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ORIGINAL ARTICLE

Soft Tissue Changes Following Combined Anterior Segmental Bimaxillary Orthognathic Procedures

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Abstract
Aims & objectives To analyze the soft tissue response in patients treated by combined anterior segmental bimaxillary procedures.
Methods A Prospective, observational and analytical study was carried out for a period of 2 years involving 37 patients with predefined inclusion and exclusion criteria; lateral cephalograms were taken by the same operator on the standardized unit immediately before and 6 months after surgery; hard and soft tissue landmarks were measured in millimeters to both horizontal and vertical reference lines; any differences in distances were recorded as a surgical change; appropriate statistical test was carried; level of significance was $p < 0.05$.
Results All patients underwent anterior maxillary osteotomy with 34 anterior mandibular osteotomies, 2 advancement genioplasties and 1 reduction genioplasty. Analysis showed significant angular, horizontal and vertical change. The significant differences in skeletal variables were observed in N–Pg distance, overjet, overbite, U1–NF angle, L1–Mp angle and soft tissue variables like labiomental angle, upper–lower lip protrusion, upper–lower lip length and lower incisor to labrale inferius distance. Nasolabial angle, interlabial gap and upper incisor exposure were extremely significant.
Conclusion Soft tissue response to surgery is perhaps more predictable after 6 months, so this may be a treatment modality of choice in adult bimaxillary/dentoalveolar protrusion patients who need instant esthetic facial results.

Keywords Soft tissue response · Orthognathic surgery · Bimaxillary segmental osteotomy · Bimaxillary protrusion

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Introduction

The perception and judgments of facial esthetic are subjective and undoubtedly depend upon cultural, social, geographic, ethnic, racial and psychological backgrounds of individuals [18]. Soft tissue profile for what constitutes an ‘excellent face’ has been repeated many times by representative of several disciplines including artists, physical anthropologists, orthodontists, and plastic and maxillofacial surgeons. However, all shows larger variation in skeletal convexity, soft tissue, lip protrusion, position of incisors and other vital landmarks [16, 18]. Even though the major goal of orthognathic procedures is not just establishing of balanced and stable dentoskeletofacial complex, more important is achievement of esthetically pleasing overlying soft tissue envelope. This mandates that surgeons should be astutely aware of soft tissue response to various orthognathic procedures.

With the advent of cephalometric and now computerized 3D analysis, the concept of producing a perfect postoperative occlusion and assuming that soft tissue will adapt itself naturally has been totally discredited; it is well documented that hard tissue characteristics alone did not reliably determine soft tissue response [4].

The purpose of this study was to analyze the soft tissue response using the pre- and postoperative lateral cephalometric in patients treated by combined anterior segmental bimaxillary osteotomy procedures, to determine how the changes occur in the position and orientation of the soft tissue overlaying the bony skeleton, to calculate the ratio of movement of fixed soft tissue to hard tissue landmark and also try to find out whether these above changes help us to use as a guide and whether some precautions can be taken to get a desired soft tissue changes postoperatively.

Methods and Materials

After obtaining ethics and research committee approval, a prospective, single-center, observational and analytical study was carried out for a period of 2 years involving 37 patients. Patient of all age and sex who are willing to give informed consent and only Non nonsyndromic patients were included in the study; patients with previous soft tissue surgery, cleft lip and palate any other congenital craniofacial anomalies, previous trauma to dento-osseous structures and medically compromised patients were excluded from the study. Cephalograms were obtained immediately before and 6 months after surgery under standardized conditions. Patients were in centric occlusion, and a relaxed (repose) lip position was obtained by requesting the patients to gently stroke their lips and relax [5]. This was repeated several times to ensure a relaxed position without any muscular contraction. Lateral cephalograms were traced manually by single examiner repeated one month later (two different occasions) by same investigator, and the average values of the two measurements were calculated to eliminate errors in measurements (paired t test); the cephalograms were analyzed using a modified soft tissue analysis on acetate tracing paper [6, 7]. The horizontal reference (HOR) line was constructed by raising a line 7° from SN plane, and a perpendicular to this line at nasion was used as the vertical reference (VER). These reference lines were transferred to postsurgical cephalograms. The hard and soft tissue landmarks (Fig. 1) were measured in millimeters to both HOR and VER reference lines in both pre- and postoperative cephalograms, and any differences in distances were recorded as a surgical change. Descriptive statistics included the mean and standard deviation (SD), and collected data were subjected to statistical analysis using WINSTAT software and SPSS 15 statistical package. The paired-sample t test was used to assess soft and hard tissue changes. Pearson correlation analysis and linear regression analysis were used to assess the degree of correlation between soft and hard tissue changes. Differences between groups were evaluated by t-test. The level of significance was $p < 0.05$.

Results

The 37 bimaxillary patients were composed of 36 females and 1 male with age group of 18–32 years and mean age of 23.21 years. All underwent the anterior maxillary osteotomy with 34 anterior mandibular osteotomies, 2 advancement genioplasties and 1 reduction genioplasty. Analysis of treatment showed significant angular, horizontal and vertical change in most of the parameters (Tables 1, 2, 3, 4).

The comparison of the mean values and standard error of means of the hard and soft tissue variables are presented in Table 1 and 2. The significant differences in skeletal variables were observed in N–Pg distance, overjet, overbite, U1–NF angle and L1–Mp angle ($p < 0.05$). In soft tissue changes, extremely significant changes are seen in nasolabial angle, NL angle, interlabial gap, upper incisor exposure and U1-Exposure ($^{**}p < 0.01$), and significant changes are seen in labiomental angle, LM angle, upper lip protrusion, UL protrusion, lower lip protrusion, LL protrusion, upper lip length ULL, lower lip length LLL and lower incisor to labrale inferius distance Li–L1($p < 0.05$).

Correlations occurred between corresponding maxillary and mandibular hard and soft tissue movements in the sagittal and vertical directions, respectively (Table 3). Sagittal changes like decrease in upper incisor exposure, U1-Exposer, were correlated with the decrease in upper incisor nasal floor angle, U1–NF angle and L1–Mp angle. Vertical changes, like increase in nasolabial angle, were correlated with the increase in NA distance and decrease in U1–NF angle. The significant decrease in labiomental angle was correlated with the increase in NA distance. The increase in lower lip length was correlated with the increase in ANB angle and decrease in U1–NF angle.

The ratios of the changes between the skeletal and corresponding soft tissue variables are presented in Table 4, and these range from 0.35 to 0.69 for maxillary and from 0.33 to 0.97 for mandibular variables, respectively. The ratio of upper lip retraction to maxillary incisor retraction was 0.66:1, and ratio of lower lip retraction to mandibular lip retraction was 0.72:1. The ratio of pronasale to anterior nasal spine was 0.52:1, but it is not significant. There were no changes in the Pg to Pg.

Discussion

Distribution of patient's gender and mean age revealed that mostly females seek this treatment for more facial esthetics and they are usually at the period beyond active orthodontics treatment; Kim et al. [16] also observed the same.

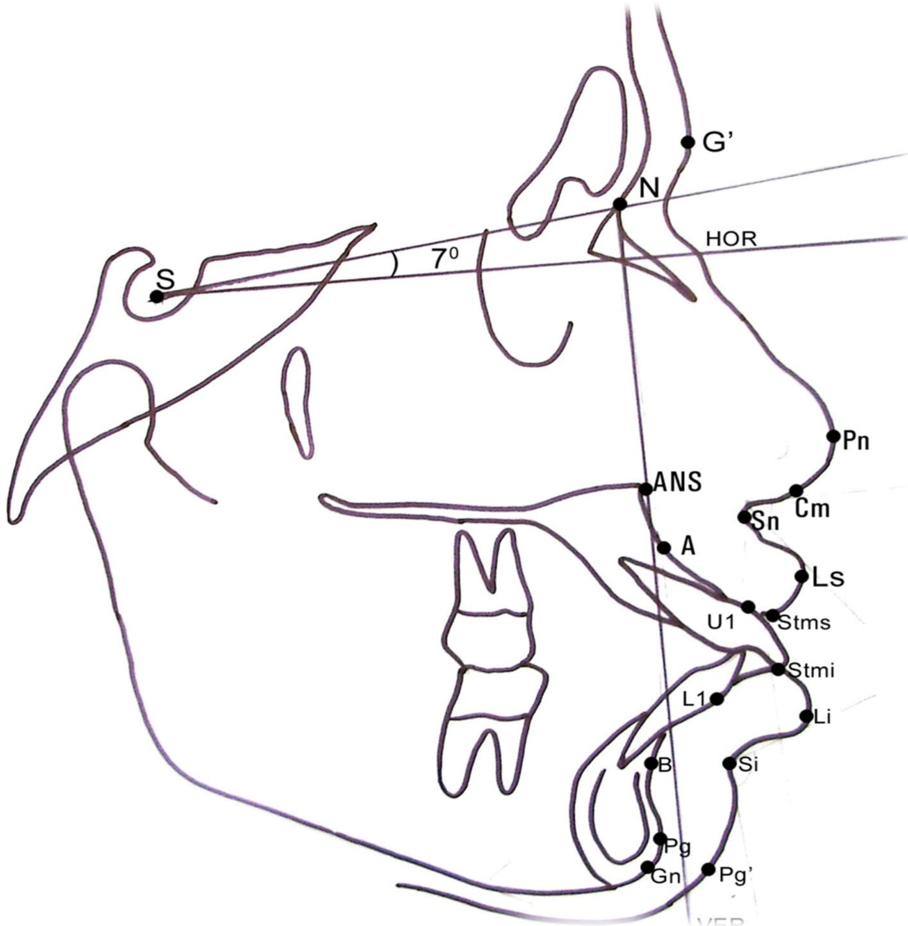

Fig. 1 Hard and soft tissue reference points and cephalometric landmarks used in the study. *HOR* horizontal reference line, *VER* vertical reference line; hard tissue landmarks: sella (S), Point A, Point B, U1, L1, pogonion (Pg), gnathion (Gn); soft tissue reference points: soft tissue glabella (G0), pronasale (Pn), columella (Cm), subnasale (Sn), labrale superius (Ls), labrale inferius (Li), stomion superius (Stms), stomion inferius (Stmi), labiomental sulcus (Si), soft tissue pogonion (Pg0)

Table 1 Surgical outcome assessed by hard tissue measurements before and after surgery

Variables	Before surgery		After surgery		Difference		't' value	p
	Mean	SD	Mean	SD	Mean	SD		
SNA angle	84.5	2.9	84.2	4.3	3	3.9	0.35	ns
SNB angle	77.8	3.1	78.9	4.5	− 11	3.9	− 1.72	ns
ANB angle	6.5	2.7	6.4	2.7	1	3.5	0.16	ns
NAPg angle	15.1	7.3	12.3	7.4	2.8	5.3	1.74	ns
NA	2.4	2.1	2.5	1.8	− 1	3.8	− 0.14	ns
NB	10.6	6.1	8.8	6.0	1.8	3.5	2.18	ns
N–Pg	12.8	7.9	10.2	6.3	2.6	3.7	2.68	*
N–ANS	50.0	4.2	45.9	9.3	4.1	8.1	1.56	ns
ANS–Gn	69.8	9.0	70.3	8.1	− 5	4.4	− 0.48	ns
Overjet	5.7	3.4	3.3	1.5	2.4	3.5	2.68	*
Overbite	4.8	3.1	2.5	1.5	2.3	3.8	2.25	*
U1–NF angle	123.4	13.8	115.1	5.0	8.3	10.7	2.34	*
L1–Mp angle	101.3	8.6	97.1	4.5	4.2	5.2	2.55	*

*$p < 0.05$; *ns* not significant

There are many reports in the literature about soft tissue response following various orthognathic procedures, but most of them are for LeFort level and bilateral sagittal split osteotomy either combined or single-jaw procedures. Only few reports are noted about combined anterior mandibulomaxillary segmental osteotomies. This may be because

Table 2 Surgical outcome assessed by soft tissue measurements before and after surgery

Variables	Before surgery		After surgery		Difference		't' value	p
	Mean	SD	Mean	SD	Mean	SD		
Facial convexity	25.8	8.6	21.1	5.0	4.7	5.6	2.62	ns
NL angle	90.9	10.5	106.4	6.1	− 15.5	8.1	− 5.77	**
LM angle	126.4	11.5	120.0	12.4	6.4	8.2	2.37	*
LM fold	12.9	2.4	12.7	1.6	2	3.4	0.35	ns
UL protrusion	20.4	5.4	17.8	4.7	2.6	3.7	2.59	*
LL protrusion	18.3	3.9	15.5	4.0	2.8	3.8	2.75	*
ULL	19.9	2.8	22.4	3.6	− 2.5	4.9	− 2.34	*
LLL	42.3	4.0	46.4	6.2	− 4.1	6.7	− 2.40	*
Sn–A (mm)	13.2	1.8	14.7	3.5	− 1.5	4.2	− 1.89	ns
Pg–Pg (mm)	8.0	3.1	10.1	2.1	− 2.1	5.4	− 1.57	ns
Si–B (mm)	13.8	3.5	13.0	1.6	8	3.6	1.04	ns
Ls–U1	11.4	4.7	12.7	3.3	− 1.3	4.5	− 1.30	ns
Li–L1	11.7	2.1	14.4	2.9	− 2.7	5.1	− 2.40	*
Interlabial gap	7.6	5.0	4.5	2.8	3.1	3.2	3.77	**
U1-Exposer	6.8	3.0	3.3	1.4	3.5	3.2	4.20	**

**$p < 0.01$; *ns* not significant

Table 3 Correlation between corresponding soft and hard tissue changes

Soft tissue changes	Hard tissue changes												
	SNA angle	SNB angle	ANB angle	NAPg angle	NA	NB	N–Pg	N–ANS	ANS–Gn	Overjet	Overbite	U1–NF angle	L1–Mp angle
Facial convexity	0.26	0.19	− 0.18	0.13	0.42	0.04	0.41	0.00	0.51	0.21	0.21	− 0.31	− 0.11
NL angle	0.40	0.27	0.25	0.22	0.63*	0.09	0.30	0.44	0.43	0.41	0.39	− 0.78**	0.15
LM angle	0.44	− 0.07	0.45	0.42	0.72*	− 0.44	0.11	0.57	0.39	0.51	0.00	− 0.20	0.03
LM fold	0.21	− 0.21	0.24	− 0.08	0.43	0.38	0.26	0.37	− 0.04	0.29	− 0.07	− 0.07	0.42
UL protrusion	0.52	0.29	0.18	0.41	0.13	0.18	0.03	− 0.21	0.58	− 0.03	0.10	0.07	0.13
LL protrusion	0.31	− 0.02	− 0.03	− 0.02	− 0.46	− 0.19	− 0.38	− 0.07	0.14	− 0.29	− 0.43	− 0.03	0.01
ULL	− 0.29	0.20	− 0.12	− 0.08	0.30	0.30	0.38	− 0.32	− 0.08	0.02	0.34	0.12	− 0.05
LLL	0.28	− 0.18	0.69*	0.58	0.15	0.34	− 0.22	0.18	0.12	0.27	0.19	− 0.74**	0.55
Sn–A (mm)	− 0.50	0.14	− 0.45	− 0.39	0.05	0.49	0.49	− 0.32	− 0.37	− 0.14	0.19	− 0.10	− 0.20
Pg–Pg (mm)	− 0.50	0.25	− 0.40	− 0.39	0.04	− 0.23	0.18	− 0.20	− 0.51	− 0.18	− 0.31	− 0.16	− 0.58
Si–B (mm)	0.08	− 0.09	0.14	− 0.08	0.19	0.38	0.34	− 0.11	− 0.22	− 0.24	− 0.27	0.06	0.06
Ls–U1	− 0.04	0.41	− 0.50	− 0.06	0.09	− 0.02	0.30	− 0.46	0.43	− 0.06	0.32	− 0.24	− 0.31
Li–L1	0.06	− 0.30	− 0.17	− 0.11	− 0.54	0.17	− 0.26	0.01	0.00	− 0.10	− 0.16	0.25	0.22
Interlabial gap	0.48	0.51	0.46	0.59	0.30	− 0.01	− 0.25	0.17	0.35	0.27	− 0.02	0.06	0.06
U1-Exposer	0.01	0.20	0.26	0.40	0.48	0.52	0.61	− 0.06	0.10	0.03	0.59	− 0.71*	− 0.05

*$p < 0.05$; **$p < 0.01$; the '*r*' values, which are not marked with '*' are insignificant

Table 4 Soft-to-hard tissue measurement ratios

Soft tissue variable	Hard tissue variable	R	R^2	R^2 (Adj)	S–H
Horizontal					
Pn	ANS	0.478	0.228	0.132	0.52
Sn	A	0.765**	0.585	0.533	0.56
Ls	U1	0.711**	0.505	0.443	0.66
Li	L1	0.869**	0.755	0.725	0.72
Si	B	0.550	0.302	0.215	0.60
Vertical					
Pn	ANS	0.455	0.207	0.108	0.52
Sn	A	0.599*	0.359	0.278	0.35
Ls	U1	0.527	0.277	0.187	0.69
Li	L1	0.881**	0.777	0.749	0.77
Si	B	0.908**	0.824	0.802	0.97

*$p < 0.05$; **$p < 0.01$

*r, Pearson correlation coefficient; R^2 (Adj), adjusted coefficient of determination

anterior segmental osteotomy was rarely performed in ordinary protrusion cases due to the availability of advanced orthodontic techniques and hence surgeons are not applying this procedure for suitable patients [23].

After 6 months, postoperative appreciable improvements were seen, and no edema was recorded clinically in any of the patients [10]. Mean facial convexity angle and NA–Pg angle were reduced but not significantly; this may be due to less sample size, variation in soft tissue thickness or surgical technique (Tables 1, 2).

Significant decrease in incisor exposure and increase in nasolabial angle were correlated with the decrease in U1–nasal floor angle, i.e., anterior maxillary dentoalveolar anterior protrusion. Significant increase in lower lip length was correlated with the increase in NAB angle and reduced U1–nasal floor angle.

Minimal attention has been focused on the influence of this surgery on the nose and facial tissues [23]; there was improvement in the nasolabial angle increase by 15.5 SD 8.1 degree and was significant while correlating with the decrease in U1–NF angle r-78 and increase in NA r-68 (Tables 2, 3), giving less prominent upper lip and more prominent nasal tip; this change was because of posterior lip rotation around subnasale. Similar improvement has been observed by Park and Hwang [23] 14.1°, Nadkarni [20] 10.55°, Kim et al. [16] 11.2°. In contrast, the nasolabial angle is relatively more increased and improved in surgical cases than in cases treated only with orthodontics [16, 18]. Race and ethnic origin may play a role in shape, size, thickness and bulk of soft tissue and also in final adaptation and settling in postoperative period. Decrease in labiomental angle and improvement in facial profile were contradictory to authors who observed no changes in them, but they did not cite any reason [23].

Decrease in lip protrusion may be because of uncurling and retraction of the upper and lower lip with associated decrease in the depth of the labial sulcus [18], so it improves the profile, lip length, interlabial gap and lip tension [17]. More increases in lower lip length are almost similar to authors [17] and increase in upper lip length in single-jaw surgery may be the results of change in the influence of lower incisor on upper lip [25].

Decrease in the interlabial gap and upper incisor exposure may be due to normalizing the angulations of anterior maxillomandibular component, uncurling and retraction of the upper and lower lip with associated decrease in the depth of the labial sulcus [18], increasing the length and relieving the tension of preoperatively stretched soft tissue lips due to protruded underlying skeleton U1-exposure to U1–NF angle (r-71*).

There was dramatic increase in lip bulk and thickness but was not significant; this may be due to variation in surgical technique such as use of electrocautery for vestibular incision which may have caused altered wound healing, excessive wound contraction and scar formation; otherwise, almost all the soft tissue procedures were followed properly in maxilla like V–Y closure, septoplasty, nasal cinching or combination of all.

Majority of the previous research is focused on either the immediate inflammatory response or the longer-term changes following surgery; typical timescales used were 0.3-3 years, because of swelling, tissue redistribution and functional adaptation; long-term follow-up is needed to assess soft tissue changes postoperatively. Most authors suggest that soft tissues stabilize after 6 months [12, 21], 12 months [24]. Hack et al. [14] found continued soft tissue settling several years after surgery. Few have attempted to evaluate the soft tissue response after the initial peak of inflammatory response [1]. One saw no changes even after 10 months [11]. Predictable success and in fact improvement in facial profile like increase in nasolabial angle, lengthening of both upper and lower lips, and decrease in interlabial gap can be achieved in as early as 3–9 months [17], 6 months [2, 8, 9], 7 months [22] as in our study which suggests that significant changes may be achieved in a minimal 6-month postoperative period.

Several ratios of soft tissue to bony movements have been provided. Common belief that changes following bimaxillary surgery are similar to changes following the separate performance of the two procedures [1] is lacking sufficient data to compare the combined procedures such as anterior bimaxillary segmental osteotomy.

Upper lip-to-maxillary incisor retraction ratio was 0.5:1, 0.43:1 and 1:3, while lower lip-to-mandibular incisor retraction ratio was 0.75:1, 0.71:1 and 2:3 [17, 19, 20]; this shows that there were much smaller maxillary changes compared to mandibular one which were almost same as in our study; this could be because of difference in amount of posterior movement of teeth, operative technique, lip strength, amount of fatty tissue and musculature.

Our ratios totally concur with reports which have showed upper lip-to-maxillary incisor retraction ratio as 0.67:1, lower lip-to-mandibular incisor retraction ratio as 0.89:1 [23] and upper lip-to-maxillary incisor retraction ratio 0.68:1 [3].

Ratio in cases of LeFort I and BSSO is almost same as our study [1]. So this band of changes suggests that there may be similar pattern of soft tissue movement in segmental osteotomies particularly for the upper lip to maxillary incisor and lower lip to mandibular incisor retraction, but more studies with more sample size are need.

Soft to hard tissue movements are minimal in the maxillary procedures, and the ratio increases almost nearly proportionally while approaching more inferiorly toward mandibular pogonion; this reflected in our study also. This weaker response may be related to the resection of the anterior nasal spine area and the variability in surgical closure of the soft tissue incision in maxillary surgery [8, 10, 15]. Nose which is fixed and does not move much with underlying hard tissue unless septal changes are done during surgical procedure and other reasons like dead space present under the lips may absorb the first proportion of a bony movement before the soft tissue is affected and becomes clinically apparent [13, 21]. It was concluded that soft tissue changes in response to surgery are perhaps more predictable after six months, so this surgery may be a treatment modality of choice in adult bimaxillary/dentoalveolar protrusion patients who need instant esthetic facial results. But study with larger sample size and longer follow-up may yield more predictable results.

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Compliance with Ethical Standards

Conflict of interest None declared.

Ethical Approval Ethical approval was obtained from the ethical and research committee mahatma Gandhi postgraduate institute of dental sciences puducherry Pondicherry India.

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