Original Article

Soft tissue changes after mandibular setback and bimaxillary surgery in Class III patients

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ABSTRACT

Objective: To evaluate the relationship between soft tissue and bone structure for Class III patients before and after bilateral sagittal split osteotomy (BSSO) and bimaxillary orthognathic surgery; to determine the impact of other factors on soft tissue change; and to evaluate correlations between thickness of tissue before surgery, SNA, SNB, and ANB angles, and soft tissue changes.

Materials and Methods: The study included 78 Class III patients treated only with BSSO or with BSSO and Le Fort I osteotomy. Lateral cephalograms were taken before and 3 months to 1 year after surgery. After all points of the Zagreb82 and Legan and Burstone profile analysis were traced, the ratio of five soft tissue points before and after surgery was evaluated.

Results: Soft tissue between points Sn and A and upper lip showed statistically significant changes for patients treated with bimaxillary surgery and BSSO. Only gender had an influence on soft tissue change. The correlation between soft tissue thickness and changes after surgery was significant. A change in SNB angle correlated with upper lip thickness for patients treated with BSSO but not for patients treated with BSSO and Le Fort I. SNA angle changes correlated with soft tissue changes between points Sn and A.

Conclusion: Results of this study show soft tissue changes after BSSO and BSSO and Le Fort I and eliminate the deficiencies that were indicated in the meta-analysis of soft tissue changes from a previous study. (*Angle Orthod.* 2013;83:817–823.)

KEY WORDS: Orthognathic surgery; BSSO; Cephalometry; Soft-tissue changes

INTRODUCTION

Treatment of severe Class III malocclusion frequently requires a combination of orthodontics and orthognathic surgical procedures to improve facial esthetics and to harmonize the facial profile.[1] Cephalometric norms are used to guide clinicians during diagnosis and treatment planning.[2] However, the ultimate goal of treatment is not to achieve ideal cephalometric values but a balanced soft tissue profile. Many studies have attempted to predict the behavior of soft tissues after surgery. A meta-analysis conducted by Joss et al.[3] showed that only eight papers could be included in the analysis and that others had many shortcomings. The purpose of our research was to correct some deficiencies indicated by Joss et al. and thus contribute to more accurate conclusions. The aims of this study were to evaluate

- The relationship between soft tissue and bone structure in Class III patients after bilateral sagittal split osteotomy (BSSO).
- The relationship between soft tissue and bone structure in Class III patients after bimaxillary surgery (BSSO + Le Fort I).
- Whether there were differences in soft tissue change with respect to age, gender, and duration of orthodontic treatment.
- Whether brackets on the teeth at the time a lateral cephalogram is taken affects the results.

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Table 1. Distribution of patients according to age, type of surgery, duration of orthodontic treatment and length of hospital stay

Gender	No.	Age (Years)*	BSSO Only	Bimaxillary Surgery	Orthodontic Treatment Before Surgery (Months)*	Orthodontic Treatment After Surgery (Months)*	Orthodontic Treatment Total (Months)*	Length of Hospital Stay (Days)*
Male	27	22.93 ± 0.73	9	18	10.62 ± 2.16	4.77 ± 1.25	15.40 ± 2.45	6.56 ± 1.80
Female	51	22.59 ± 0.69	17	34	11.05 ± 1.84	4.43 ± 1.10	15.49 ± 2.20	7.06 ± 1.65

* Means ± standard deviation.

- Correlations between preoperative thickness and postoperative soft tissue changes.
- Correlations between mandibular and maxillary movement with soft tissue changes.

PATIENTS AND METHODS

The study included patients treated from 1999 to 2011 who satisfied the following conditions:

- Classified as Class III
- Orthodontically and surgically treated at the department
- No syndromes and no cleft lip or palate
- No surgical intervention other than BSSO or BSSO and Le Fort I
- Lateral cephalograms before surgery and 3 to 12 months after surgery

This study followed the Declaration of Helsinki on medical protocol and ethics. The Ethical Review Board of University Hospital Dubrava and School of Dental Medicine, University of Zagreb, both approved it.

Surgical treatment of patients included BSSO and rigid fixation with three bicortical titanium screws 2 mm in diameter on both sides. In patients treated by bimaxillary osteotomy, an additional Le Fort I osteotomy was performed with rigid fixation using four plates with four titanium screws 2 mm in diameter. A postoperative splint or intermaxillary fixation was not used; only elastics for guidance were used for 3 weeks. All patients who had undergone the presurgical orthodontic stage were treated by the same orthodontist, and all were operated on by three surgeons who used the same operating methods. After reviewing the documentation, 78 patients (27 men and 51 women) met all of the conditions. Table 1 shows the distribution of patients by gender and surgery, average age at the time of surgery, duration of orthodontic treatment, and number of days in the hospital.

Power analysis was performed on the paired samples *t*-test for patients who were treated only with BSSO (smaller sample) and for the variable that had the smallest statistically significant change. The result of the power analysis was 0.753.

Cephalograms were obtained under standardized conditions. Patients were placed in the centric occlusion, and a relaxed lip position was obtained by asking the patients to gently lick their lips and relax. Two devices were used during 11 years. Until October 2008, cephalograms were taken with the Planmeca PM 2002 CC Proline; Planmeca, Helsinki, Finland). Analog cephalograms were digitized by scanning. After October 2008, cephalograms were stored on a CD-ROM or via e-mail in digital format and were taken with the Orthopantomograph OP200D, (Instrumentarium Oy, Tuusula, Finland) with an average exposure of 10 seconds with a value of 85 kV – 13 mA.

Cephalometric analysis was performed with Onyx-Ceph 3D (Image Instruments GmbH, Chemnitz, Germany). The same investigator traced all cephalometric reference points for the Zagreb82 MOD2[4] and Legan and Burstone[5] analysis of soft tissue (Figures 1 and 2). Systematic and accidental errors of the cephalometric analysis were evaluated by duplicate determinations of 10 cephalograms selected at random using a random number generator. The cephalograms were retraced a second time by the same examiner 1 month after the first assessment. No systematic errors were found when the values were evaluated with a paired *t*-test. The accidental errors (si) were calculated using the following formula:

$$\sqrt{\frac{\sum d^2}{2n}},$$

where d is the difference between the repeated measurements and n is the number of duplicate determinations. The average accidental error for all variables was 1.03. The average accidental error for each variable was 0.33 $\pm$1.52° or millimeters. Selected variables are shown in Table 2. Results are also shown before and after surgery along with the significance of the changes.

In addition to cephalometric values before and after surgery, we took into account the demographic data (gender and age at the time of surgery), duration of orthodontic treatment, existence of bonded brackets at the time lateral cephalograms were taken, and hospital stay.

Statistical analysis of the data was performed with IBM software package SPSS Statistics version 18 (SPSS Inc, Chicago, IL, USA). Descriptive statistics included means and standard deviatiosn. Differences

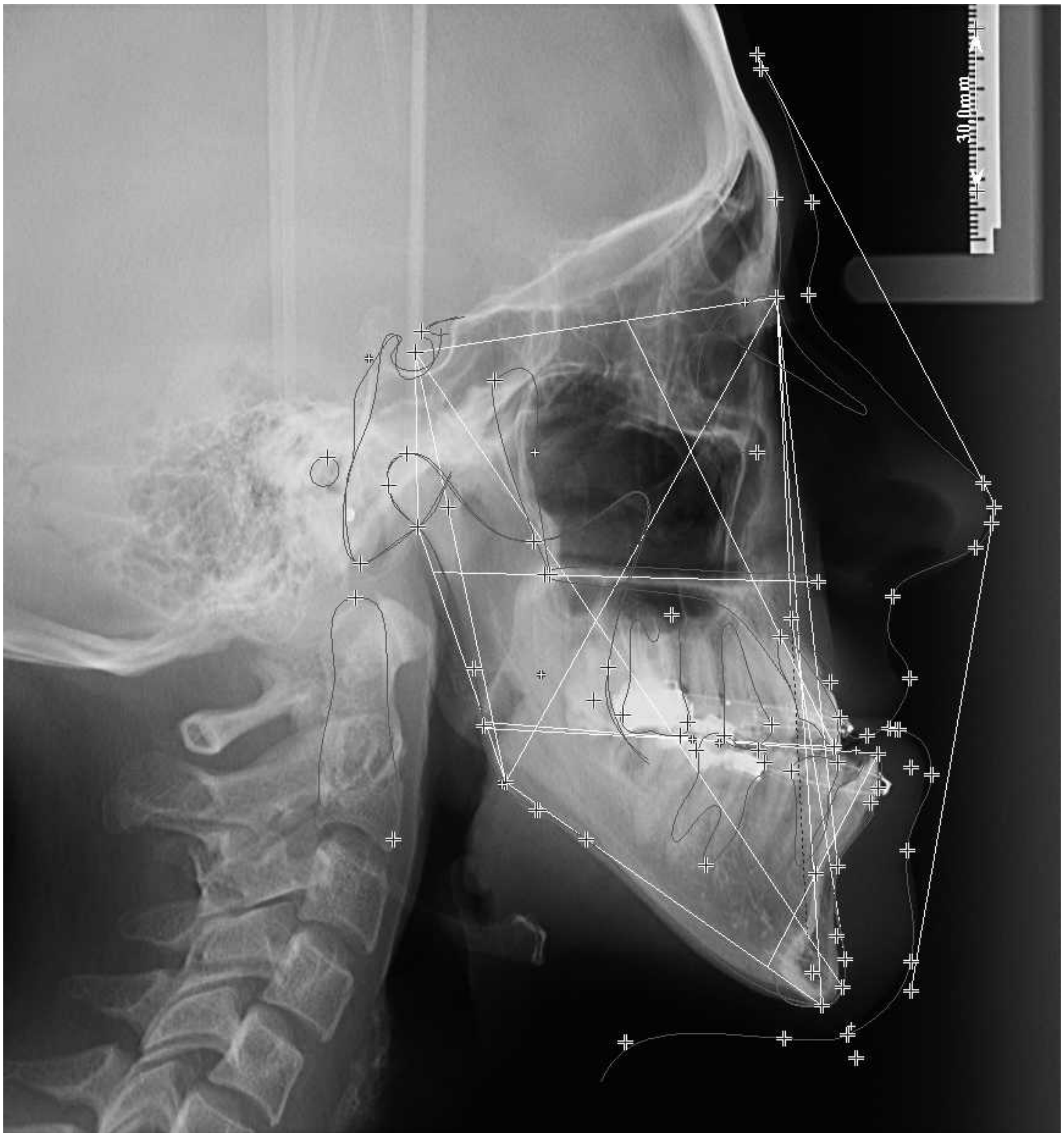

Figure 1. Cephalometric reference points for the Zagreb82 MOD2 analysis.[4]

between groups were compared with Student's *t*-test for independent samples, with a significance level of $P < .05$. Differences between the results before and after surgical orthodontic therapy were compared with *t*-tests for paired samples. Correlations between certain variables were determined with Pearson's correlation coefficient. Power analysis was conducted using Java applets for power and sample size.[6]

RESULTS

The study included 78 patients (27 [35%] men and 51 [65%] women). Of these, 26 patients were treated only with BSSO (9 men and 17 women), while 52 had bimaxillary osteotomy (18 men and 34 women). Comparison of patient age, duration of treatment, and hospital stay showed no statistically significant differences between males and females (Table 1).

Changes of variables before and after treatment are shown in Table 2. The thickness of soft tissue in the area of the lower lip, mentolabial sulcus, and chin was not significantly different regardless of the surgical procedure. The relative relationships between soft tissue before and after surgery, according to the type of surgery, are shown in Table 3. The *t*-tests showed that patients who underwent only the mandibular surgery had the same statistically significant changes as those who had bimaxillary surgery (Table 4).

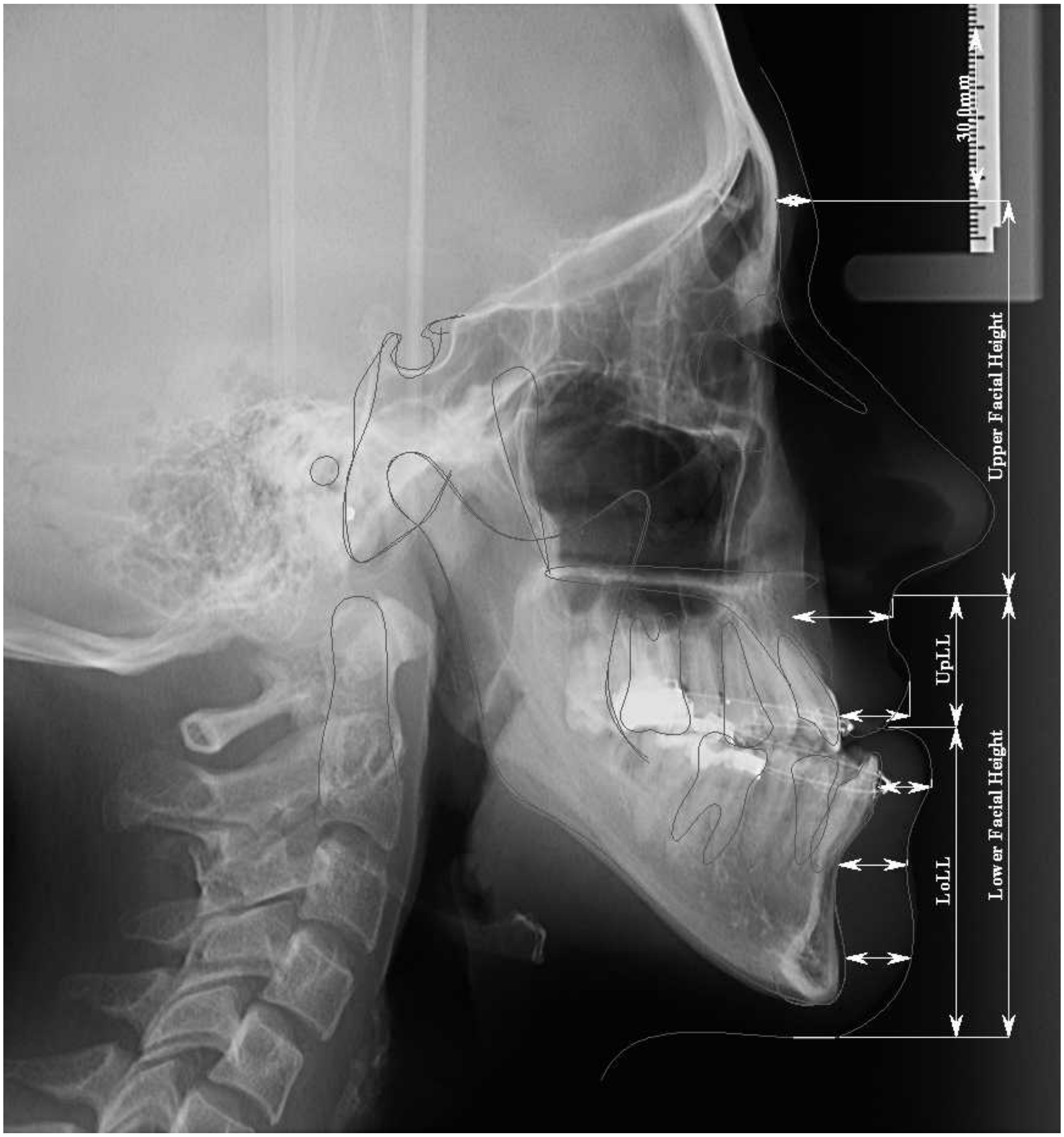

Figure 2. Cephalometric reference points for Legan and Burstone[5] analysis of soft tissue.

Table 2. Mean ± standard deviation (SD) values of selected cephalometric variables before and after surgery and *t*-test for differences before and after surgery with accidental error for each variable

	Before Surgery		After Surgery		Difference		Accidental Error	
Variables	Mean	SD	Mean	SD	*t*	*P*	*P*	Si
Sn-A	17.56	2.85	15.72	1.78	6.920	<.001*	.360	0.82
Ls1u-Ls	13.68	2.83	11.76	1.36	7.189	<.001*	.393	0.56
Li1l-Li	11.89	2.19	12.29	1.23	−1.620	.109	.244	2.72
Sm-B	11.35	2.27	11.54	1.13	−.793	.430	.320	0.74
Pog′-Pog	10.56	2.18	10.47	1.50	0.407	.685	.464	0.07
S-N-A	81.44	3.59	84.38	3.98	−7.585	<.001*	.067	0.50
S-N-B	86.89	4.88	83.95	3.54	8.142	<.001*	.636	1.20
A-N-B	−5.45	3.19	0.44	2.35	−17.749	<.001*	.951	1.70

Table 3. Ratio of soft tissue variables before and after surgery for all patients, for patients who had bimaxillary surgery, and for patients who had BSSO only

	All Surgeries			BSSO Only			Bimaxillary Surgery		
Variable	N	Mean	SD	N	Mean	SD	N	Mean	SD
SN-A ratio	78	90.95	12.35	26	95.67	11.51	52	88.59	12.18
Ls1u-Ls ratio	78	88.58	16.89	26	93.80	16.34	52	85.98	16.69
Li1l-Li ratio	78	106.77	22.71	26	109.28	23.17	52	105.51	22.60
Sm-B ratio	78	105.11	20.84	26	105.85	18.18	52	104.75	22.20
Pog′-Pog ratio	78	102.03	21.02	26	103.99	20.76	52	101.05	21.28

Correlation analysis showed a statistically significant change between gender and soft tissue thickness in the area under the nose ($r = 0.245$; $P = .031$) and upper lip ($r = 0.232$; $P = .041$), which was more reduced in men. Soft tissue changes in the chin were not statistically significant but were considerable ($r = -0.208$; $P = .067$).

Correlation analyses were performed to determine whether there was a correlation between patient age at the time of surgery and soft tissue changes and duration of orthodontic treatment and soft tissue changes. Pearson's correlation coefficient showed no statistically significant correlations.

To determine the relationship between the thickness of soft tissues before and after surgery, correlation analyses between variables was performed. The results are shown in Table 5.

A statistically significant correlation was observed between changes in the SNB angle before and after surgery and changes in the soft tissue of the upper lip in patients treated with BSSO only. In patients who underwent bimaxillary surgery, SNB angle changes negatively correlated with soft tissue ratios in the mentolabial sulcus area (Table 6). Changes in SNA angle significantly correlated with change in thickness of tissue beneath the nose ($r = -0.401$; $P < .001$). To determine the effect of brackets on soft tissues changes, patients were separated into groups that had the similar bracket pattern on both radiographs and those that did not. Student's *t*-test did not show a statistically significant difference between the groups.

DISCUSSION

The results of our study showed differences between the number of male and female patients. Considering that studies of the prevalence of Class III disorders in the population show no difference between the sexes[7] and our results match those from the literature,[8] we can conclude that women are more likely to choose orthognathic surgery because they are motivated by improved appearance and masticatory function after surgery.[9] Duration of postoperative hospital stay for patients treated at the department (88 ± 1.71) was significantly higher than in other clinical centers. For example, in a study conducted in the United Kingdom, Garg et al.[10] showed that monomaxillary orthognathic surgery patients stayed in the hospital just one night, while bimaxillary patients stayed for two nights. Huaman et al.[11] showed a hospital stay of 1.7 ± 1.2 days, indicating that a considerable factor in reducing the length of a hospital stay is the transition from intermaxillary to rigid fixation. Given that all patients treated at the department had rigid fixation, the reduction of patient hospital stay should be considered to significantly reduce the costs of hospital treatment.

Isolated mandibular prognathism occurs in only 20% to 25% of all Class III patients, while 75% have some degree of maxillary skeletal deficiency.[12] This trend is why a small number of patients were treated exclusively with BSSO, while a larger number of patients also underwent Le Fort I osteotomy. Regardless of whether the patient underwent an operation involving only the mandible or both jaws, the results of this study

Table 4. The *t*-test results for changes of soft tissue variables before and after BSSO and bimaxillary surgery

	BSSO Only			Bimaxillary Surgery		
Variable	*t*	df	*P*	*t*	df	*P*
Sn-A	2.468	25	.020*	6.849	51	<.001*
Ls1u-Ls	2.714	25	.011*	7.005	51	<.001*
Li1l-Li	−1.519	25	.141	−0.874	51	.386
Sm-B	−1.003	25	.325	−0.305	51	.762
Pog′-Pog	−0.365	25	.718	0.686	51	.496

Table 5. Difference in changes of soft tissue variables according to gender

	Bimaxillary Surgery			BSSO Only		
Variable	*t*	df	*P*	*t*	df	*P*
SN-A ratio	−1.127	50	.265	−2.552	24	.017*
Ls1u-Ls ratio	−1.356	50	.181	−1.779	24	.088
Li1l-Li ratio	−0.907	50	.369	−0.511	24	.614
Sm-B ratio	−0.366	50	.716	−1.881	24	.072
Pog′-Pog ratio	1.406	50	.166	1.196	24	.244

* $P < .05$.

Table 6. Correlation between soft tissue thickness and soft tissue changes before and after surgery

Variables Before Surgery	SN-A Ratio	Ls1u-Ls Ratio	Li1l-Li Ratio	Sm-B Ratio	Pog′-Pog Ratio
Sn-A					
r	−0.717**	−0.573**	−0.309**	−0.208	0.040
P	<.001	<.001	.006	.068	.728
Ls1u-Ls					
r	−0.397**	−0.775**	−0.429**	−0.129	−0.011
P	<.001	<.001	<.001	.261	.925
Li1l-Li					
r	−0.303**	−0.437**	−0.823**	−0.306**	−0.222
P	.007	<.001	<.001	.006	.051
Sm-B					
r	−0.278*	−0.290*	−0.363**	−0.829**	−0.306**
P	.014	.010	.001	<.001	.006
Pog′-Pog					
r	−0.064	−0.177	−0.283*	−0.460**	−0.667**
P	.578	.121	.012	<.001	<.001

* $P < .05$; $P < .01$.

indicate that the same variables were statistically significantly changed.

According to our research, the thickness of tissue in the area below the nose (Sn-A) and upper lip (Ls1u-Ls) was reduced to 80% to 95% of its value before surgery, while the soft tissues of the lower lip, chin, and mentolabial sulcus increased in thickness; results, however, were not statistically significant. In a study of profile changes after vertical ramus osteotomy, Naoumova et al.[13] also reported reduced thickness of the upper lip (an average of 2 mm; SD 3.0). The probable reason for the reduction of the upper lip, even when an intervention on the upper jaw was not performed, is the pseudo-position of the lip before surgery, which occurs as a result of compensation in Class III.[14]

Correlation analysis was conducted to determine whether there was a significant difference between the sexes and changes in the thickness of soft tissue. Mobarak et al.[15] stated that soft tissue changes were more pronounced for the soft tissues of the upper lip and chin in females. Our research also showed a statistically significant difference for variables of the upper lip and soft tissue between points Sn and A, while changes in soft tissue of the chin were very close to statistical significance ($r = -0.208$; $P = .067$).

In this study we tried to answer some questions raised by Joss et al.[3] These authors conducted a meta-analysis of research that investigated the behavior of soft tissues, but they did not determine how changes of soft tissues after surgery depend on the thickness of the tissue before it. Correlation analysis showed a strong negative correlation between the thickness of soft tissues before surgery and changes in soft tissue. According to the results of this research, surgery will significantly reduce the thickness of soft tissue in patients with thicker soft tissue before surgery, and thickness will increase after surgery for patients with thin soft tissue before surgery.

Correlation analysis was conducted to determine the relationship between changes in SNA and SNB angles and changes in soft tissue. According to our research, reduction in SNB angles significantly correlated with a reduction in the thickness of the upper lip in patients who underwent BSSO. However, if the patient also underwent Le Fort osteotomy, the correlation was not significant and the shift of the upper jaw affected the thickness of the upper lip. Ingervall et al.[14] reported that increasing displacement of the mandible results in greater retraction and extension of the upper lip, but we did not find results that showed the difference in correlation between patients who were treated with BSSO and those with bimaxillary osteotomy in the available literature. Changes in the SNA angle affect the thickness of tissue under the nose, which is reduced by increasing the SNA angle. In future studies, it would be interesting to see if there is a correlation between the Wits variable and changes of soft tissue.

Joss et al.[3] cited a problem regarding orthodontic brackets in the evaluation of changes in the thickness of soft tissue. We divided patients into two groups based on whether they had brackets on cephalograms. Patients with the same situation on both cephalograms were classified into the first group, and all other patients were placed in the second group. Results showed that there was no statistically significant difference between the two groups.

CONCLUSIONS

- Soft tissue of the upper lip and between points Sn and A decreased in thickness after BSSO.
- Soft tissue of the upper lip and under the nose decreased in thickness after bimaxillary surgery.
- Changes in soft tissue between points Sn and A and the upper lip area were more pronounced in women.
- Banded brackets had no effect on changes in the thickness of soft tissue.
- There was a strong correlation between thickness of the soft tissue before the operation and changes in the soft tissue after surgery.
- There was a significant correlation between the change in SNB angle and thickness of the upper lip in patients treated with BSSO only; however, that correlation was not seen in patients who underwent both BSSO and Le Fort I osteotomy.

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