Comparative Study of Facial Soft Tissue Profile Changes following Bilateral Sagittal Split and Subcondylar Osteotomies in Patients with Mandibular Prognathism

[1]Shahla Momeni Danaei [2]Barbod Zamiri *[3]Farzaneh Khajeh [4]Sepideh Torkan [5]Sahar Ghodsi Bushehri

[1]Professor, Orthodontic Research Center, School of Dentistry, Shiraz University of Medical Sciences, Shiraz- Iran.

[2]Associate Professor, Dept. of Oral & Maxillofacial Surgery, School of Dentistry, Shiraz University of Medical Sciences, Shiraz- Iran.

*[3]Corresponding Author: Assistant Professor, Dept. of Orthodontics, School of Dentistry, International Branch of Shiraz University of Medical Sciences, Shiraz- Iran. E-mail: fary822002@yahoo.com

[4]Assistant Professor, Dept. of Orthodontics, Dental School, Lorestan University of Medical Sciences, Lorestan- Iran.

[5]Undergraduate student, Research Committee, School of Dentistry, Shiraz University of Medical Sciences, Shiraz- Iran.

Abstract

Objective: Programming for a successful operation and accurate prediction of the outcome of orthognathic surgery result in correction of occlusal and skeletal relations and improve the facial esthetics and function of patients. This retrospective study sought to assess the soft tissue changes following subcondylar and bilateral sagittal split osteotomy (BSSO) to retrude mandible in patients with mandibular prognathism.

Methods: This retrospective experimental study evaluated 35 patients with mandibular prognathism and a mean age of 25.5 years (range 18.8 to 30.9 yrs). Cephalometric variables were measured on lateral cephalograms of patients before and after surgery and recorded. A total of 12 patients had undergone BSSO while 23 subjects had received subcondylar surgery. Cephalometric variables were analyzed using paired t- and independent t-tests.

Results: The study results demonstrated that the mean changes in cephalometric soft tissue variables of Ls-Pr ($P<0.05$), Li-Id ($P<0.01$) and G-Sn/Sn-Me ($P<0.05$) after BSSO were significantly higher that the rates in Subcondylar surgery group. However, the mean changes in soft tissue variables of SLs-A ($P<0.05$), a2 facial angle ($P<0.05$) and LFH ($P<0.001$) in subcondylar surgery group were significantly higher than the rates in BSSO group. In patients that had undergone subcondylar surgery, the lower facial height and the mentocervical angle had increased which is indicative of a shift towards a straight facial profile after this type of surgery.

Conclusion: This study showed that a greater improvement in profile is achieved after BSSO compared to subcondylar surgery according to the current esthetic parameters.

Key words: Subcondylar osteotomy, Prognathism, Soft tissue, Mandibular setback surgery, BSSO

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Introduction:

Reconstruction of dentofacial defects by surgery has greatly developed since its invention in late 19th century. Surgical correction of mandibular retrusion or protrusion to improve occlusal function and achieve better esthetics has become a popular treatment option (1). Thus, the role of orthodontic treatment and related surgery in patients' esthetics cannot be ignored. Several surgical methods have been proposed for mandibular setback surgery but at present, two methods of subcondylar osteotomy and especially BSSO are more commonly used (2). Selection of surgical technique depends on various factors such as the severity of dentofacial defect, rate of movement of the respective jaw and the expected change in the soft tissue (3). Use of osteotomy to retrude mandible was started in 1900 but BSSO was first invented by Obwegezer and Trauner in 1957 and is now commonly used to correct mandibular prognathism. Some modifications have also been made in methods of controlling bone segments and their fixation after surgery (4). A successful surgical treatment plan for patients who need orthognathic surgery not only includes hard tissue but also should consider the cephalometric analysis of the soft tissue that indicates the defective skeletal structure beneath it. However, these data can be misleading in many cases and do not provide accurate information about the profile and exact proportions of the face. The thickness of the facial soft tissue is highly variable. Various shapes and forms of teeth and bones are available as well. Therefore, the results of the mentioned analysis can be highly different from the soft tissue appearance. Thus, a method is required to provide a comprehensive cephalometric analysis of the soft tissue in addition to that of the hard tissue (5). The increased tendency towards facial esthetics and soft tissue profile is due to the fact that facial beauty has been known as the most important factor in physical attractiveness and beauty (6).

Although several studies have evaluated soft tissue changes following mandibular osteotomy, no study has assessed the association between soft tissue changes and surgical technique. A successful surgery not only results in correction of occlusion in balanced skeletal relations, but also leads to improved function and esthetics. Thus, prediction of the soft tissue changes following surgery is an important part of the presurgical treatment planning. The present study aimed at assessing the facial soft tissue profile changes following BSSO and subcondylar surgery.

Methods:

In this retrospective study, 35 Iranian patients with a mean age of 25.5 years (range 18.8-30.9 yrs.) who had undergone orthodontic treatment and mandibular surgery were evaluated. Patients were divided into 2 groups: the first group contained 23 patients who had undergone subcondylar osteotomy and the second group comprised 12 patients who had undergone BSSO. Patients who had history of any syndrome, cleft lip or cleft palate, trauma, open bite or soft tissue surgery (like rhinoplasty or genioplasty) were excluded from the study. The selected patients for the study (inclusion criteria) were all adults with completed growth and natural teeth who were candidates for mandibular setback surgery and were under treatment with Edgewise standard system with fixed appliance and 0.022 inch slot before and after surgery with a similar protocol and had an acceptable occlusion after surgery. Presurgical orthodontic treatment had been started with the aim of creating a stable occlusion after surgery, creating a level curve of Spee, expansion of dental arches, correcting the inclination of incisal teeth, leveling and aligning the malpositioned teeth and extraction of premolars if necessary. Since in this study anonymous cephalograms had been selected from the treated patients' medical files, there was no need for the approval from the Medical Ethics committee. All samples were selected from the archives of an orthodontist's private office that had treated them with Edgewise standard system with fixed appliance and 0.022 inch slot. The patients had undergone surgery by two maxillofacial surgeons with over 15 years of work experience. One of the surgeons had only used intraoral subcondylar osteotomy method and intermaxillary wire fixation (IMF) while the other used BSSO and rigid fixation for mandibular setback. The mean duration of presurgical orthodontic treatment was 1.6 years in the first group and 1.4 years in the second group which was also continued after surgery. The mean duration of orthodontic treatment was 2.2 years in the first and 2.1 years in the second group after surgery. In this study, difference in values of variables before (T1) and after (T2) surgery was considered as a "change". SPSS version 15 software was used for statistical analysis. In order to compare the mean changes (difference:T2-T1) in the understudy variables before and after surgery in both groups, paired t-test and for the comparison of mean changes in variables between the two groups independent t-test were employed. $P<0.05$ was considered statistically significant.

Cephalometric analysis

Cephalometric radiographs had been obtained before initiation of orthodontic treatment (T1) and at a minimum of 6 months after surgery and removal of fixed orthodontic appliance (T2) under standard condition and with natural head position (NHP)(7), habitual occlusion and relaxed posture of the lips (8).

Lateral cephalograms were traced manually by one person. Cephalometric reference points were specified on an acetate tracing paper. Frankfurt horizontal plane (FH) as a transverse reference line and a line perpendicular to this plane dropped from Glabella point (G) were specified as the vertical reference lines. These reference lines were transferred to post-operative lateral cephalograms and used for measurement (in mm) of the point image of hard and soft tissue landmarks. Difference (mm) in measurements was considered as post-surgical changes. Seven hard tissue and 14 soft tissue landmarks were selected (Table 1 and Figure 1) and 23 linear and 5 angular variables were used (Table 2).

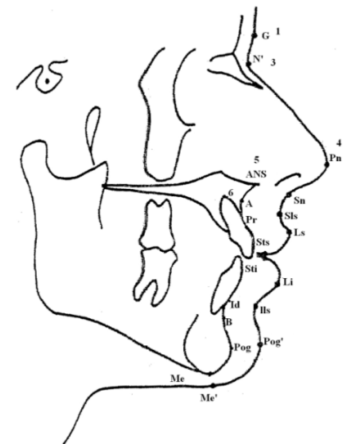

Figure 1- Hard and soft tissue landmarks

In order to assess the reliability of measurements, cephalometric tracings were repeated one month later by the same person and intra-examiner reliability=0.9 was obtained.

Table 1- Definition of the used hard and soft tissue landmarks

Definition	Landmarks
	Hard tissue
The most anterior point on the maxilla at the nasal base	ANS
The most posterior point in the concavity between the ANS and the prosthion	A
The most inferior point of the maxillary alveolar process in the midline	Pr
The most superior anterior point on mandibular alveolar process between the central incisors	Id
The most posterior point in the concavity between the Pog and Id	B
The most anterior point on the chin	Pog
Lower most point on the mandibular symphysis on a lateral cephalogram	Me
	Soft tissue
The most prominent and anterior point in the midsagittal plane of the forehead	G
The most projecting part of the nose	Pn
The junction of the columella (nasal septum) with the upper cutaneous lip	Sn
The point of greatest concavity on the contour of the upper lip between subnasale and labrale superius	Sls
A point indicating the mucocutaneous border of upper lip	Ls
The lowermost point on the vermillion of the upper lip	Sts
The uppermost point on the vermilion of the lower lip	Sti
The median point on the lower margin of the lower membranous lip	Li
Deepest point of the concavity of the lower lip between labrale inferius and soft tissue pogonion (mentolabial sulcus)	ILs
The most prominent point on the chin on midsagittal plane	Pog’
The most inferior point on the soft tissue of the chin	Me’
Pn-Pog’	E line
Line drawn from the midpoint of the S-shaped curve between pronasale (P) and subnasale (Sn) to soft-tissue pogonion (Pog’),	S line
Lower facial height	LFH (ANS-Me)

Table 2- Landmarks used in this study

Landmarks	**Hard tissue**		ANS	The most anterior point on the maxilla at the nasal base
			A	The most posterior point in the concavity between the ANS and the prosthion
			Pr	The most inferior point of the maxillary alveolar process in the midline
			Id	The most superior anterior point on mandibular alveolar process between the central incisors
			B	The most posterior point in the concavity between the Pog and Id
			Pog	The most anterior point on the chin
			Me	Lower most point on the mandibular symphysis on a lateral cephalogram
	Soft tissue	Forehead and nose	G	The most prominent and anterior point in the midsagittal plane of the forehead
			Pn	The most projecting part of the nose
			Sn	The junction of the columella (nasal septum) with the upper cutaneous lip
			Sls	The point of greatest concavity on the contour of the upper lip between subnasale and labrale superius
			Ls	A point indicating the mucocutaneous border of upper lip
		Lip	Sts	The lowermost point on the vermillion of the upper lip
			Sti	The uppermost point on the vermilion of the lower lip
			Li	The median point on the lower margin of the lower membranous lip
			ILs	Deepest point of the concavity of the lower lip between labrale inferius and soft tissue pogonion (mentolabial sulcus)
			Pog'	The most prominent point on the chin on midsagittal plane
		Chin	Me'	The most inferior point on the soft tissue of the chin
			E line	Pn-Pog'
			S line	Line drawn from the midpoint of the S-shaped curve between pronasale (P) and subnasale (Sn) to soft-tissue pogonion (Pog')
	Lower facial height			
	Nasolabial angle (a1+a2)			Formed by drawing lines tangent to the columella and Ls
			a_1	Formed by drawing a line tangent to the columella and a line parallel to FH that passes Sn
			a_2	Formed by drawing a line tangent to Ls and a line parallel to FH that passes Sn
	Mentocervical angle			
	Soft tissue facial convexity			
	Soft tissue facial			Angle defined by glabella-to-pogonion line intersecting with menton-to-cervical point line (intersection of N'-Pog'-FH)

a_1: Angle between the line tangent to columella and horizontal a_2: Ange between horizontal and Sn-Ls

Results:

Changes in means, standard deviations and p-values of various cephalometric parameters before and after surgery in BSSO and subcondylar surgery groups are demonstrated in Table 3. Parameters that did not show any significant change after the surgery in the BSSO group included E line-SLs, E line-Li, S line-Ls, S line-Li, SLs-Ls prep, soft tissue angle of Pog-Pog',Sn-ANS Me' Me convexity, nasolabial angle (a_1, a_2) and mentocervical angle; whereas, in the subcondylar osteotomy group, all variables except for the mentocervical angle significantly changed.

<u>Comparison of BSSO and subcondylar osteotomies:</u>

Although changes were observed in all understudy parameters after surgery, seven parameters showed significant changes. P-values of these parameters have been demonstrated in Table 4 which include facial angle ($P<0.00$), Li-Id ($P<0.002$), SLs-A ($P<0.015$), Ls-Pr ($P<0.022$), G- ($P<0.040$), a_2 ($P=0.32$) and LFH, Sn/Sn-Me (P<0.01).

Table 3- Linear (mm) and angular (°) soft tissue measurements in patients with mandibular prognathism following subcondylar surgery and BSSO (based on their location)

Variables		Measured variable			
Linear (mm)	I	Soft tissue thickness	Sn-ANS SLs-A Ls-Pr	St-mid (OJ-OB) Li-Id ILs-B	Pog-Pog' Me-Me'
	II	Lip morphology	E line- Ls E line- Li S line- Ls	S line- Li E line- SLs E line- ILs	SLs- Ls perp Ils- Li perp
	III	Sagital relationship of soft tissue profile	G- Sn G- Ls	G-Li G- Pog'	
	IV	Vertical relationship of soft tissue profile	$\frac{G-Sn}{Sn-Me'}$	$\frac{Sn-Sts}{Sti-Me'}$	
	V	Nasal morphology	Sn-Pn		
Angular (*)	I	Nasolabial (a_1+a_2)	a_1 a_2		
	II	Mentocervical			
	III	Facial convexity soft tissue	G-Sn-Pog'		
	IV	Soft tissue facial	N'-Pog'-FH		

Although these osteotomies had been performed only on the mandible, significant differences were observed between the results of the two types of surgery on the upper lip which were revealed from the evaluation of changes in a2 and SLs-A angles. These two parameters decreased following BSSO while increased after subcondylar osteotomy. Ls-Pr value increased after BSSO and decreased following subcondylar surgery. Li-Id value increased after both surgeries and this increase was statistically significant. G-Me' Sn/Sn value increased following BSSO and decreased after subcondylar surgery.

Table 4- Change in mean, standard deviation and P-value of different cephalometric variables before and after surgery in BSSO and subcondylar surgery groups

Variables	BSSO (T_2-T_1)		Subcondylar (T_2-T_1)		
	Mean± SD	P value †	Mean±SD	P value †	P value‡
Sn-ANS	-0.67±2.27	0.078	-0.65±2.30	0.028	NS
SLs-A	-1.04±1.38	0.001	+0.98±2.05	<0.001	<0.05
Ls-Pr	0.04±1.03	<0.001	-1±1.49	<0.001	<0.05
St-mid (OJ-OB)	1.09±1.90	0.003	-0.18±2.07	0.008	
Li-Id	2.58±1.58	0.025	0.32±2.24	0.014	<0.01
ILs-B	0.25±1.50	0.011	0.17±1.63	<0.001	
Pog-Pog'	-0.12±3.1	0.688	0.48±2.30	<0.001	
Me-Me'	0.67±2.97	0.396	0.40±2.05	0.012	
E line- Ls	+2.33±2.02	0.17	+2.16±2.36	0.002	
E line- Li	-0.66±2.37	0.051	-1.00±1.9	<0.001	
S line- Ls	1.54±1.54	0.052	1.47±1.78	<0.001	
S line- Li	-1.17±2.10	0.076	-1.15±1.99	<0.001	
E line- SLs	-1.67±1.86	0.052	-2.10±2.04	0.010	
E line- ILs	-1.67±1.86	0.007	-2.11±2.04	0.002	
SLs- Ls perp	0±0.97	0.142	-0.7±1.05	<0.001	

ILs-Li perp	0.67±1.54	0.044	1.47±2.51	0.005	
Gp-Sn	0.04±3.31	0.005	0.46±3.10	<0.001	
Gp- Ls	0.64±0.20	<0.001	0.42±2.1	<0.001	
Gp-Li	1.67±1.1	0.003	0.51±2.2	<0.001	
Gp- pog	-1.65±1.5	0.007	0.85±1.8	0.025	
LFH	1.05±1.2	0.002	-0.02±1.5	<0.001	
Sn-Sts/Sti-Me'	0.03±0.04	0.022	0.51±8.69	<0.001	
G-Sn/Sn-Me'	0.04±0.10	<0.001	1.51±0.06	<0.001	<0.05
Sn-Pn	-0.33±1.02	<0.001	0.08±1.68	<0.001	
Nasolabial angle	0.45±11.65	0.253	5.79±8.62	<0.001	
a_1	0.95±6.33	0.900	0.13±5.77	0.001	
a_2	-1.12±9.34	0.123	5.21±7.12	0.001	<0.001
mentocervical angle	5.70±6.46	0.178	8.56±1.91	0.438	
soft tissue angle of convexity	5.41±4.22	0.751	8.69±6.54	0.017	
soft tissue facial angle	-0.75±2.62	0.005	-3.84±1.79	<0.001	<0.001

Discussion:

In the present study, in order to reduce complications, all samples were selected according to precise inclusion criteria. Post-surgical assessment of samples was done based on the lateral cephalograms present in patients' records similar to Altug-Atac et al study in 2008 (9). Outcome of treatment was evaluated by assessing two lateral cephalograms before (T1) and after (T2) treatment. The advantage of using pre- and post-orthodontic treatment radiographs is the absence of brackets since their presence may result in misinterpretation of soft tissue changes especially in the lips area (9). In this study, all patients underwent orthodontic treatment and had fixed orthodontic appliance at the time of surgery whereas in some of the previous similar studies orthodontic treatment had not been carried out (10).

Pre-surgical records of patients had been taken right before initiation of their orthodontic treatment and the duration of post-surgical follow up was 6 months. Previous studies have demonstrated that changes that occur long time after surgery are minimal (9, 11-13) because soft tissue forms in a new balanced position soon after surgery (3).

Altug-Atac et al, in 2008 showed that changes following bimaxillary surgery are exactly similar to the changes that occur following separate surgeries on the two jaws (9). However, in this study we focused on soft tissue changes that occur following monomaxillary surgeries. In another research, Gjørup et al. (1991) reported significant associations between hard tissue and soft tissue changes in the sagittal plane (3). Changes that occur following mandibular setback surgery have demonstrated significant improvement in facial dimensions. They concluded that skeletal and soft tissue profile became straight and posture of lips improved. Also, it was demonstrated that a normal relationship between upper and lower incisors achieved by surgery can affect the covering soft tissue and lead to improved lip competence and posture (3).

In evaluation of upper lip changes, Altug-Atac et al, in 2008 reported that the greater effect of bimaxillary surgery on the upper lips is due to the closer distance of upper lip to the surgical site and therefore, scarring of the surgical incision site during the period of wound healing has a greater effect on the upper compared to the lower lip and chin (9). However, it seems that change in the upper lips following mandibular surgery, despite no movement of maxillary hard tissue, is due to the contraction of orbicularis oris and soft tissue traction (15). In some studies using Pearson's correlation coefficient, it has been shown that the thickness of upper and lower lips and soft tissue of the chin are affected by the primary and presurgical thickness of these areas. Posture of the upper and lower lips also play a role in this respect (3). The relation of incisors before the surgery is also considered a pseudoposition because has been somehow compensated (3, 14). Gjørup et al, in 1991 stated that the upper lip becomes flat following bilateral vertical ramus osteotomies (3) which is in accord with the findings of previous studies (15). Results of Chunmaneechote et al, in 1999 also demonstrated a reduction in the thickness of upper lip following mandibular setback surgery (16) which is in agreement with the present findings. On the other hand, in the present study, following BSSO Nasolabial angle and length of SLs-A reduced while the length of Ls-Pr increased. These three variables all showed significant differences with the baseline values at T1 and indicated an increase in the thickness of upper lip in patients who received BSSO. Also, increased G-Ls after surgery is in accord with the recent findings. On the other hand, in subcondylar surgery group, Nasolabial angle (a2) and length of SLs-A increased whereas length of Ls-Pr decreased which is completely in contrast to the findings in our other group and indicates a reduction in lip thickness in these patients. This finding has been mentioned in previous studies as well (3, 16). Thus, it seems that in patients with adequate lip thickness, subcondylar surgery does not cause any problem but in cases with low thickness of lips, BSSO will be a better option.

In evaluation of lower lip and chin area, it should be mentioned that the lower lip morphologically is different from other soft tissue landmarks and is directly affected by movement of upper and lower incisors, perioral muscles, and underlying muscular attachments. Its thickness and tonicity are also different among different individuals. In the present study, lower lip thickness increased following both types of osteotomies which is in accord with the results of Chunmaneechote and Friede (1999)(16). However, this increase in BSSO was significantly greater than in subcondylar surgery. Some researchers did not find any change in lower lip thickness following mandibular setback surgery and only mentioned an insignificant increase in the chin area (7). Yu-Jin Jung et al, in 2009 stated that changes in the chin area are markedly greater than those of the lower lip. These findings show that the lower lip is more affected by the muscles than bone (15). However, Chunmaneechote and Friede (1999) reported an increase in thickness of lower lip after mandibular setback surgery (16). Chin thickness showed a significant increase after subcondylar surgery when comparing T1 and T2 but no increase was observed in this respect following BSSO. No significant difference was detected between the two surgeries in terms of change in chin thickness. More prominent lips are more favorable for women and more retruded lips, and more prominent nose and chin are more favorable for men (17, 18). Also, physical appearance is an important factor in determining people's position in the community. Thus, considering the study results and the above mentioned points, BSSO surgery seems to offer more favorable results in terms of patients' lip posture.

In terms of lower facial height, the study results showed that lower facial height decreased in BSSO and increased in the subcondylar groups. This finding is similar to that of Jung et al, in 2009. They noticed mandibular movement along the maxillary occlusal plane as well as the posterior and superior movement of chin following BSSO surgery which resulted in a reduction in lower facial height (15). However, this result is not in concord with the result of Gjørup et al, study (1991) who did not report any change in the anterior facial height (3).

In our study, the facial angle in the two groups significantly decreased following surgery. It is obvious that mandibular setback surgery brings such outcome. However, this reduction was significantly greater in the subcondylar surgery group compared to BSSO which can be due to the clockwise rotation of mandible in patients that have undergone subcondylar surgery. In conclusion, following BSSO, a counter clockwise rotation occurs in the mandible. Considering the small sample size, a clinical trial is recommended to be performed on a larger sample size.

Conclusion:

Assessment of soft tissue changes following subcondylar surgery and BSSO revealed that following BSSO, lips became more prominent while increased lower facial height and mentocervical angle after subcondylar surgery were indicative of a shift towards a straight facial profile. Overall, it may be stated that from the esthetics point of view, the outcome of BSSO is more favorable than that of subcondylar surgery in improving patients' facial profile.

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