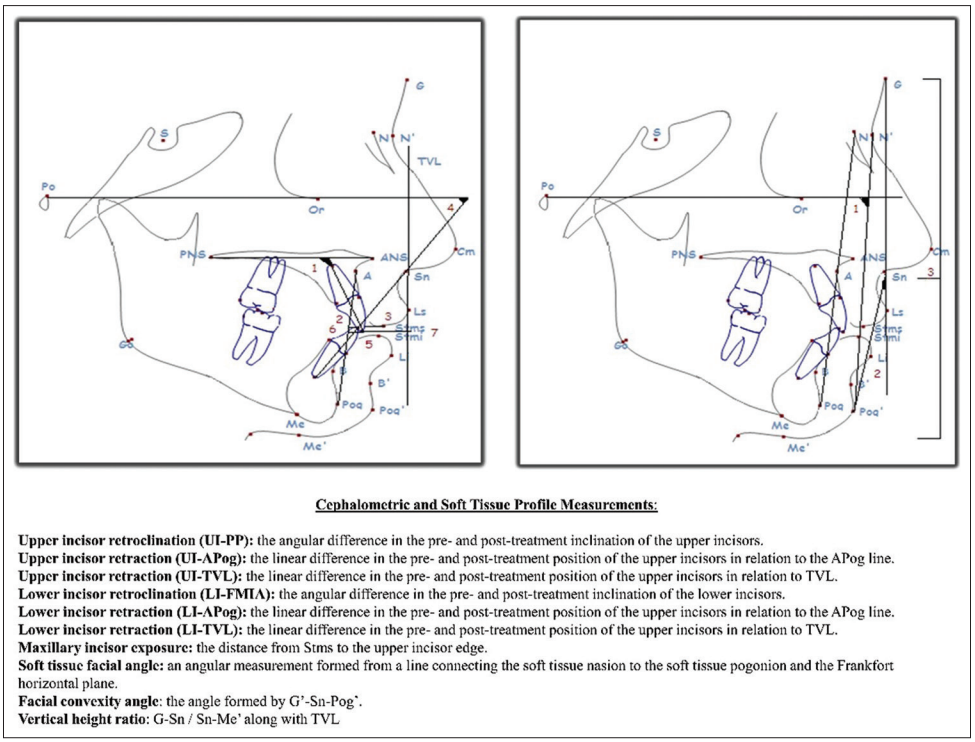
Cephalometric Variables	Pearson's coefficient of correlation (*r*)										
	Upper lip length (Sn-StSup)	Lower lip length (StInf-B)	Upper lip anterior (ULA-Sn)	Upper lip to S-Line	Lower lip protrusion	Lower lip to S-Line	Upper lip protrusion (UL-SnPg')	Lower lip protrusion (LL-SnPg')	Upper lip thickness (UL-vermilion)	Facial convexity angle (G'-Sn-Po')	Nasolabial angle (Col-Sn-UL)
Upper lip length (Sn-StSup) (mm)	1	0.139	-0.051	0.045	0.098	0.063	0.124	0.15	-0.136	-0.129	0.222
Lower lip length (StInf-B') (mm)		1	0.458*	0.336	0.284	0.561**	0.509**	0.596**	0.616**	0.32	-0.529**
Upper lip anterior (ULA-Sn) (mm)			1	0.627**	0.651**	0.420*	0.761**	0.459*	0.538**	0.498**	-0.779**
Upper lip to S-Line (mm)				1	0.143	0.649**	0.939**	0.615**	0.474**	-0.002	-0.557**
Lower lip protrusion (mm)					1	0.450*	0.297	0.534**	0.244	0.507**	-0.231
Lower lip to S-Line (mm)						1	0.669**	0.981**	0.450*	0.05	-0.377*
Upper lip protrusion (UL-SnPg')							1	0.680**	0.633**	0.227	-0.720**
Lower lip protrusion (LL-SnPg')								1	0.496**	0.162	-0.386*
Upper lip thickness (UL-vermilion)									1	0.351	-0.702**
Facial convexity angle (G'-Sn-Po')										1	-0.386*
Nasolabial angle (Col-Sn-UL) (°)											1
Mentolabial sulcus depth (mm)											
Lower lip length (mm)											
Interlabial gap (mm)											
Upper incisor retroclination (UI-PP)											
Upper incisor retraction (UI-APog)											
Lower incisor retraction (LI-APog)											
Lower incisor retroclination (LI-FMIA)											
Lower incisor retraction (LI-APog)											
Lower incisor to Mandibular plane (°)											
Lower incisor to NB plane (mm)											

Contd...

Table 3: Contd...

Cephalometric Variables	Pearson's coefficient of correlation (*r*)									
	Mentolabial sulcus depth	Lower lip length	Interlabial gap	Upper incisor retroclination (UI-PP)	Upper incisor retraction (UI-APog)	Lower incisor retraction (LI-APog)	Lower incisor retroclination (LI-FMIA)	Lower incisor retraction (LI-APog)	Lower incisor to Mandibular plane	Lower incisor to NB plane
Upper lip length (Sn-StSup) (mm)	0.134	-0.486**	-0.442*	0.346	0.462*	0.497**	-0.416*	0.351	0.477**	0.366
Lower lip length (StInf-B') (mm)	-0.106	0.543**	0.571**	0.326	0.522**	0.28	-0.203	0.26	0.08	0.295
Upper lip anterior (ULA-Sn) (mm)	-0.333	0.392*	0.461*	0.05	0.217	-0.095	-0.042	0.023	-0.12	0.12
Upper lip to S-Line (mm)	-0.052	0.201	0.232	-0.085	0.149	-0.061	-0.202	-0.071	-0.036	0.005
Lower lip protrusion (mm)	-0.179	0.321	0.155	0.231	0.257	0.197	-0.045	0.419*	0.156	0.500**
Lower lip to S-Line (mm)	-0.132	0.408*	0.341	0.199	0.328	0.256	-0.362	0.390*	0.242	0.475**
Upper lip protrusion (UL-SnPg')	-0.189	0.285	0.333	0.043	0.259	0.011	-0.229	0.024	-0.022	0.103
Lower lip protrusion (LL-SnPg')	-0.151	0.410*	0.281	0.253	0.371*	0.326	-0.387*	0.445*	0.289	0.510**
Upper lip thickness (UL-vermilion)	-0.284	0.540**	0.439*	0.092	0.06	0.124	-0.084	0.159	-0.083	0.161
Facial convexity angle (G'-Sn-Po')	-0.263	0.308	0.194	0.179	0.13	0.066	0.02	0.166	-0.078	0.043
Nasolabial angle (Col-Sn-UL) (°)	0.492**	-0.483**	-0.618**	0.024	-0.097	0.173	0.072	0.145	0.198	0.057
Mentolabial sulcus depth (mm)	1	-0.198	-0.404*	-0.307	-0.116	-0.09	0.203	-0.109	-0.054	-0.182
Lower lip length (mm)		1	0.593**	-0.127	-0.017	-0.158	0.164	-0.063	-0.302	-0.05
Interlabial gap (mm)			1	0.145	0.182	-0.234	0.17	-0.006	-0.321	0.038
Upper incisor retroclination (UI-PP)				1	0.811**	0.554**	-0.314	0.446*	0.328	0.452*
Upper incisor retraction (UI-APog)					1	0.591**	-0.458*	0.379*	0.425*	0.460*
Lower incisor retraction (LI-APog)						1	-0.781**	0.744**	0.850**	0.695**
Lower incisor retroclination (LI-FMIA)							1	-0.571**	-0.765**	-0.621**
Lower incisor retraction (LI-APog)								1	0.629**	0.876**
Lower incisor to Mandibular plane (°)									1	0.590**
Lower incisor to NB plane (mm)										1

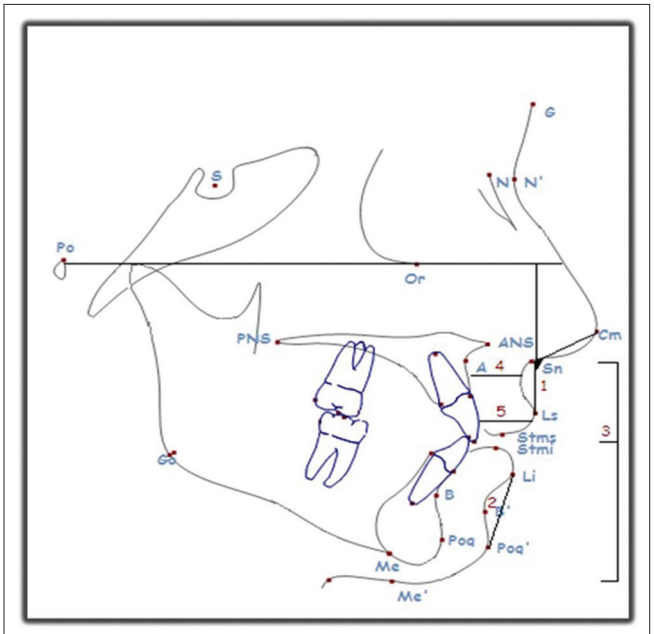
**. Correlation is significant at the 0.01 level (2-tailed)/*. Correlation is significant at the 0.05 level (2-tailed)



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: Lateral cephalometric tracing showing the linear and angular measurements used to evaluate soft tissue changes following orthodontic retraction of anterior teeth



Soft Tissue Angle Measurements

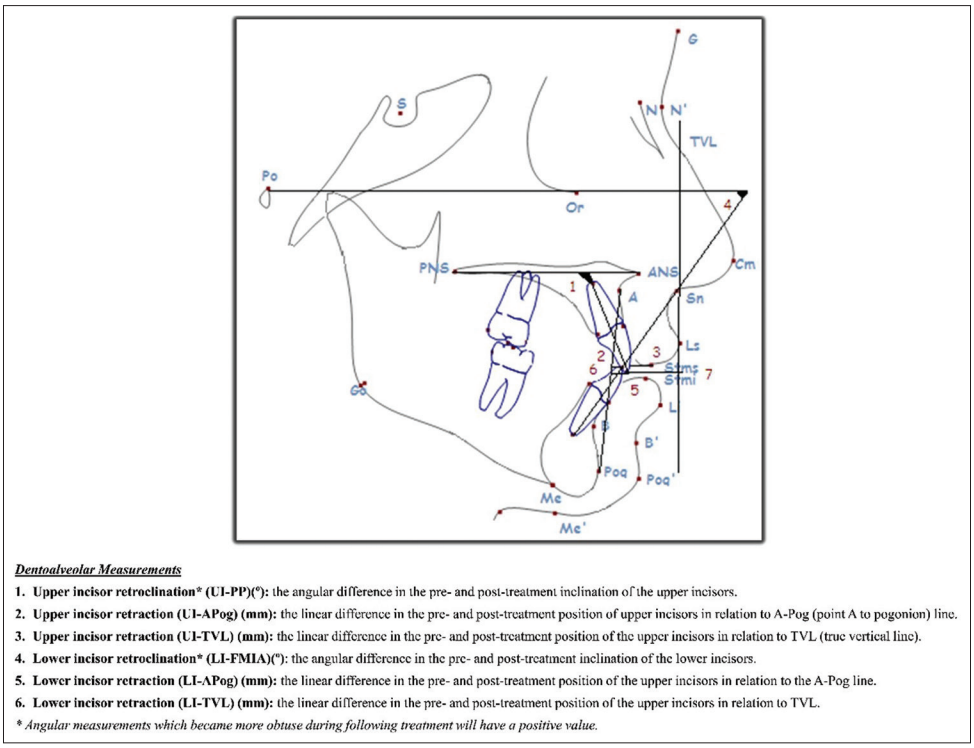
Nasolabial angle: the angle formed by Cm-Sn-Ls.
Mentolabial sulcus depth: the distance from B' to Li-Pog'.
Vertical lip-chin ratio: Sn-Stms / Stmi-Me' along TVL.
Basic upper lip thickness (UL-A point): the distance from a point about 3 mm below point A to the drape of the upper lip.
Upper lip thickness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

Figure 4: Lateral cephalometric tracing showing the angular measurements used to evaluate soft tissue changes following orthodontic retraction of anterior teeth

lip length, nasolabial angle, and mentolabial sulcus depth [Table 3].

Discussion

Over the years, the issue of facial profile changes has been widely analyzed in different populations with varied facial forms and expanded the horizons of orthodontic treatment outcomes.[25] In the present study, 23 linear measurements, five angular measurements, and two ratios were used to analyze the postorthodontic soft tissue facial form variations.[22,26] The previous studies comparing the facial esthetics of extraction and nonextraction cases reported interesting results.[23] Luppanapornlarp and Johnston (1993) reported that subjects treated with extraction of four first premolars had pleasing postorthodontic profiles with a definite reduction in the convexity close to the ideal facial balance.[8] In the present study, comparison of the pre and postorthodontic soft tissue profiles revealed a significant reduction in the facial convexity (P = 0.04, mean SD = −0.96). This finding was similar to earlier studies that evaluated first premolar extraction as the adopted treatment modality.[27] Further, it was observed that the change in upper incisor inclination had a significant positive correlation with the upper lip length, lower lip length, and lower lip protrusion. Similarly, the changes in the lower incisor retraction and lower lip to mandibular plane angle had a significant positive



Dentoalveolar Measurements

1. **Upper incisor retroclination* (UI-PP)(°):** the angular difference in the pre- and post-treatment inclination of the upper incisors.
2. **Upper incisor retraction (UI-APog) (mm):** the linear difference in the pre- and post-treatment position of upper incisors in relation to A-Pog (point A to pogonion) line.
3. **Upper incisor retraction (UI-TVL) (mm):** the linear difference in the pre- and post-treatment position of the upper incisors in relation to TVL (true vertical line).
4. **Lower incisor retroclination* (LI-FMIA)(°):** the angular difference in the pre- and post-treatment inclination of the lower incisors.
5. **Lower incisor retraction (LI-APog) (mm):** the linear difference in the pre- and post-treatment position of the upper incisors in relation to the A-Pog line.
6. **Lower incisor retraction (LI-TVL) (mm):** the linear difference in the pre- and post-treatment position of the upper incisors in relation to TVL.

** Angular measurements which became more obtuse during following treatment will have a positive value.*

Figure 5: Lateral cephalometric tracing showing the linear and angular measurements used to evaluate dental changes following orthodontic retraction of anterior teeth

correlation with the upper lip length. Interestingly, there was a significant negative correlation between the upper lip length and lower lip protrusion, when compared to a change in the lower incisor retroclination.

In a previous study comparing the effects of extraction of the first and second premolars on the soft tissue profile, minimal retraction was reported in the second premolar extraction group.[23] However, in our study, an appreciable amount of upper incisor retraction was evident. In addition, upper incisor retraction was positively correlated with upper and lower lip protrusion. This reported variable measure could have a profound influence on the treatment protocol in deciding the criteria for orthodontic extraction of the first or second premolars. Further in a recent study, the amount of upper incisor retraction achieved with second premolar extraction was measured under controlled facial convexity. Similar to our study, there was a greater retrusion of the upper lip position (by 0.15 mm) in the second premolar group in par with first premolar extraction.{Omar, 2018 #21} The literature reveals that extraction of the first four premolars is recommended only when a greater amount of lower incisor retraction is the desired outcome.[28] Hence, the pretreatment position of the lower incisor is a major determinant in deciding the extraction protocols.

Current clinical scenarios have revealed that the majority of the patient population preferred to settle with a straighter profile.[3] Ironically, most of the studies have assessed the perceived esthetics of individuals with frontal views and not their actual profiles.[29] Thus, proper assessment of the facial angles and proportions is an essential requirement for attaining posttreatment patient satisfaction with esthetic concerns.[5] In any retrospective cohort studies, as the samples are recruited based on a particular exposure (extraction of all four second premolars), the effect of confounding factors cannot be prevented.[30]

Conclusion

This study revealed profound soft tissue changes when patients with bimaxillary protrusion were treated with extraction of the four second premolars and subsequent retraction of the anterior teeth. Contrary to the established general assumption, the extraction of the second premolars can also be adopted by orthodontists with an evident improvement in facial profile.

List of Abbreviations

- N = Nasion
- S = Midpoint of sella (the center of sella turcica)
- B = point B, supramentale, the deepest point on the outer contour of the mandible
- A = point A, subnasale, the deepest midline point on the anterior outer contour of the maxillary alveolar process

- NB angle-Nasion and point B angle.

Ethical compliance

The research was conducted with the approval by the Institutional Ethics Committee, IRB. No. E-18-3029. This study followed the Declaration of Helsinki on medical protocol and ethics.

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Conflicts of Interest

All the authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or nonfinancial interest in the subject matter or materials discussed in this manuscript.

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