

# Facial Soft Tissue Changes in Class III Patients Treated With Bimaxillary, Maxillary Advancement or Mandibular Set Back Orthognathic Surgery

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## Abstract

**Objective:** To determine the effect of orthognathic surgery on soft tissue in Class III patients and to compare the results of different surgical techniques.

**Materials and Methods:** Forty-eight Class III adult patients were included in the study to assess the changes in the soft tissue after orthognathic surgery. Nine patients were treated with Maxillary Advancement (MA), seven patients were treated with Mandibular Set back (MS) and 32 patients were treated with Bimaxillary (BM) surgery. Cephalometric records were taken before treatment, after surgery and approximately 1 year after surgery (at the end of the treatment).

**Results:** A significant change in mentolabial sulcus, St-Me, Sn-Me ( $p < 0.01$ ); G1-Sn/Sn-Me, Pg<sup>^</sup>-HR ( $p < 0.05$ ) was observed in BM group. B<sup>^</sup>-VR and LLA-VR differed significantly in BM and MS groups after surgery ( $p < 0.01$ ). ULA-VR and Sn-VR parameters differed significantly in MA and BM groups ( $p < 0.01$ ). Sn-HR, LLA-HR ( $p < 0.05$ ); ULA-HR, B<sup>^</sup>-HR, Sn-St ( $p < 0.01$ ) change differed significantly between MA-BM groups, whereas B-B<sup>^</sup> ( $p < 0.05$ ), Sn-St ( $p < 0.01$ ) change differed significantly between MA-MS groups. In the BM surgery group; Pr, Sn and ULA-VR was affected or further with the underlying hard tissue movement in the comparison to the MA surgery. In the MS surgery LLA-VR and Pg<sup>^</sup> was affected more from the mandibular posterior movement when compared to the BM group.

**Conclusion:** The ratio of the mean amount of soft tissue change and the skeletal change differ in three surgical groups, thus soft tissue prediction ratios should be done separately for three surgery groups.

*Key Words: Soft Tissue, Orthognathic surgery*

## Introduction

Treatment of a severe Class III malocclusion frequently requires a combination of orthodontics and orthognathic surgical procedures. During recent decades, orthognathic surgery has become widely accepted as the preferred method of correcting moderate to severe skeletal deformities. The aim of such procedures is to improve and harmonize facial esthetics. Therefore it is crucial to predict soft tissue changes after orthognathic surgery in order to have better treatment planning.

The orthognathic approach is expected to lead to optimal functional, esthetic and stable results, thus satisfying the patient's needs. The success of orthognathic surgery depends upon the anatomical details of the patient, the direction and extent of the necessary displacement, and the precision of pre-surgical orthodontic planning. Class III skeletal deformity can be the result of mandibular prognathism and/or maxillary deficiency. Before orthognathic surgery the amount of deficiency in the maxilla and/or mandible and the recognition of aesthetic factors and the prediction of the final facial profile play an increasingly important role in orthognathic treatment planning [1].

Studies have attempted to evaluate the relationship between hard tissue surgery and its effect on soft tissues [2-8]. However, the most of the studies evaluated post-operative soft tissue changes in only one type of surgery group [9-14]. The purpose of the study was to quantify the soft tissue changes after orthognathic surgery, as well as to assess the differences in soft tissue changes in the middle and lower third of the face between the 1- and 2-jaw surgery groups, in Class III patients.

## Materials and Methods

The patients were selected from University of Ankara, Faculty of Dentistry, Department of Orthodontics. Inclusion criteria were adult patients with skeletal and dental Class III deformity, surgical treatment consisting of mandibular set back and/or maxillary advancement, and lateral cephalograms of good quality. Exclusion criteria included previous orthognathic surgery, genioplasty, OSA, cleft, and craniofacial anomalies. For this study an approval from the Ethical committee of Ankara University Faculty of Dentistry and the consent of each patient was received. Twenty of the patient radiographs were obtained from the university archive. Twenty-eight of the patients were treated orthodontically and surgically by the same doctor and treatment protocol. Nine of the patients were treated with Maxillary Advancement (MA), seven of the patients were treated with Mandibular Set back (MS) and 32 of the patients were treated with the Bimaxillary (BM) surgical procedure. The distribution of patients with respect to surgical technique and gender is shown in *Table 1*. Bilateral sagittal split ramus osteotomy with semi-rigid fixation and/or Le Fort I osteotomy with rigid fixation were used for the mandible and maxilla. In the Le Fort I surgical technique, the maxilla was positioned upwards when needed.

*Table 1. The Distribution of Patients With Respect to Surgical Technique and Gender.*

Surgical Technique	Male	Female	Total
Maxillary advancement	1	8	9
Mandibular set back	3	4	7
Bimaxillary	15	17	32
Total	19	29	48

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**Cephalometric Analysis**

The lateral cephalometric radiographs were taken by the same operator on the same device before treatment (T1), before surgery (T2), and at the end of the fixed treatment (T3). Cephalograms were obtained under standardized conditions in natural head positions with the mandible in centric relation; and a relaxed lip position was obtained by requesting the patients to gently stroke their lips and relax [15].

Lateral cephalograms were traced and cephalometric reference points were determined by using acetate paper. Seven degrees to the sellanasion plane through sella point was taken as the Horizontal Reference plane (HR) and perpendicular to HR through S point was taken as the Vertical Reference plane (VR) (Figure 1). These reference planes were used as the guides in measuring the projected distances of the reference landmarks. The hard and soft tissue landmarks were measured in millimeters to horizontal and vertical reference lines in presurgical and postsurgical cephalograms and any differences in the distance were recorded as surgical change. 8 skeletal and 25 soft tissue parameters were used in the study (Figures 1-3). Linear and angular measurements were prepared with the aid of the Pordios program.

**Statistical Analysis**

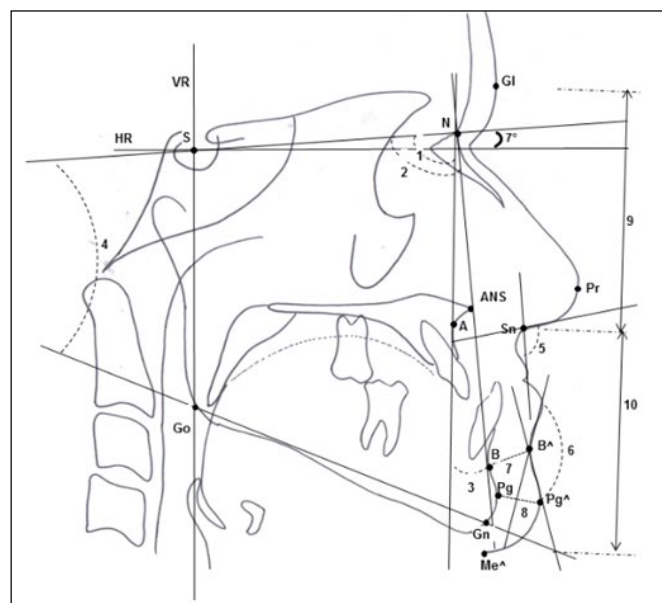
The statistical analysis of the study was performed by using a repeated-measures analysis of a variance and Bonferroni test. Repeated-measures analysis of variance was used to compare intragroup and intergroup cephalometric measurements at each time interval. The Bonferroni test was used when interaction was observed.

**Error Study**

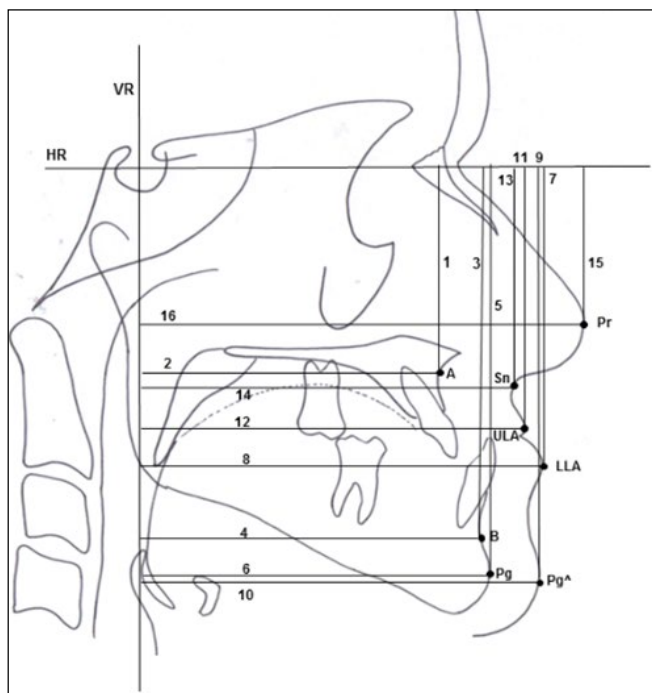
All digitizing points and measurements were repeated on 35 randomly selected radiographs. Measurements were compared and correlation coefficients ( $r^2$ ) were obtained. Cephalometric landmarks of the radiographs were digitized twice to eliminate errors in measurements.

**Results**

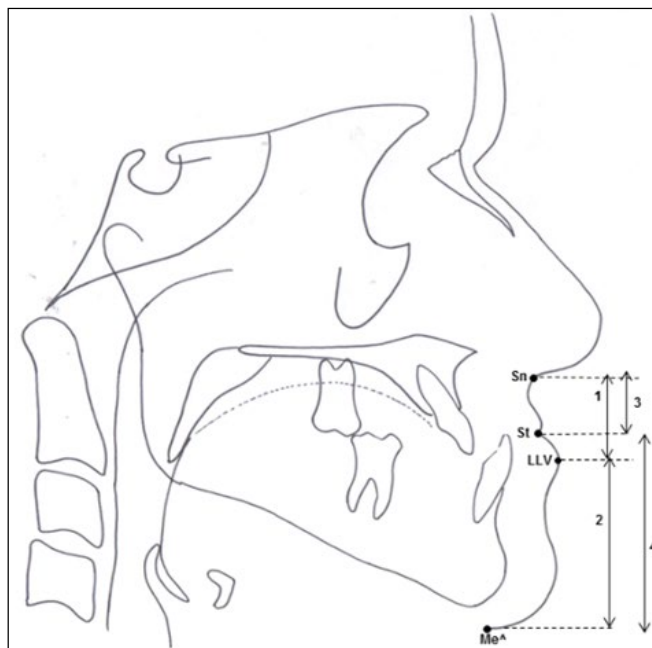
The reliability of the method was high, with the correlation



**Figure 1.** Skeletal and soft tissue variables: (1) SNA, (2) SNB, (3) ANB, (4) GoGnSN, (5) Nasolabial Angle, (6) LLA-B<sup>^</sup>-Pg<sup>^</sup>, (7) B-B<sup>^</sup>, (8) Pg-Pg<sup>^</sup>, (9) Gl-Sn, (10) Sn-Me.



**Figure 2.** Skeletal and soft tissue variables: (1) A-HR, (2) A-VR, (3) B-HR, (4) B-VR, (5) Pg-HR, (6) Pg-VR, (7) LLA-HR, (8) LLA-VR, (9) Pg<sup>^</sup>-HR, (10) Pg<sup>^</sup>-VR, (11) ULA-HR, (12) ULA-VR, (13) Sn-HR, (14) Sn-VR (15) Pr-HR, (16) Pr-VR.



**Figure 3.** Soft tissue variables: (1) Sn-LLV, (2) LLV-Me<sup>^</sup>, (3) Sn-St, (4) St-Me.

coefficients ranging between 0.9916 and 0.9985. In Table 2, the mean values and standard error of the means of the variables at each time interval for three surgery groups are presented. Table 3 shows the comparison of the changes among three surgery groups and time intervals (repeated-measures analysis of variance and Bonferroni test). According to Table 3; Pr-HR, Pg-Pg<sup>^</sup>, Gl-Sn, Sn-St/St-Me parameters did not differ significantly between time intervals and groups. Sn-HR, ULA-HR, LLA-HR, B<sup>^</sup>-HR parameters differed significantly between MA and BM groups while B-B<sup>^</sup> parameter differed significantly between MA and MS groups and Sn-St between MA-MS and MA-BM groups. Nasolabial angle differed significantly between MS and BM groups.

Parameters showing interaction are evaluated on Table

**Table 2.** The Mean Values and Standard Error of the Means of the Variables at Each Time Interval for Three Surgery Groups.

Parameters	GROUPS								
	MA			MS			BM		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
	X ± Sx	X ± Sx	X ± Sx	X ± Sx	X ± Sx	X ± Sx	X ± Sx	X ± Sx	X ± Sx
<b>Skeletal</b>									
SNA (°)	77.35 ± 1.57	77.06 ± 1.60	81.97 ± 1.57	78.48 ± 1.89	78.14 ± 1.64	78.44 ± 1.72	78.83 ± 0.60	78.39 ± 0.60	81.73 ± 0.63
SNB (°)	68.44 ± 3.96	66.78 ± 4.28	67.16 ± 4.39	66.03 ± 4.26	65.28 ± 4.21	60.59 ± 3.76	70.13 ± 1.32	69.31 ± 1.46	65.93 ± 1.16
ANB (°)	-4.50 ± 0.66	-3.94 ± 0.57	0.87 ± 0.65	-2.23 ± 1.22	-2.06 ± 1.24	0.71 ± 0.89	-4.58 ± 0.52	-4.46 ± 0.51	0.58 ± 0.38
GoGnSN(°)	30.07 ± 2.47	30.83 ± 2.56	31.04 ± 2.50	38.19 ± 2.77	38.90 ± 2.75	38.30 ± 3.42	37.23 ± 0.89	37.62 ± 0.82	35.32 ± 0.84
A-HR (mm)	50.01 ± 1.04	50.36 ± 1.12	51.52 ± 1.27	52.71 ± 1.09	53.22 ± 1.12	53.13 ± 1.18	55.64 ± 0.69	56.15 ± 0.69	54.95 ± 0.69
A-VR (mm)	64.63 ± 2.65	64.15 ± 2.72	69.38 ± 2.68	65.45 ± 2.53	65.29 ± 2.37	65.65 ± 2.40	64.77 ± 0.91	64.46 ± 0.92	68.09 ± 0.90
B-HR (mm)	89.69 ± 1.92	90.25 ± 1.65	90.01 ± 1.93	98.50 ± 1.65	99.20 ± 1.60	98.02 ± 1.04	103.33 ± 1.40	103.30 ± 1.39	99.81 ± 1.31
B-VR (mm)	68.44 ± 3.96	66.78 ± 4.28	67.16 ± 4.39	66.03 ± 4.26	65.28 ± 4.21	60.59 ± 3.76	70.13 ± 1.32	69.31 ± 1.46	65.93 ± 1.16
<b>Soft Tissue</b>									
Pr-HR (mm)	41.45 ± 1.34	42.34 ± 1.47	41.26 ± 1.41	44.43 ± 0.61	44.78 ± 0.67	45.02 ± 0.34	46.23 ± 0.86	46.2 ± 0.86	45.14 ± 0.93
Pr-VR (mm)	100.67 ± 2.79	100.41 ± 2.88	101.29 ± 2.70	101.94 ± 3	102.03 ± 2.90	102.35 ± 2.95	101.12 ± 1.17	101.16 ± 1.13	102.51 ± 1.15
Sn-HR (mm)	51.61 ± 1.14	52.09 ± 1.12	51.83 ± 1.22	54.15 ± 0.92	54.78 ± 0.99	54.72 ± 0.88	56.01 ± 0.82	56.36 ± 0.79	55.78 ± 0.81
Sn-VR (mm)	83.80 ± 2.99	83.17 ± 3.16	85.67 ± 3.12	85.88 ± 3.26	85.87 ± 3.13	85.68 ± 3.11	83.51 ± 1.09	83.26 ± 1.07	85.30 ± 1.02
ULA-HR (mm)	64.05 ± 1.06	64.62 ± 1.20	65.04 ± 1.21	71.13 ± 0.71	71.78 ± 0.90	71.59 ± 0.62	71.27 ± 0.01	71.3 ± 1.05	71.58 ± 0.98
ULA-VR (mm)	83.77 ± 3.58	83.07 ± 3.67	86.83 ± 3.86	84.94 ± 3.56	84.25 ± 3.38	84.38 ± 3.36	84.87 ± 1.24	85.06 ± 1.29	87.79 ± 1.16
LLA-HR (mm)	77.66 ± 1.23	79.12 ± 1.17	80.40 ± 1.37	85.65 ± 1.74	86.73 ± 1.62	86.62 ± 0.98	87.01 ± 1.37	88 ± 1.47	87.64 ± 1.26
LLA-VR (mm)	85.54 ± 4.18	85.37 ± 4.25	85.35 ± 4.59	86.24 ± 3.78	85.95 ± 3.79	81.65 ± 3.66	87.88 ± 1.40	88.74 ± 1.58	85.85 ± 1.26
B <sup>^</sup> -HR (mm)	87.10 ± 1.64	88.88 ± 1.37	88.92 ± 1.73	96.48 ± 2.44	98.7 ± 2.41	96.26 ± 1.76	99.90 ± 1.65	101.83 ± 1.74	102.31 ± 1.73
B <sup>^</sup> -VR (mm)	79.76 ± 4.09	78.60 ± 4.37	78.80 ± 4.47	79.47 ± 3.94	78.89 ± 3.97	74.08 ± 3.70	82.58 ± 1.38	81.88 ± 1.53	78.32 ± 1.22
Pg <sup>^</sup> -HR (mm)	102.91 ± 2.02	104.86 ± 1.93	104.00 ± 2.15	111.28 ± 1.90	111.63 ± 1.53	111.69 ± 1.45	116.33 ± 1.69	117.25 ± 1.77	113.86 ± 1.6
Pg <sup>^</sup> -VR (mm)	84.16 ± 13.23	82.35 ± 4.75	82.31 ± 4.90	79.97 ± 4.46	79.16 ± 4.39	75.04 ± 4.29	83.91 ± 1.48	83.07 ± 1.61	80.93 ± 1.29
B-B <sup>^</sup> (mm)	11.74 ± 0.50	12.08 ± 0.46	12.08 ± 0.38	14.16 ± 0.62	14.37 ± 0.61	14.04 ± 0.83	14.37 ± 0.61	13.17 ± 0.34	12.75 ± 0.21
Pg-Pg <sup>^</sup> (mm)	12.86 ± 0.51	12.79 ± 0.63	13.18 ± 0.74	14.54 ± 0.79	14.74 ± 0.79	13.94 ± 0.77	12.72 ± 0.41	12.71 ± 0.43	12.79 ± 0.42
GI-Sn (mm)	73.89 ± 1.64	73.73 ± 1.13	72.65 ± 1.38	73.50 ± 1.42	72.80 ± 1.87	74.33 ± 1.88	74.93 ± 0.77	75.73 ± 0.79	75.84 ± 0.83
Sn-Me (mm)	69.39 ± 1.51	70.32 ± 1.60	70.44 ± 2.01	75.56 ± 1.38	76.80 ± 1.51	76.16 ± 1.68	77.95 ± 1.22	78.74 ± 1.26	75.99 ± 1.15
Sn-St (mm)	18.57 ± 0.58	18.62 ± 0.43	23.39 ± 0.77	23.07 ± 0.60	23.9 ± 0.71	20.88 ± 0.63	22.14 ± 0.54	21.9 ± 0.49	23.59 ± 0.54
St-Me (mm)	50.82 ± 1.42	51.7 ± 1.55	49.56 ± 2.11	52.49 ± 1.09	53.41 ± 1.29	52.26 ± 1.51	55.81 ± 0.85	56.84 ± 0.87	52.40 ± 0.72
Sn-LLV (mm)	27.44 ± 0.70	28.08 ± 0.41	30.08 ± 0.79	32.00 ± 1.44	32.50 ± 1.38	32.85 ± 0.95	31.86 ± 0.95	32.56 ± 1.11	33.06 ± 0.74
LLV-Me (mm)	41.95 ± 1.31	42.23 ± 1.60	40.37 ± 2.04	43.56 ± 1.44	44.30 ± 1.57	43.30 ± 1.53	46.09 ± 1.00	46.18 ± 1.11	42.93 ± 0.69
LLA.B <sup>^</sup> .Pg <sup>^</sup> (°)	133.25 ± 4	132.2 ± 5.10	129.03 ± 4.29	145.85 ± 3.96	148.53 ± 2.46	138.03 ± 3.36	152.82 ± 1.69	148.82 ± 1.95	134.74 ± 1.75
<b>Nasolabial angle (°)</b>									
GI-Sn/Sn-Me	1.09 ± 0.01	1.00 ± 0.02	1.09 ± 0.01	1.11 ± 0.02	1.11 ± 0.02	1.12 ± 0.02	1.07 ± 0.02	1.09 ± 0.01	1.10 ± 0.01
Sn-St/St-Me	0.94 ± 0.03	0.97 ± 0.04	0.95 ± 0.06	1.01 ± 0.05	1.01 ± 0.05	1.04 ± 0.05	1.08 ± 0.04	1.06 ± 0.03	1.02 ± 0.03
Sn-LLV/LLV-Me	1.05 ± 0.93	0.92 ± 0.8	0.96 ± 0.82	0.7 ± 0.59	0.69 ± 0.59	0.71 ± 0.57	0.10 ± 0.00	0.10 ± 0.01	0.13 ± 0.00

**Table 3.** Comparison of the Changes Among Three Surgery Groups and Time Intervals.

Parameters	Group	Time	MA-MS	MS-BM	MA-BM	T1-T2	T1-T3	T2-T3	
Pr-HR	NS	NS							
Pr-VR	NS	**					**	**	
Sn-HR	*	*			*	*		*	
ULA-HR	**	NS			**				
LLA-HR	*	*			*	*	*		
B <sup>^</sup> -HR	**	**			**	**		**	
Pg <sup>^</sup> -VR	NS	**					**	**	
B-B <sup>^</sup>	*	NS	*						
Pg-Pg <sup>^</sup>	NS	NS							
GI-Sn	NS	NS							
Sn-St	**	**	**		**		**	**	
Sn-LLV	NS	*					*		
LLV-Me	NS	**					**	**	
<b>Nasolabial angle</b>									
Sn-St/St-Me	NS	NS		*					

MA indicates maxillary advancement; MS, mandibular set back; BM, bimaxillary; T1, before treatment; T2, before surgery; and T3, end of fixed treatment. \* P<0.05, \*\* P<0.01. NS indicates not significant.

4. Sn-VR and ULA-VR parameters differed significantly between time intervals in MA and BM groups after surgery, LLA-VR, B<sup>^</sup>-VR in MS and BM groups, Pg<sup>^</sup>-HR, Sn-Me, St-

Me, LLA.B<sup>^</sup>.Pg<sup>^</sup>, GI-Sn/Sn-Me differed in BM group after surgery.

The mean amount of differences between T3 and T1

Periods for the Three Surgery Groups is shown on *Table 5*. The relationship of linear sagittal changes in soft-tissue variables to the repositioning of skeletal landmarks was expressed using the following formula (*Table 6*).

$$Ratio = \frac{T3 - T1 \text{ mean of soft tissue changes}}{T3 - T1 \text{ mean of skeletal changes}}$$

### Discussion

Soft tissue response to orthognathic surgery has been widely evaluated either in three dimensional methods or with cephalometric radiography. A review of literature demonstrated that the majority of previous research focused on either mandibular set back surgeries or double jaw surgeries [9,11,16-18]. However there is a lack of information about the comparison of MS, MA and BM groups under same standardized conditions like surgical technique, cephalometry, pre and post-surgical treatment period, parameter evaluation.

Although three-dimensional evaluating techniques can be preferred for orthognathic surgery patients, for routine orthognathic surgery cases, cephalometry is common and a less expensive tool that has the potential to analyze and predict the resulting profile. According to Rustemeyer and Martin especially in Class III cases cephalometry is still a feasible standard in evaluating orthognathic surgery cases [17].

The relatively small sample size of the MS and MA groups is a result of the extent of BM operations in our clinic. Improvements in skeletal, dental and soft tissue variables were achieved after surgery in all patients included in the study.

The mean amount of setback in MS group at point B was

5.44 mm, the lower lip (LLA-VR) moved backward 0.84%; B<sup>^</sup>, 0.99%; Pg<sup>^</sup>, 0.90% (*Table 6*) which is in accordance with 3D study of Kim et al. [13]. The mean amount of setback in BM group 4.20 mm, the lower lip moved backward 0.48%; B<sup>^</sup> 1.01% and Pg<sup>^</sup>0.70%. In the literature the ratios for lower lip movement varies from 0.54%-0.70% for bimaxillary surgery operations [15-20]. In our BM surgery group the lower lip movement was slightly milder than we had expected. According to our results lower lip backward movement ratio was almost twice in MS group when (0.84%) compared with BM group (0.48%), however there was no significant intergroup difference.

In our study, the mean amount of maxillary movement in BM group was 3.32 mm, the upper lip (ULA-VR) moved forward 0.87%, Sn 0.53%, Pr 0.41% which was higher than the results in literature [9,21,22]. The mean amount of maxillary advancement in MA group was 4.75 mm, the upper lip moved forward 0.64%, Sn and Pr moved forward 0.39% and 0.13% respectively. In BM surgery operation the upper lip, Sn and Pr were affected more with the movement of underlying hard tissue.

After mandibular setback operation the upper lip moved backward 0.10% which was insignificant. This result is similar to the other cephalometric studies that reported backward movement of the upper lip [19,20]. The soft tissue change on the upper lip, most likely occurs owing to continuity of

*Table 5. The Differences Between T3 and T1 Periods for Three Surgery Groups.*

PARAMETERS	Maxillary Advancement (D)	Mandibular Set Back (D)	Bimaxillary (D)
SNA	4.62	-0.04	2.90
SNB	-0.68	-5.44	-4.20
ANB	5.37	2.94	5.16
GoGnSN	0.97	0.11	-1.91
A-HR	1.51	0.42	-0.71
A-VR	4.75	0.20	3.32
B-HR	0.32	-0.48	-3.52
B-VR	-1.28	-5.44	-4.20
Pr-HR	-0.19	0.59	-1.09
Pr-VR	0.62 **	0.41 **	1.39 **
Sn-HR	0.22	0.57	-0.23
Sn-VR	1.87 **	-0.20	1.79 **
ULA-HR	0.99	0.46	0.31
ULA-VR	3.06 **	-0.56	2.92 **
LLA-HR	2.74	0.97	0.63
LLA-VR	-0.19	-4.59 **	-2.03 **
B <sup>^</sup> -HR	1.82	-0.22	2.41
B <sup>^</sup> -VR	-0.96	-5.39 **	-4.26 **
Pg <sup>^</sup> -HR	1.09	0.41	-2.47 *
Pg <sup>^</sup> -VR	-1.85 **	-4.93 **	-2.98 **
B-B <sup>^</sup>	0.34	-0.12	-1.62
Pg-Pg <sup>^</sup>	0.32	-0.60	0.07
Gl-Sn	-1.24	0.83	0.91
Sn-Me	1.05	0.59	-1.96
Sn-St	4.82 **	-2.19**	1.45 **
Sn-Me	-1.26	-0.23	-3.41 **
Sn-LLV	2.64 *	0.85 *	1.20 *
LLV-Me	-1.58**	-0.26 **	-3.16 **
LLA <sup>^</sup> -B <sup>^</sup> -Pg <sup>^</sup>	-4.22	-7.82	-15.08 **
Nasolabial angle	-3.00	1.16	-1.08
Gl-Sn/Sn-Me	0.00	0.01	0.03 *
Sn-St/St-Me	0.01	0.03	-0.06
Sn-LLV/LLV-Me	-0.09 *	0.01	0.03

*Table 4. Parameters Showing Interaction.*

Parameters	Group	T1-T2	T1-T3	T2-T3
Sn-VR	MA		**	**
	MS			
	BM		**	**
ULA-VR	MA		**	**
	MS			
	BM		**	**
LLA-VR	MA			
	MS		**	**
	BM		**	**
B <sup>^</sup> -VR	MA			
	MS		**	**
	BM		**	**
Pg <sup>^</sup> -HR	MA			
	MS			
	BM		*	*
Sn-Me	MA			
	MS			
	BM		**	**
St-Me	MA			
	MS			
	BM		**	**
LLA.B <sup>^</sup> .Pg <sup>^</sup>	MA			
	MS			
	BM		**	**
Gl-Sn/Sn-Me	MA			
	MS			
	BM		*	*
Sn-LLV/LLV-Me	MA	*		
	MS			
	BM			

**Table 6.** The Ratios of the Movements of the Skeletal and Soft Tissue Variables Following Orthognathic Surgery (T3-T1).

MA		MS		BM	
Pr-VR/A-VR (%)	0.13	Pr-VR/B-VR (%)	0.07	Pr-VR/A-VR (%)	0.41
Sn-VR/A-VR (%)	0.39	Sn-VR/B-VR (%)	0.03	Sn-VR/A-VR (%)	0.53
ULA-VR/A-VR (%)	0.64	ULA-VR/B-VR (%)	0.10	ULA-VR/A-VR (%)	0.87
LLA-VR/A-VR (%)	0.04	LLA-VR/B-VR (%)	0.84	LLA-VR/B-VR (%)	0.48
B^-VR/A-VR (%)	0.20	B^-VR/B-VR (%)	0.99	B^-VR/B-VR (%)	1.01
Pg^-VR/A-VR (%)	0.38	Pg^-VR/B-VR (%)	0.90	Pg^-VR/B-VR (%)	0.70

MA indicates maxillary advancement; MS, mandibular set back; BM, bimaxillary; T1, before treatment; and T3, end of fixed treatment.

the orbicularis oris muscle and soft tissue tension. Although there was no maxillary advancement the nose significantly moved forward which is similar to results reported by Jung et al. [10] and Lim et al. [14]. This result can be due to indirect movement of the nose by orbicularis oris muscle and soft tissue tension [14]. Although not significant nasolabial angle increased 21% of the pre-operative value after surgery. This is in accordance with other studies [6,10,23].

There was a significant backward movement of soft tissue Pg (0.38%) and insignificant backward movement soft tissue B (0.20%) after maxillary advancement. The backward movement of soft tissue Pg and B can be due to stretching of the soft tissue chin area before surgery and relaxation after surgery.

After mandibular set back operation, Sn-St decreased significantly after surgery. This can be because of the hyperdivergency of the group and the patients inability to close their lips. According to studies especially in hypodivergent Class III patients upper lip length increases after surgery [13,19,23,24]. There was a significant increase in Sn-LLV. This can be due to decrease in lower lip tension after setback which would allow for replacement of the upper lip and opposing change in vermilion border. This result can be explained by the repositioning of the vermilion to downward. After the surgery normal lip posture is maintained. The mentolabial sulcus became deeper after surgery (not

significant) while in bimaxillary group the decrease was higher and significant.

Changes in the soft tissue thickness of the upper and lower lips and the chin are known to be influenced by the initial preoperative thickness of the corresponding area [19] and are closely correlated with the amount and direction of hard tissue movement after mandibular or maxillary surgery [20]. Therefore soft tissue variables show variability in the literature. The other reason for the variability can be different methods to evaluate soft tissue parameters.

Even with the same skeletal movement three surgical techniques have different effect on soft tissues. Our results are in accordance with Ghassemi et al. [25]. They observed significant changes in the nasolabial angle and in the distance between the lower lip and esthetic line according to the surgical approach taken. From overall results in all patients harmonized facial profile was maintained, however it is important to plan the best type of surgery and skeletal movement for the patient and to enable clinically accurate predictions for satisfactory outcomes.

## Conclusion

The ratio of the mean amount of soft tissue change and the skeletal change differ in three surgical groups, thus soft tissue prediction ratios should be done separately for three surgery groups.

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