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Soft tissue stability after segmental distraction of the anterior mandibular alveolar process: a 5.5 year follow-up

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Abstract. Soft tissue changes were analysed retrospectively in 17 patients following distraction osteogenesis (DO) of the mandibular anterior alveolar process. Lateral cephalograms were traced by hand, digitized, superimposed, and evaluated at T1 (17.0 days), after DO at T2 (mean 6.5 days), at T3 (mean 24.4 days), at T4 (mean 2.0 years), and at T5 (mean 5.5 years). Statistical analysis was carried out using Kolmogorov–Smirnov test, paired *t*-test, Pearson's correlation coefficient, and linear backward regression analysis. 5.5 years postoperatively, the net effect for the soft tissue at point B′ was 88% of the advancement at point B while the lower lip (labrale inferior) followed the advancement of incision inferior to 24%. Increased preoperative age was correlated ($p < 0.05$) with more horizontal backward movement (T5–T3) for labrale inferior and pogonion′. Higher NL/ML′ angles were significantly correlated ($p < 0.05$) to smaller horizontal soft tissue change at labrale inferior (T5–T3). The amount of advancement at point B was significantly correlated with an upward movement (T5–T3) of labrale inferior ($p < 0.01$) and stomion inferior ($p < 0.05$). It can be concluded that further change in soft tissues occurred between 2.0 and 5.5 years postoperatively. The physiological process of ageing and loss of soft tissue elasticity should be considered as possible reasons.

Keywords: distraction osteogenesis; soft tissue stability; soft tissue to hard tissue ratio; soft tissue change; cephalometry; mandibular advancement.

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The combination of orthodontic treatment and maxillofacial surgery aims to provide optimal function and the best aesthetic results for the patient. The clinician needs precise information to increase his ability to predict the surgical effect of skeletal displacement on the patient's overlying soft tissue profile. Commonly, in a two-dimensional analysis the amount of change necessary to provide appropriate soft tissue profile change by maxillofacial surgery is determined by the use of ratios between the soft tissues and the underlying skeletal and dental base.

Little is known about the effect of mandibular DO on the change in shape and position of the soft tissue profile[1–3] when compared with bilateral sagittal split osteotomy (BSSO) for mandibular advancement.[4–9] Commonly used lateral cephalograms can only reproduce a two-dimensional pre- and postoperative situation whereas in recent years there has been a trend in quantifying soft tissue profile

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changes using three-dimensional evaluation (i.e. optical laser surface scanners,[10] stereophotogrammetry with cameras,[11] or computed tomography assisted imaging[12]).

Recently, skeletal and soft tissue changes 2 years after DO of the anterior mandibular alveolar segment have been examined.[2,13,14] The net effect of the soft tissue at point B′ was 100% of the advancement at point B while the lower lip (labrale inferior) followed the advancement of incision inferior to 46% examined 2.0 years postoperatively.[13] Skeletally, 5.5 years after DO the horizontal backward relapse measured −0.3 mm or 8.3% at point B and −1.8 mm or 29.0% at incision inferior.[14] To the authors' knowledge, evaluation of the soft tissue profile and its change in the long-term is lacking. The aim of the present study was to evaluate soft tissue changes 5 years after treatment in adult patients treated with DO of the anterior mandibular alveolar process and to relate it to different parameters.

Materials and methods

The study represents a follow-up of an initial sample of 33 patients published previously.[2,13] The initial patient sample consisted of 33 Caucasian patients (27 females and six males) aged 16.5–56.0 years (mean age 30.3 years, SD 10.7). Of these 33 patients, 17 patients could be re-examined. The follow-up group (T1) consisted of 17 Caucasian patients (14 females and three males); aged 16.5–56.0 years (mean age 29.8 years, SD 11.9). Ethical approval was obtained from the ethic committee of the Kanton Zürich, Switzerland (number 593). All subjects gave written, informed consent.

All patients were treated orthodontically by one orthodontist (MA) and underwent DO of the anterior mandibular alveolar process to correct a skeletal Class II and large overjet with or without incisor crowding at the Pyramide Clinic in Zürich, Switzerland in the years 1998–2004. The female patients in the follow-up group had a mean age of 31.7 years (17.1–56.0 years, SD 12.0 years) and the male patients 21.5 years (16.5–31.4 years, SD 8.6 years) at T1. The surgical procedure was performed by one experienced maxillofacial surgeon (AT); the technique has been published previously.[15,16] Patients receiving other surgical procedures simultaneously on the mandible and maxilla, such as genioplasty, BSSO, and Le Fort, were excluded. Syndromic or medically compromised patients were excluded. Five cephalograms were taken: the first on average 17.0 days before surgery (T1); the second (T2) between 0 and 12 days (mean 6.5 days) after the osteotomy and before any distraction was carried out; the third (T3) between 13 and 92 days (mean 24.4 days); the fourth (T4) between 0.9 and 3.7 years (mean 2.0 years), and the fifth (T5) between 2.7 and 8.3 years (mean 5.5 years) after distraction of the anterior mandibular alveolar process. The distraction was completed at T3 and the orthodontic treatment at T4. The position of the lower incisors was retained with a bonded only on canine to canine retainer. The DO procedure has been described previously.[15,16]

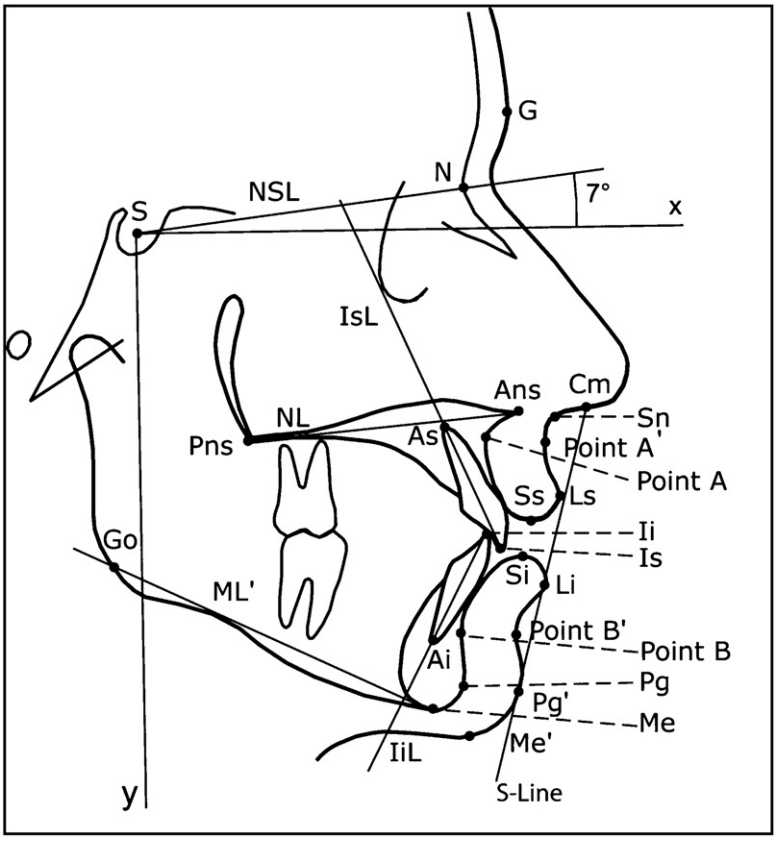

Fig. 1. Reference points and lines used in the cephalometric analysis. The coordinate system had its origin at point S (sella), and its *x*-axis formed an angle of 7° with the reference line NSL. G, glabella; S, sella; NSL, nasion-sella-line; N, nasion; *x*, horizontal reference plane; NL, nasal line; Cm, columella; Sn, subnasale; ILs, upper incisal line; Ans, anterior nasal spine; Pns, posterior nasal spine; As, apex superior; point A; point A′, soft tissue point A; Ls, Labrale superior; Ss, stomion superior; Ii, incision inferior; Is, incision superior; Si, stomion inferior; Li, labrale inferior; Go, gonion; ML′, mandibular line prime; Ai, apex inferior; point B; point B′, soft tissue point B; Pg, pogonion; Pg′, soft tissue pogonion; Me, menton; Me′, soft tissue menton; S-Line; and *y*, vertical reference plane.

Cephalometric analysis

Soft tissue changes were evaluated on profile cephalograms taken with the teeth in the intercuspal position, and including a linear enlargement of 1.2%. The cephalograms were taken with the subject standing upright in the natural head position and with relaxed lips. The same X-ray machine and the same settings were used to obtain all cephalograms.

The lateral cephalograms were scanned and evaluated with the Viewbox 3.1® program (dHal software, Kifissia, Greece). The conventional cephalometric analysis for T1, T2, T3, T4, and T5 was carried out by one author (CUJ) and included the reference points and lines shown in Fig. 1. Horizontal (*x*-values) and vertical (*y*-values) linear measurements were obtained by superimposing the tracings of the different stages (T2, T3, T4 and T5) on the first radiograph (T1), 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 which undergo minimal remodelling.[17]

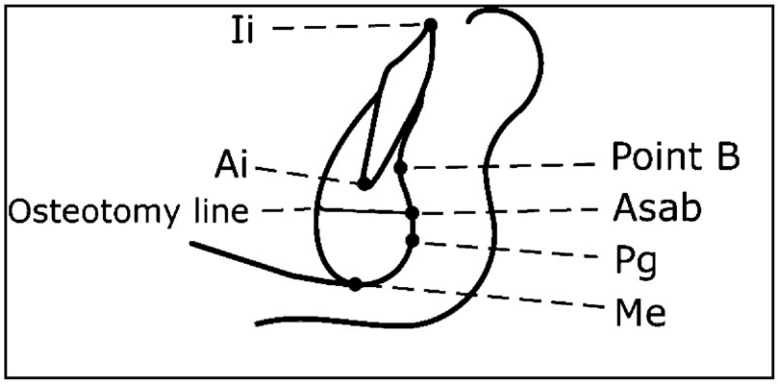

Fig. 2. Reference points used in the cephalometric analysis of the lower apical base in DO patients. Ii, incision inferior; point B; Ai, apex inferior; Asab, apical surgical anterior base; Pg, pogonion; and Me, menton. Asab is the most anterior and inferior point of the lower anterior segment resulted by the surgical osteotomy; the reason for its introduction is given in the text.

A template of the outline of the mandible of the preoperative cephalogram (T1) was made to minimize errors for superimposing on subsequent radiographs.

Conventional cephalometric variables as well as the coordinates of the reference points were calculated by the computer program. The coordinate system had its origin at point S (Sella), and its x-axis formed an angle of 7° with the reference line NSL (Fig. 1). Overjet and overbite were calculated from the coordinates of the points Is (incision superior) and Ii (incision inferior).

The lateral cephalograms of T2 were only used to locate the cephalometric point, called the alveolar surgical anterior base (Asab) before postoperative distraction of the alveolar process was carried out. Asab is the most anterior and inferior point of the lower anterior segment resulting from the surgical osteotomy (Fig. 2). This cephalometric point was introduced to evaluate the movement (rotation vs. translation) of the lower anterior segment base in comparison to the lower incisors as the ratio $\frac{\text{Ii}(x\text{-value, T3}-\text{T2})}{\text{Asab}(x\text{-value, T3}-\text{T2})}$

Error of the method

To determine the error of the method, 21 randomly selected cephalograms were retraced and re-analysed after a 2 week interval. Horizontal (x-values) and vertical (y-values) linear measurements were reobtained by superimposing the tracings of the different stages (T2, T3, T4 and T5) on the first radiograph (T1). The error of the method (si) was calculated with the formula $si = \sqrt{\sum d^2/2n}$ where d is the difference between the repeated measurements and n is the number of duplicate determinations.[18]

Statistical analysis

Statistical analyses were conducted using SPSS software (version 19.0, SPSS Inc., Chicago, IL, USA). Normal distribution was confirmed with the Kolmogorov–Smirnov test. The effect of treatment (i.e. the differences between the variables and co-ordinates at T3 and T1, T5 and T1, T5 and T3, T5 and T4) was tested with a paired t-test. The relationships between soft tissue and skeletal variables, age, and gender were analysed with the Pearson's product moment correlation coefficient and linear backward regression analysis. The drop-out analysis included the unpaired t-test to compare drop-outs with the remaining patients for age and cephalometric features at T1, T2, T3 and T4, and the χ^2 test for gender and age.

Results

Error of the method and drop-out analysis

The random errors are presented in Table 1. The measurement of the nasiolabial angle (Cm–Sn–Ls) and menton′ (x-value) were excluded due to the increased random error. No systematic errors were found when the values were evaluated with a paired t test.

No significant differences were found between the drop-outs and the remaining patients for age, gender and cephalometric features at T1, T2, T3 and T4.

Horizontal and vertical changes

Table 2 shows the descriptive statistics for the selected cephalometric variables at T1 and T5. The mean changes, standard deviations, and ranges (horizontal and vertical direction) before surgery and during the subsequent observation periods are given in Tables 3 and 4.

Negative values imply a backward, and positive values a forward, movement of the point in the horizontal plane. Negative values imply an upward, and positive values a downward, movement of the point in the vertical plane.

Soft to hard tissue ratios

The net effect (T5–T1) in labrale inferior was 24% of the advancement in incision inferior. The corresponding value for point B′ to point B was 88% and for labrale superior to incision inferior −11%.

Correlations and linear regression

In the period T5–T3, an increase in the patient's age was significantly correlated with a downward movement of the vertical or y-value of pogonion′ ($p = 0.014$; $R = 0.538$). Increased patient's age was significantly correlated to a backward movement of the horizontal or x-values of labrale inferior ($p = 0.045$; $R = -0.492$) and pogonion′ ($p = 0.036$; $R = -0.512$) in the period T5–T3.

Table 1. Random errors (Si) of the cephalometric landmarks and variables.

Variable	Si	Variable	Si	Reference point	Si (mm)	
					X	*Y*
SNA (°)	1.14	Overjet (mm)	0.36	Incision sup.	0.48	0.21
SNB (°)	0.82	Overbite (mm)	0.53	Incision inf.	0.58	0.55
ANB (°)	0.48	Cm–Sn–Ls (°)	3.32	Point B	0.28	0.45
NSL/NL (°)	0.86	G–Sn–Pg′ (°)	1.14	Asab	0.35	0.25
NSL/ML′ (°)	1.01	Ls/Cm–Pg′ (mm)	0.67	Pogonion	0.37	1.19
NL/ML′ (°)	0.84	Li/Cm–Pg′ (mm)	0.49	Menton	0.89	0.45
IsL/NSL (°)	1.52			Labrale sup.	0.78	1.30
IsL/NL (°)	1.31			Stomion sup.	1.68	0.99
IiL/ML′ (°)	1.39			Labrale inf.	1.07	1.01
IsL/IiL (°)	1.63			Stomion inf.	1.15	0.85
				Point B′	1.20	1.10
				Pogonion′	1.19	1.15
				Menton′	3.07	1.21

Table 2. Values of selected cephalometric variables at T1 (before surgery) and T5 (5.5 years after surgery).

Variable	T1			T5		
	Mean	SD	Range	Mean	SD	Range
SNA (°)	80.9	3.7	73.1–85.7	80.0	2.8	74.0–84.4
SNB (°)	76.7	4.2	69.8–83.8	77.3	3.8	70.7–85.5
ANB (°)	4.2	2.2	0.3–7.1	2.7	3.0	−2.9 to 6.3
NSL/NL (°)	7.4	4.1	−1.9 to 15.0	7.6	3.7	0.1–13.0
NSL/ML′ (°)	33.6	7.9	21.4–53.7	34.7	7.1	23.9–53.7
NL/ML′ (°)	26.2	6.4	16.2–44.8	27.1	5.8	19.8–45.2
IsL/NSL (°)	109.3	9.8	81.7–120.5	105.0	7.1	91.3–117.0
IsL/NL (°)	116.7	9.4	91.0–126.7	112.6	6.2	99.0–121.8
IiL/ML′ (°)	91.0	6.8	77.2–104.6	96.5	6.6	81.5–108.3
IsL/IiL (°)	126.2	14.0	106.9–157.3	123.8	6.6	81.5–108.3
Overjet (mm)	7.7	2.1	4.5–11.9	2.8	0.9	1.3–4.5
Overbite (mm)	4.4	1.7	1.0–7.3	3.0	1.5	0.2–5.5
Facial convexity (°)	15.3	6.9	6.4–32.0	13.2	6.6	−3.3 to 29.0
Upper lip to S-line (mm)	−2.3	2.7	−8.0 to 2.4	−5.0	3.1	−9.6 to 0.8
Lower lip to S-line (mm)	−1.9	3.7	−8.5 to 3.2	−3.4	3.3	−7.7 to 3.6

Facial convexity, G–Sn–Pg′; upper lip to S-line, Ls/Cm–Pg′; lower lip to S-line, Li/Cm–Pg′.

The amount of advancement (T3–T1, *x*-value) at point B was significantly correlated to an upward movement of the *y*-values of labrale inferior ($p = 0.006$; $R = -0.637$) and stomion inferior ($p = 0.019$; $R = -0.561$). The amount of advancement (T3–T1, *x*-value) at incision inferior and the ratio $\frac{\text{Ii}(x\text{-value, T3–T2})}{\text{Asab}(x\text{-value, T3–T2})}$ was not significantly correlated to the amount of change (T4–T3, *x*- and *y*-values) measured at soft tissue points.

A preoperative larger NL/ML′ angle (T1) was significantly correlated ($p = 0.044$; $R = 0.494$) with a smaller horizontal change at labrale inferior (T5–T3, *x*-value). No significant correlations were

Table 3. Changes (mm or°) in the variables and co-ordinates of the mandible and lower incisors as the immediate (T3–T1) and final (T5–T1) result of DO surgery.

	Variable or coordinate	T3–T1[a]				T5–T1[b]			
		Mean	*p*	SD	Range	Mean	*p*	SD	Range
Horizontal									
x-Value (mm)	Incision sup.	1.1	**	1.4	−1.3 to 3.2	−0.4	ns	1.9	−4.1 to 3.0
	Incision inf.	6.2	***	2.5	−0.5 to 10.9	4.6	***	3.2	−1.6 to 11.5
	Point B	3.6	***	2.0	−0.21 to 7.6	3.2	***	2.3	−0.2 to 7.3
	Asab	2.2	***	2.1	−1.1 to 5.4	1.2	*	2.1	−2.2 to 4.7
	Pogonion	0.1	ns	1.0	−1.7 to 1.8	0.5	*	1.0	−0.8 to 2.4
	Labrale sup.	0.9	*	1.4	−1.3 to 3.8	−0.5	ns	1.3	−2.8 to 1.7
	Labrale inf.	3.8	***	2.6	0.1–8.7	1.1	ns	2.2	−2.4 to 5.7
	Point B′	5.4	***	2.1	1.9–10.5	2.8	***	2.2	−1.1 to 7.7
	Pogonion′	4.9	***	1.9	1.5–8.6	3.0	***	2.3	−0.6 to 7.3
	Menton′	4.6	***	2.9	−0.3 to 8.6	3.8	***	2.7	−0.7 to 8.8
Vertical									
y-Value (mm)	Labrale sup.	1.4	*	2.1	−2.6 to 6.2	−0.6	ns	1.5	−2.9 to 1.9
	Stomion sup.	−0.6	ns	1.7	−4.5 to 1.7	0.8	*	1.3	−1.1 to 2.9
	Labrale inf.	0.7	ns	2.1	−2.8 to 4.2	−0.2	ns	2.3	−4.8 to 3.4
	Stomion inf.	0.5	ns	2.2	−3.6 to 7.2	0.3	ns	1.6	−3.8 to 2.6
	Point B′	3.5	***	3.3	−3.5 to 8.2	2.6	**	3.3	−2.8 to 7.3
	Pogonion′	0.2	ns	3.3	−6.9 to 5.8	0.2	ns	4.6	−9.7 to 8.5
	Menton′	0.9	ns	2.2	−3.9 to 4.7	0.5	ns	2.6	−3.6 to 5.5
Angular (°) and linear measurements (mm)									
	Facial convexity	−3.3	***	3.3	−7.8 to 3.7	−2.0	***	2.0	−7.2 to 0.9
	Ls to S-line	−1.1	**	1.4	−4.2 to 1.2	−2.6	***	1.5	−5.4 to 0.2
	Li to S-line	0.8	ns	2.1	−2.5 to 4.4	−1.5	**	1.7	−4.0 to 1.5
	Ii/Asab	1.8		7.5	−22.4 to 9.7				

Negative values imply a backward and positive values a forward movement of the point in the horizontal plane. In the vertical plane, negative values imply an upward and positive values a downward movement of the point.

T1, before surgery; T3, 24.4 days after surgery; T5, 5.5 years after surgery.

[a] T3–T2 for Asab, Ii (*x*-value, T3–T2)/Asab (*x*-value, T3–T2) instead mean value the median was taken for this ratio and no paired *t*-test was possible because measured on a single occasion.

[b] T5–T2 for Asab.

* $p \leq 0.05$.

** $p \leq 0.01$.

*** $p \leq 0.001$.

Table 4. Changes (mm,° or ratio) in the variables and coordinates of the mandible and lower incisors as the relapse (T5–T3) and the long-term change (T5–T4) of DO surgery.

Variable or coordinate		T5–T3				T5–T4			
		Mean	*p*	SD	Range	Mean	*p*	SD	Range
Horizontal									
x-Value (mm)	Incision sup.	−1.5	**	1.7	−5.4 to 1.2	0.1	ns	0.6	−1.6 to 0.9
	Incision inf.	−1.8	***	1.9	−5.4 to 0.6	−0.2	ns	0.6	−1.6 to 1.4
	Point B	−0.3	ns	1.3	−2.7 to 3.3	0.3	ns	0.7	−1.0 to 2.0
	Asab	−1.0	***	0.9	−2.4 to 1.1	0.1	ns	0.6	−1.1 to 1.5
	Pogonion	0.4	ns	1.0	−1.6 to 2.9	−0.1	ns	0.7	−1.0 to 2.0
	Labrale sup.	−1.3	**	1.8	−4.5 to 2.9	−0.2	ns	0.7	−1.4 to 1.7
	Labrale inf.	−2.7	***	2.0	−9.2 to −0.4	−0.6	ns	1.2	−72.9 to 1.4
	Point B′	−2.7	***	1.4	−5.0 to 0.6	−0.3	ns	0.9	−1.9 to 1.0
	Pogonion′	−1.9	***	1.8	−6.8 to 1.5	−0.1	ns	1.1	−2.1 to 2.1
	Menton′	−0.8	ns	2.5	−7.9 to 2.9	0.5	ns	2.6	−4.2 to 4.8
Vertical									
y-Value (mm)	Labrale sup.	−2.0	***	1.8	−5.2 to 1.1	−1.0	*	1.6	−3.3 to 2.2
	Stomion sup.	1.4	***	1.4	−0.6 to 5.1	0.7	*	1.1	−1.6 to 3.0
	Labrale inf.	−0.9	ns	2.5	−6.3 to 2.5	−1.0	ns	2.9	−6.4 to 4.2
	Stomion inf.	−0.2	ns	2.4	−5.4 to 2.6	−0.4	ns	2.2	−5.8 to 3.1
	Point B′	−1.0	ns	2.0	−5.3 to 2.3	−0.5	ns	2.1	−5.9 to 2.6
	Pogonion′	0.0	ns	3.1	−6.0 to 8.0	−0.5	ns	2.8	−5.4 to 4.4
	Menton′	−0.4	ns	1.9	−3.6 to 3.8	−0.6	ns	2.2	−4.4 to 3.4
Angular (°) and linear measurements (mm)									
	Facial convexity	1.3	ns	2.9	−5.3 to 4.8	0.3	ns	2.4	−3.3 to 3.9
	Ls to S-line	−1.5	**	1.7	−4.8 to 1.1	−0.4	ns	1.2	−3.3 to 2.1
	Li to S-line	−2.3	***	2.0	−6.6 to 0.0	−1.4	**	1.7	−5.2 to 0.9

T3, 24.4 days after surgery; T4, 2.0 years after surgery; T5, 5.5 years after surgery. Negative values imply a backward and positive values a forward movement of the point in the horizontal plane. In the vertical plane, negative values imply an upward and positive values a downward movement of the point.

* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.

found between the change at T5–T3 of all soft tissue points and gender.

Correlations were significant between horizontal (*x*-value) hard to soft tissue movements for point B and point B′ (T3–T1: $p = 0.003$; $R = 0.681$; T5–T3: $p = 0.017$; $R = 0.569$), for incision inferior and labrale inferior (T3–T1: $p = 0.005$; $R = 0.649$; T5–T3: $p = 0.092$; $R = 0.422$), for incision inferior and labrale superior (T3–T1: $p = 0.067$; $R = 0.454$; T5–T3: $p = 0.012$; $R = 0.592$).

Results for the linear regression analysis are shown in Tables 5 and 6.

Discussion

This research represents the continuation of the authors' previous studies[2,13] on soft tissue changes in patients undergoing DO of the anterior mandibular alveolar process. A uniform group of 17 patients was obtained as patients with additional surgical procedures of the mandible (genioplasty, BSSO) and maxilla were excluded. An evaluation of alveolar segmental DO without the influence of other confounding surgical procedures was thus possible. The effect of growth as a confounding factor was excluded by examining only skeletally mature patients (mean age 30.3 years, SD 10.7). An inherent problem of long-term studies is the loss of patients for follow-up examinations. The authors performed a drop-out analysis for all patients for whom they had no records at T5 by comparing their cephalometric variables at all other time points with the remaining patients. The analysis showed that the dropouts and the remaining patients were comparable, minimizing the risk of bias due to patients lost to follow-up.

In the present study on 17 patients, point B′ followed point B to 88% and lower lip (labrale inferior) the advancement of incision inferior to 24%. In the authors' previous study on 33 patients 2.0 years postoperatively, the net effect of the soft tissue at point B′ was 100% of the advancement at point B while the lower lip (labrale inferior) followed the advancement of incision inferior to 46%.[13] The effects of ageing and soft tissue elasticity have to be considered when analysing long-term effects of maxillofacial surgery on the lips and chin. In his longitudinal

Table 5. Linear regression. Dependent variable: point B′ (*x*-value) T5–T3.

Model	B	95% confidence interval for B		Significance	*R*	R^2
		Lower bound	Upper bound			
(Constant)	5.578	−1.801	12.956	.125	0.791	0.626
Age	−.022	−.067	.024	.324		
IiL/ML′ at T1	−.082	−.165	.001	.053		
$\frac{\text{Ii}(x\text{-value, T3}-\text{T2})}{\text{Asab}(x\text{-value, T3}-\text{T2})}$	−.015	−.051	.020	.358		
Point B (*x*-value) T5–T3	.618	.169	1.066	.011		

Table 6. Linear regression. Dependent variable: labrale inf. (*x*-value) T5–T3.

Model	B	95% confidence interval for B		Significance	*R*	R^2
		Lower bound	Upper bound			
(Constant)	.328	−2.098	2.754	.773	0.721	0.520
Age	−.070	−0.148	.008	.075		
NL/ML′ at T1	.013	−.717	.742	.971		
Incision inf. (*x*-value) T5–T3	.049	−.573	.671	.866		
Incision sup. (*x*-value) T5–T3	.599	−.098	1.296	.086		

study on facial growth Forsberg[19] reported that from the age of 24 to 34 years the nose grew forward, the lips retruded, and soft tissue pogonion moved backwards. This agrees with the authors' findings when comparing their long-term data for 5.5 years with that found earlier at 2.0 years after surgery. The net effect of point B′ and the labrale inferior decreased over time. Another reason for the difference in point B′ and labrale inferior could be the missing data from the 16 patients who could not be re-examined for the 5.5 year follow-up.

5.5 years postoperatively, correlations were found between patient's age and changes (T5–T3) of different soft tissue points. An increase in the patient's age was significantly correlated with a downward movement of the vertical or *y*-value of pogonion′ ($p < 0.05$) and to a backward movement of the horizontal or *x*-values of labrale inferior and pogonion′ (both $p < 0.05$). Thus it is possible that soft tissue strength was reduced in this patient sample by further ageing.

To the authors' knowledge, there is no other published data on adult patients after DO of the anterior mandibular alveolar process which makes a direct comparison of the data impossible. Soft tissue changes compared to skeletal changes were reported after DO for mandibular elongation in children with hypoplastic mandibles evaluated on lateral cephalograms[3] or photographs combined with postero-anterior cephalograms.[1] Melugin et al.[3] found in 27 paediatric patients that point B′ followed point B and pogonion′ to pogonion to 90% at post-consolidation. The magnitude of the advancement, and age, and sex of the patients had no effect on these ratios.

In contrast, Joss et al.[20]systematically reviewed the effect of BSSO with rigid internal fixation (RIF) or wire fixation (WF) for mandibular advancement on soft tissue ratios. Short- and long-term ratios for lower lip to lower incisor in RIF or WF can be described as 50%. No difference between short- and long-term ratios for point B′ to point B and pogonion′ to pogonion could be observed. It could be characterized as a 1 to 1 ratio. The exception was that pogonion′ to pogonion with RIF tended to be higher than a 1 to 1 ratio in long-term results. The upper lip showed mainly retrusion but high variability. The ratios for the lower lip and point B′ found in that review on BSSO for mandibular advancement in RIF and WF[2] are in accordance with the present authors' earlier data 2.0 years after surgery. The data from the present study show that point B′ followed point B not in a 1 to 1 ratio but only to 80% and labrale inferior only to 24%.

The amount of advancement (T3–T1, *x*-value) at point B was significantly correlated with an upward movement of the *y*-values of labrale inferior ($p < 0.01$) and stomion inferior ($p < 0.05$). Joss et al.[6] could not show any correlation between the relapse in soft tissue and the amount of advancement at point B in their long-term study on hard and soft tissue change in patients with BSSO for mandibular advancement and RIF. It is interesting to note that the amount and type (rotational vs. translational) of advancement in the same patient population examined earlier were not correlated with the amount of skeletal relapse measured at incision inferior or point B.[2,14]

An important short-term effect of maxillofacial surgery and a confounding variable is postoperative swelling (oedema from retraction, irritations, and inflammation). For this reason, the immediate short-term soft tissue profile changes measured on lateral cephalograms always include swelling and thickness of the orthodontic brackets.[20] Furthermore, RIF in the form of the miniplates used in the present study adds more volume to the labial surface of the chin bone which affects the soft tissue profile and limits the exact location of the cephalometric landmarks. Miniplates were present at T2 and T3 but surgically removed before T4 in all but one patient. The removal of the miniplates could have led to a slight increase in soft tissue change (T4–T3) of point B′.[13] In addition, the interface of the surgical section of the anterior aspect of the symphysis was more susceptible to resorption and bony remodelling.[2,14]

In conclusion, this long-term follow-up of 5.5 years found that further change in soft tissues occurred between 2.0 and 5.5 years postoperatively regarding point B′ and labrale inferior. The physiological process of ageing and loss of soft tissue elasticity should be considered as possible reasons.

Competing interest

None declared.

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Ethical approval

Yes. Ethical approval was admitted by the Ethic Committee of the Kanton Zürich, Switzerland, number 593.

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