Stability of Soft Tissue Profile After Mandibular Setback in Sagittal Split Osteotomies: A Longitudinal and Long-Term Follow-Up Study

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Purpose: The aim of the study was to conduct a long-term prospective follow-up on the stability of soft tissues after bilateral sagittal split osteotomy (BSSO) with rigid internal fixation to set back the mandible.

Patients and Methods: Seventeen consecutive patients (6 females, 11 males) were re-examined 12.7 years (T5) after surgery. The precedent follow-ups included: before surgery (T1), 5 days (T2) after surgery, 6.6 months (T3) after surgery, and 14.4 months after (T4) surgery. Lateral cephalograms were traced by hand, digitized, and evaluated with the Dentofacial Planner program (Dentofacial Software, Toronto, Canada). The x-axis for the system of coordinates ran through Sella (point 0) and the line NSL −7°.

Results: The net effect of the soft tissue chin (soft tissue pogonion) was 79% of the setback at pogonion. At the lower lip (labrale inferior) it was 100% of the setback at lower incisor position. Point B′ followed point B to 99%. Labrale inferior and menton′ also showed a significant backward, as well as a downward, movement (T5 to T2). Gender correlated significantly ($P = .004$) with the anterior displacement of point B′ and pogonion′ ($P = .012$). The soft tissue relapse 12.7 years after BSSO setback surgery at point B′ was 3% and 13% at pogonion′.

Conclusion: Among the reasons for 3-dimensional long-term soft tissue changes of shape, the surgical technique, the normal process of human aging, the initial growth direction, and remodeling processes must be considered. Growth direction positively influenced the long-term outcome of setback surgery in female compared with male patients because further posterior movement of the mandibular soft tissue occurred.

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The bilateral sagittal split osteotomy (BSSO) was first introduced by Trauner and Obwegeser,[1,2] and has gained much popularity, especially when combined with rigid internal fixation (RIF). Several modifications of the BSSO have been proposed.[3-6] Orthognathic surgery has an effect on maxilla-mandibular function, the neurosensibility of the operated mandible or maxilla, the influence on hard tissue stability, and the facial esthetics of the patient.

The prognathic patient seeks help primarily in combined orthodontic–orthognathic procedures to improve his or her facial esthetic. Accurate prediction of the postoperative facial profile should be an essential part of the diagnostic and treatment-planning procedure of the combined surgical–orthodontic therapy.

Compared with mandibular advancement after BSSO with RIF, the same procedure with isolated mandibular setback and its influence on the soft tissue profile has not been widely reported. Schatz and Tsimas[7] observed 13 patients 1 year after BSSO setback surgery and RIF without genioplasty. They concluded that soft tissue points followed the postoperative anterior displacement (relapse) of the hard tissue to the same extent ($P < .01$). point B′ and pogonion′ fol-

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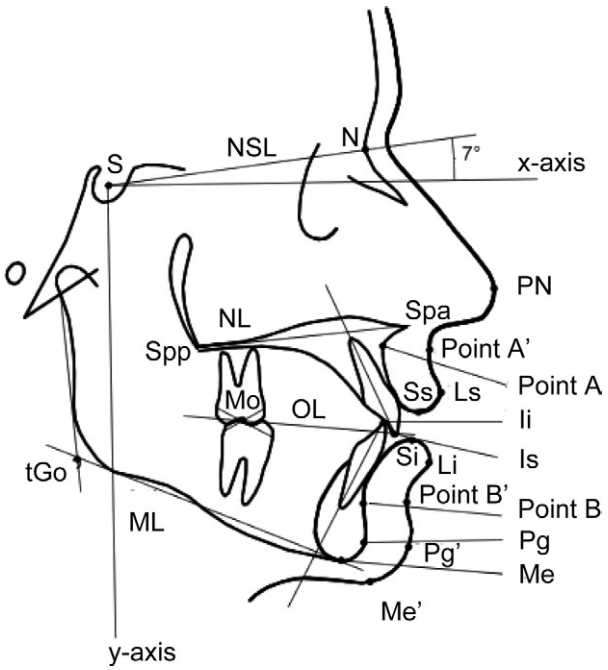

FIGURE 1. Reference points and lines used in the cephalometric analysis. Ii, lower incisor position; ILs, upper incisal line; Is, upper incisor position; Li, Labrale inferior; Ls, labrale superior; Me, menton, Me', soft tissue menton; ML, mandibular line; Mo, molar; N, nasion; NL, nasal line; NSL, nasion-Sella-line; OL, occlusal line; Pg, pogonion; Pg', soft tissue pogonion; PN, pronasion; S, Sella; Si, stomion inferior; Spa, spina nasalis anterior; Spp, spina nasalis posterior; Ss, stomion superior; tGo, tangent gonion; x, horizontal reference plane; y, vertical reference plane.

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lowed their corresponding hard tissue to 108% and 128%, respectively. The lower lip was 90% of the setback of the mandibular incisor.

The effects on facial profile and the relationship between hard and soft tissue changes have been documented by Gaggl et al.[8] They examined 60 patients for mandibular setback and wire fixation 12 to 16 weeks after BSSO. The soft tissue pogonion followed the underlying hard tissue pogonion to 83.9%; the Labrale inferior followed the lower incisor position to 83.4%.

A combination of a Le Fort I osteotomy of the maxilla and a BSSO of the mandible seems to be the current trend for skeletal Class III treatment.[9-11] In a review of a surgical–orthodontic database, Bailey et al[9] showed that before 1985, 50% of all cases were treated by isolated mandibular setback, whereas only 15% underwent maxillary advancement. One third had 2-jaw surgery. From 1990 to 1992, isolated mandibular setback was performed in 10%, whereas 40% had maxillary advancement, and 50% had 2-jaw surgery.

The aim of the present study was to evaluate the long-term effect of mandibular setback with BSSO and RIF on the soft tissue profile.

Patients and Methods

As a continuation of our recent study,[12] 17 consecutive patients (6 females, 11 males), aged 18.9 to 40.5 years (mean age, 27.1 years), who underwent a solitary mandibular setback procedure at the Department of Craniomaxillofacial Surgery, University of Bern, in the years 1986 to 1989 were studied prospectively.

The patients had a moderate or marked dental and skeletal Class III that was corrected with a BSSO of the mandible and RIF. The sagittal splits were fixed with 3 titanium lag screws (3.5-mm diameter) on each side. None of the patients underwent genioplasty. The surgery was carried out by 1 of 4 senior surgeons of the department, and the patients were referred to the department by various orthodontists. The surgical technique[13] was the same for all patients, and each of the surgeons was experienced in this procedure. No splint was used for stabilization of the mandible during the surgery, but the patients were subjected to maxillomandibular fixation for 4 to 8 days after surgery.

The soft tissue changes brought about by the surgical procedure and their stability were evaluated

Table 1. ACCIDENTAL ERRORS (SI) OF THE CEPHALOMETRIC ANALYSIS

Variable	Si (°)	Reference Point (Skeletal)	*Si* (mm)		Reference Point (Soft Tissue)	*Si* (mm)	
			x	y		x	y
SNA	0.57	N	0.56	0.08	PN	0.38	0.47
SNB	0.34	Point A	0.83	0.52	Point A′	0.47	1.44
ANB	0.57	Point B	0.66	0.96	Labrale superior	0.62	0.74
NL/NSL	0.82	Upper incisor position	0.57	0.52	Labrale inferior	0.47	0.70
ML/NSL	0.45	Lower incisor position	0.52	0.30	Stomion superior	0.86	0.55
ML/NL	0.89	Pogonion	0.84	0.82	Stomion inferior	0.71	0.62
N-Spa	0.58	Menton	0.72	0.42	Point B′	0.71	0.74
Spa-Me	0.54	tGonion	1.09	0.32	Pogonion′	0.86	0.85
N-Me	0.37	Spa	0.69	0.59	Menton′	2.09	0.75
S-tGo	0.30	Spp	0.63	0.48			

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with profile cephalograms. The cephalograms were taken with the same machine, and the teeth were in the intercuspal position and included a linear enlargement of 3.3%. The cephalograms were taken with the subject standing upright and trying to assume a natural position of the head and relaxed lips.

The cephalogram at T1 was taken 0 to 5 days (mean, 1 day) before surgery, the second (T2) between 3 and 9 days (mean, 5 days), at T3 between 4.2 and 9.7 months (mean, 6.6 months), at T4 between 11.5 and 18.7 months (mean, 14.4 months), and at T5 between 11.1 and 14.0 years (mean, 12.7 years) after surgery.

The cephalometric analysis was carried out by 1 examiner (C.U.J.) and included the reference points and lines shown in Figure 1. The cephalogram was then traced by the same examiner and the reference points were digitized with the Dentofacial Planner (Dentofacial Software, Toronto, Canada). The author (C.U.J.) was blind to the degree of mandibular setback and the date of the postoperative radiograph. Conventional cephalometric variables as well as the coordinates of the reference points (Table 1) were calculated by computer. The coordinate system had its origin at the point s (Sella), and its x-axis formed an angle of 7° with the reference line NSL (Fig 1). The tracings of the different stages were superimposed on the first radiograph, and the reference lines were transferred to each consecutive tracing. During superimposition, particular attention was given to fitting the tracings of the cribriform plate and the anterior wall of the Sella turcica. These are areas that undergo minimal remodelling.[14]

The systematic and accidental errors of the cephalometric analysis were evaluated by duplicate determinations of 11 cephalograms selected at random. This cephalograms were retraced and remeasured for a second time by the same examiner 2 weeks 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 with the formula

$$si = \sqrt{\frac{\sum d^2}{2n}}$$

where d is the difference between the repeated measurements and n is the number of duplicate determinations.[15] Most of the angular variables and coordinates of the skeletal reference points had accidental errors less than 1.0 degree or 1.0 mm, respectively. Errors are given in Table 1.

STATISTICAL METHODS

The effect of the treatment (ie, the differences between the variables and coordinates on the occasions T1 and T2, T4 and T5, T2 and T5, as well as T1 and T5) were tested with the Wilcoxon's matched-pairs, signed-rank test. To increase the level of significance, Bonferroni adjustments were carried out on the P value. Relationships between variables were analyzed with the Spearman rank correlation coefficient.

Results

Table 2 shows selected variables before (T1) and 12.7 years after surgery (T5). The mean changes, standard deviations, and ranges in selected cephalometric parameters before surgery and during subsequent observation periods are given in Tables 3 and 4. Negative values imply a backward movement and positive values imply a forward movement of the point in the horizontal plane. Negative values imply an upward movement and positive values imply a

Table 2. VALUES OF SELECTED CEPHALOMETRIC VARIABLES BEFORE SURGERY (T1) AND 12.7 YEARS AFTER SURGERY (T5)

	Mean	SD	Range
T1			
SNA (°)	78.30	5.09	69.1-90.0
SNB (°)	83.18	5.95	93.7-71.0
ANB (°)	−4.88	4.02	−11.7-2.2
NSL/NL (°)	7.99	5.05	−2.7-18.6
NSL/ML (°)	34.05	8.06	21.6-48.8
NL/ML (°)	26.08	7.73	15.5-37.2
Gonion angle (°)	131.32	6.22	120.0-141.3
Anterior facial height (N-Me) (mm)	124.61	11.39	97.3-147.4
Upper facial height (N-Spa) (mm)	52.18	4.15	44.6-61.2
Lower facial height (Spa-Me) (mm)	73.32	9.61	52.7-93.9
Posterior facial height (S-tGo) (mm)	82.49	10.85	65.3-100.9
Overjet (mm)	−3.15	3.99	−11.3-2.0
Overbite (mm)	1.42	2.65	−1.9-8.1
T5			
SNA (°)	78.78	5.05	68.2-88.1
SNB (°)	79.74	5.58	69.0-89.8
ANB (°)	−0.95	2.59	−5.0-3.1
NSL/NL (°)	9.13	4.88	1.8-20.2
NSL/ML (°)	34.49	8.49	50.3-21.9
NL/ML (°)	25.36	8.16	15.1-40.1
Gonion angle (°)	126.45	7.70	114.3-139.6
Anterior facial height (N-Me) (mm)	124.14	10.20	99.2-144.1
Upper facial height (N-Spa) (mm)	52.59	4.05	45.3-62.1
Lower facial height (Spa-Me) (mm)	72.61	8.12	54.0-89.1
Posterior facial height (S-tGo) (mm)	81.18	10.93	59.3-101.8
Overjet (mm)	2.20	1.70	−0.5-5.8
Overbite (mm)	2.67	0.81	1.3-4.3

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Table 3. CHANGES OF THE COORDINATES OF THE LOWER LIP AND THE SOFT TISSUES OF THE LOWER FACE

	T1-T2				T4-T5			
Variable or Coordinate	Mean	*P*	SD	Range	Mean	*P*	SD	Range
Horizontal (x-value [mm])								
Labrale superior	1.02	ns	1.63	−2.2-3.4	−1.76	*	1.75	−4.6-2.9
Labrale inferior	−3.08	*	3.52	−8.9-2.7	−0.53	ns	2.22	−6.1-2.1
Point B′	−5.58	†	4.30	−13.0-0.8	0.43	ns	2.61	−4.6-4.2
Pogonion′	−5.19	*	5.34	−13.6-3.0	0.38	ns	3.10	−5.9-4.7
Menton′	−5.19	*	6.55	−15.2-8.6	−1.68	ns	4.14	−12.8-4.1
Vertical (y-value [mm])								
Labrale superior	0.56	ns	1.33	−2.5-2.9	0.46	ns	2.17	−3.9-3.8
Stomion superior	1.79	‡	1.78	0.1-5.7	0.57	ns	1.98	−3.2-4.6
Stomion inferior	1.72	ns	2.64	−3.8-6.5	0.67	ns	2.01	−2.8-3.8
Labrale inferior	3.92	†	3.50	−3.9-9.9	−0.37	ns	3.09	−6.2-5.9
Point B′	0.92	ns	3.04	−4.1-7.6	0.01	ns	3.10	−4.9-6.1
Pogonion′	0.07	ns	2.83	−6.2-4.6	2.24	ns	3.89	−5.3-8.3
Menton′	0.86	ns	2.64	−3.4-5.9	0.83	ns	2.76	−3.6-8.6

Bonferroni adjustments (*P*/n, n = 4).
*$P \leq .0125$.
†$P \leq .0025$.
‡$P \leq .00025$.

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downward movement of the point in the vertical plane.

SKELETAL CHANGES

Amount and Changes of Horizontal Skeletal Changes

The skeletal changes were discussed previously.[16] The mean setback of the mandible right after surgery (T1-T2) was 6.29 mm at point B, 6.97 mm at pogonion, and 6.98 mm at lower incisor position. At 12.7 years after surgery, the mean relapse (T2-T5) at point B was 0.94 mm and nonsignificant ($P = .124$). It represented 15% of the surgical setback. The mean relapse at pogonion (T2-T5) was 1.46 mm and nonsignificant ($P = .07$). It represented 21% of the surgical setback. The mean relapse (T2-T5) at lower incisor position was nonsignificant with 1.67 mm ($P = .023$) or 24% of the surgical setback (T1-T2).

Table 4. CHANGES OF THE COORDINATES OF THE LOWER LIP AND THE SOFT TISSUES OF THE LOWER FACE

	T2-T5				T1-T5			
Variable or Coordinate	Mean	*P*	SD	Range	Mean	*P*	SD	Range
Horizontal (x-value [mm])								
Labrale superior	−4.14	‡	2.43	−8.6- −0.7	−3.12	†	2.35	−7.8-1.4
Labrale inferior	−2.89	‡	2.45	−7.8-0.2	−5.97	‡	3.58	−11.3-0.2
Point B′	0.16	ns	2.82	−5.8-4.8	−5.42	†	4.08	−11.6-0.9
Pogonion′	0.67	ns	3.75	−7.6-6.2	−4.52	*	5.48	−14.2-5-3
Menton′	−2.34	ns	4.49	−10.3-6.4	−7.54	†	7.11	−20.1-5.4
Vertical (y-value [mm])								
Labrale superior	1.78	*	2.16	−1.8-6.1	2.34	†	2.19	−1.4-6.0
Stomion superior	1.09	ns	1.84	−2.2-5.1	2.89	†	2.69	−2.1-8.0
Stomion inferior	0.69	ns	2.61	−5.3-4.9	2.42	*	3.09	−2.7-8.1
Labrale inferior	−2.10	ns	4.28	−10.8-4.5	1.82	ns	3.63	−3.9-7.8
Point B′	−0.25	ns	3.24	−5.2-5.7	0.68	ns	4.09	−7.3-8.0
Pogonion′	1.74	ns	4.37	−7.6-10.2	1.81	ns	4.78	−7.5-13.2
Menton′	−0.38	ns	2.39	−4.5-7.1	0.49	ns	2.98	−2.8-10.0

Bonferroni adjustments (*P*/n, n = 4).
*$P \leq .0125$.
†$P \leq .0025$.
‡$P \leq .00025$.

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SOFT TISSUE CHANGES

Amount and Changes of Horizontal Soft Tissue Changes

The postsurgical change (T2-T5) of labrale superior showed a significant posterior movement of 4.14 mm ($P = .000$). The posterior movement at T1-T5 was 3.12 mm and significant ($P = .001$). Labrale inferior had a significant posterior movement of 2.89 mm ($P = .000$) in the period T2-T5. Thus the final result (T1-T5) showed a significant decrease of 5.97 mm ($P = .000$).

Both point B′ (0.16 mm, $P = .619$) and pogonion′ (0.67 mm, $P = .407$) moved nonsignificantly anteriorly in the period T2-T5. The final result (T1-T5) was significant for point B′ (5.42 mm, $P =$. 001) and pogonion′ (4.52 mm, $P = .005$) in a posterior manner.

The change in labrale inferior was 100% of the setback at lower incisor position at T5. The corresponding values for point B′ to point B and pogonion′ to pogonion were 99% and 79% at T5.

The soft tissue change (T2-T5) compared with the initial setback (T1-T2) at point B′ was 3% and 13% at pogonion′.

Amount and Changes of Vertical Soft Tissue Changes

The postsurgical change (T2-T5) of labrale superior showed a significant ($P = .007$) downward movement of 1.78 mm. This was significant ($P = .001$) with 2.34 mm at T1-T5. Stomion superior also moved nonsignificantly ($P = .026$) downward by 1.09 mm in the period T2-T5. It still remained significantly ($P = .002$) downward (2.89 mm) at the final result (T1-T5).

Stomion inferior moved as well nonsignificantly ($P = .193$) downward by 0.69 mm in the period T2-T5. At T1-T5 a significant ($P = .008$) downward movement of 2.42 mm was seen. Menton showed a nonsignificant ($P = .381$) upward movement of 0.38 mm (T2-T5). At T1-T5, there was a nonsignificant ($P = .795$) downward movement of 0.49 mm.

Correlations

No significant correlations were found for the age of the patients and relapse at any time. Relapse (T2-T5) at lower incisor position (x-value) did not correlate ($R = 0.335$, $P = .189$) with relapse at labrale inferior (x-value). Relapse (T2-T5) at point B (x-value) correlated significantly ($R = 0.907$, $P = .000$) with relapse at point B′ (x-value). The same correlation ($R = 0.860$, $P = .000$) was seen for relapse (T2-T5) at pogonion (x-value) with pogonion′ (x-value).

The gender correlated significantly ($R = -0.654$, $P = .004$) with the relapse (T2-T5) of point B′ (x-value), ie, females in contrast to males showed even further posterior movement of the soft tissue instead of anterior movement or horizontal stability in the period T2-T5. The x-values of pogonion′ ($R = -0.591$, $P = .012$) and labrale inferior ($R = -0.617$, $P = .008$) showed similar correlations.

Discussion

Isolated mandibular prognathism occurs only in 20% to 25% of all Class III patients.[17] That means that 75% of the Class III patients have some degree of maxillary skeletal deficiency. Thus trends in orthognathic surgery lean more toward solitary maxillary Le Fort I or bimaxillary surgery to correct skeletal Class III patients.[9] The achieved esthetic result (ie, a flat profile and a stretched soft tissue) is the major concern of the surgeon, orthodontist, and patient. The fact that these prospectively studied 17 patients had solitary BSSO setback surgery makes this long-term sample unique in literature.

The y-value of labrale superior underwent an interesting change with years. A continuous lengthening of labrale superior was seen, even though surgery provided support of the upper lip by the lower lip through contact. The mean increased significantly in the period T2-T5 by 1.78 mm. The x-value moved in the same time span highly significantly posteriorly by 4.14 mm. This also was shown in other studies.[18-24] This posterior movement could be due partly to the removal of brackets after surgery. The lengthening and a part of the posterior movement of labrale superior can be attributed to the lack of soft tissue strength with age.

It is likely that the upper lip, because of the abnormal incisal relationship before surgery, was kept in a "pseudoposition" as a form of adaptation and compensation.

The mean of labrale inferior (x-value) moved significantly posteriorly by 2.89 mm in the period T2-T5. The authors assume that the healing of the trauma after surgery was connected with a swelling around the lips as well as soft tissue remodeling and the removal of orthodontic devices. A further nonsignificant posterior movement of 0.53 mm in the period between T4 and T5 is probably due to a lack of tissue strength with increased age.

The vertical length (y-value) of labrale inferior moved (T1-T2) significantly upward by 3.92 mm probably due to postoperative swelling. The period T2-T5 showed the same pattern as at labrale superior with a non-significant downward movement of 2.10 mm due to a possible lack of tissue strength.

Another way to quantify the effect of surgery on the soft tissue is to measure the distance between the soft tissue and its underlying bony structures. In the

present study, point B′ followed point B to 99%, pogonion′ followed pogonion to 79%, and labrale inferior followed lower incisor position to 100%. Only a few studies that examined the soft tissue changes after BSSO and mandibular setback are found in the literature.[7,8,12,17,19-22,24-26]

Published values for different types of mandibular setback surgery with RIF or WF include: point B′ to point B, between 87% and 112%; pogonion′ to pogonion, between 75% and 107%; and labrale inferior to the lower incisor position, between 66% and 132%.[7,8,12,17,19-22,24-26] The postoperative follow-ups in these studies were from immediately after surgery to 14 months after surgery. Long-term follow-ups are lacking entirely. A lack of precision in the literature gives testimony to the possible unpredictability of postoperative lip position after different types of mandibular setback surgery. Further research in this field, especially for BSSO with RIF for mandibular setback, is needed.

Recently Chou et al[25] examined retrospectively a group of 64 patients with BSSO without genioplasty and RIF 1 year after surgery. They found that soft tissue pogonion′ followed pogonion to 87.5%.

Labrale inferior in mandibular advancement and setback patients seems to behave differently. In mandibular advancement labrale inferior follows to 60%[26-28] and in setback to 90%. A different pattern for advancement and setback patients at point B′ and pogonion′ cannot be seen.

The y-value for soft tissue menton did not change significantly in the postsurgical period T2-T5 (by 0.38 mm). The surgical net effect (T1-T5) was 0.49 mm. This goes more or less with the findings of Behrents.[29,30] He described a forward and downward movement of menton′ and pogonion′ with age.

It is evident that mandibular advancement surgery has a positive "lifting-effect" of the soft tissue on the profile due to its stretching. Unfortunately, setback surgery leads to a compression of soft tissues due to the shortening of mandibular bone length. This relative increase of soft tissue could lead to a double-chin, relative deepening of the mentolabial-fold, loss of tissue strength, and in consequence, to premature ageing of the face. The decrease in the size of the oropharynx due to mandibular setback surgery also can lead to a prominence of the tongue mass in the floor of the mouth. This could lead to increased pressure in a forward direction of the mandible. On the other hand, Weinstein et al[31] supported the explanation for distribution of soft tissue in a transverse dimension.

The analysis of the correlations between different variables showed that gender correlated very significantly ($R = -0.654$, $P = .004$) with the change (T2-T5) of point B′ (x-value). Females, in contrast to males, showed even further posterior movement of the soft tissue instead of anterior movement or horizontal stability in T2-T5. Similar correlations were seen for the x-value of pogonion′ ($R = -0.591$, $P = .012$) and labrale inferior ($R = -0.617$, $P = .008$). Our recent study[16] showed similar correlations for the hard tissue points, ie, gender correlated very significantly ($P = .002$) with the x-value at point B (T2-T5) and lower incisor position ($P = .010$). Age or the amount of setback did not correlate with any variable.

This could be due to the fact, as shown by Behrents,[29,30] that the chin and the surrounding soft tissue in female patients is likely to grow downward but not backward or forward. Remaining growth and remodeling processes in male patients let the chin grow downward and forward. The mandible rotates anteriorly in males and posteriorly in women.

Forsberg[32] carried out a longitudinal study of facial growth over a 10-year period in 49 subjects between 24 and 34 years of age. He found a forward movement of the nose and a retrusion of the lips. A posterior movement of soft tissue pogonion′ similar to the one that took place in the underlying hard tissue pogonion could be measured only in females. He pointed out that a close relationship between the changes of soft tissue and underlying hard tissue could not be expected. The soft tissues are also subject to the influence of tension of the oral muscles and the amount of subcutaneous fat present at different ages.

In the long term, point B′ followed point B to 99%, pogonion′ followed pogonion to 79%, and labrale inferior followed the lower incisor position to 100%.

The soft tissue relapse 12.7 years after BSSO setback surgery at point B′ was 3% and 13% at pogonion′.

Among reasons for 3-dimensional long-term soft tissue changes of shape, the surgical technique, the normal process of human aging, the initial growth direction and remodeling processes must be considered. Growth direction positively influenced the long-term outcome of setback surgery in female compared with male patients because further posterior movement of the mandibular soft tissue occurred.

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