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Skeletal and dental stability of segmental distraction of the anterior mandibular alveolar process. A 2-year follow-up

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Abstract. 33 patients (27 females; 6 males) were retrospectively analysed for skeletal and dental relapse before distraction osteogenesis (DOG) of the mandibular anterior alveolar process at T1 (17.0 days), after DOG at T2 (mean 6.5 days), at T3 (mean 24.4 days), and at T4 (mean 2.0 years). Lateral cephalograms were traced by hand, digitized, superimposed, and evaluated. Skeletal correction (T3 − T1) was mainly achieved through the distraction of the anterior alveolar segment in a rotational manner where the incisors were more proclined. The horizontal backward relapse (T4 − T3) measured −0.8 mm or 19.0% at point B ($p < 0.001$) and −1.6 mm or 25.0% at incision inferior ($p < 0.001$). Age, gender, amount and type (rotational versus translational) of advancement were not correlated with the amount of relapse. High angle patients (NL/ML′; $p < 0.01$) and patients with large gonial angle ($p < 0.05$) showed significantly smaller relapse rates at point B. Overcorrection of the overjet achieved by the distraction was seen in a third of the patients and could be a reason for relapse. Considering the amount of skeletal relapse the DOG could be an alternative to bilateral sagittal split osteotomy for mandibular advancement in selected cases.

Key words: distraction osteogenesis skeletal stability; dental stability; relapse; cephalometrics.

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Since the clinical introduction of distraction osteogenesis (DOG) in the field of maxillofacial surgery by McCarthy et al.[7] the indications for use in the craniofacial area have significantly increased. The applications comprise mandibular lengthening[20] or widening[4], reconstruction of the alveolar process for implant placement[2], DOG for bone transport after trauma or tumour resection for reconstruction of segmental defects or a neocondyle[15], maxillary DOG for unilateral and bilateral cleft patients[16], and midfacial or cranial DOG for different types of craniosynostosis[9].

The main applications of mandibular distraction were in congenital micrognathia[17], such as hemifacial microsomia[10,14], and different syndromes, such as Treacher-Collins, Pierre Robin, Nager, and Goldenhar. A review by Swennen et al.[17] showed that less frequent indications of mandibular DOG were in acquired micrognathia (trauma, temporomandibular joint ankylosis), and that almost no patient data are available for mandibular retrognathia in non-syndromic adult patients, and there is a lack of appropriate data on long-term results with skeletal relapse rates in DOG.

DOG of the lower alveolar segment was introduced by Triaca et al.[18,19], and allows the creation of space to align teeth and/or implant placement in patients with increased overjet and retruded alveolar process. The extraction of lower premolars for tooth alignment can thus be eliminated. It is possible to achieve overjet reduction by moving the mandibular anterior alveolar process in a more translational or rotational manner. It is still not clear how translational and rotational movements of the lower alveolar segment influence the skeletal stability of DOG.

The aim of the present study was to evaluate the immediate skeletal and dental effect as well as the amount of skeletal relapse and dental changes 2 years after treatment in patients treated with DOG of the mandibular anterior alveolar process, and to identify factors related to skeletal and dental stability.

Materials and methods

The patient sample consisted of 33 Caucasians (27 females; 6 males), aged 16.5–56.0 years (mean age 30.3 years, SD 10.7). They were treated orthodontically by one orthodontist (MA) and underwent DOG of the mandibular anterior alveolar process to correct a skeletal Class II and large overjet with or without incisor crowding from 1998 to 2004. The female patients had a mean age of 30.8 years (16.8–56.0 years, SD 10.9 years) and the male patients 28.3 years (16.5–43.7 years, SD 10.5 years). The surgical procedure was performed by one experienced maxillofacial surgeon (AT); the technique has been published[18,19]. Patients simultaneously receiving other surgical procedures on the mandible and maxilla, such as genioplasty and bilateral sagittal split osteotomy (BSSO) were excluded. Syndromic or medically compromised patients were excluded.

Ethical approval was admitted by the Ethic Committee of the Kanton Zürich, Switzerland, number 593. All subjects signed a written, informed consent.

Four cephalograms were taken: the first on average 17.0 days before surgery (T1), the second (T2) between days 0 and 12 (mean 6.5 days) after the osteotomy and before any distraction was carried out. The third (T3) cephalogram was taken between days 13 and 92 (mean 24.4 days), and the fourth (T4) between 0.9 and 3.7 years (mean 2.0 years) after distraction of the mandibular anterior alveolar process. The distraction was completed at T3 and the orthodontic treatment at T4. The retention of the lower incisors was achieved with a bonded canine-to-canine retainer. The DOG procedure has been described earlier[18,19].

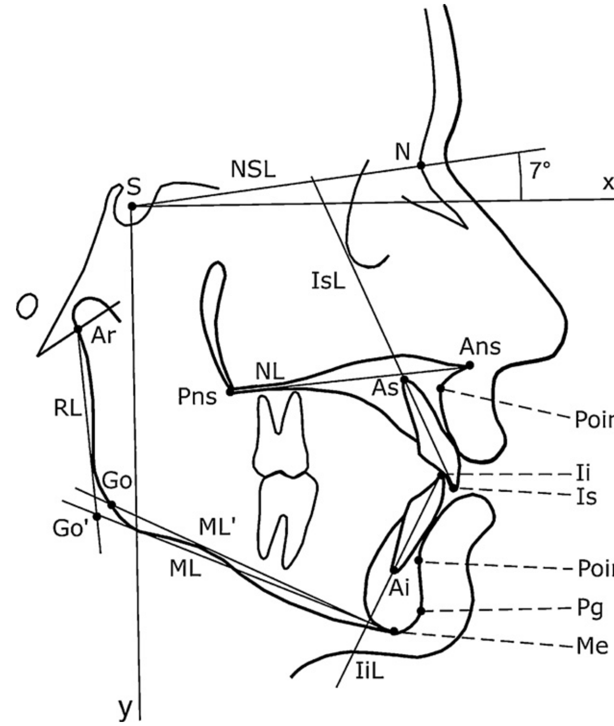

Fig. 1. Reference points and lines used in the cephalometric analysis. The coordinate system had its origin at point S (sella), and its *x*-axis formed an angle of 7° with the reference line NSL. S, sella; NSL, nasion–sella-line; N, nasion; *x*, horizontal reference plane; NL, nasal line; ILs, upper incisal line; Ar, articulare; RL, ramus line; Ans, anterior nasal spine; Pns, posterior nasal spine; As, apex superior; point A; Ii, incision inferior; Is, incision superior; Go, gonion; Go′, gonion prime; ML′, mandibular line prime; ML, mandibular line; Ai, apex inferior; point B; Pg, pogonion; Me, menton; and *y*, vertical reference plane. The Holdaway ratio is the distance between Ii vertical to N–B-line minus distance Pg vertical to N–B-line and the Jarabak ratio is the distance from S to Go′/distance N to Me.

Cephalometric analysis

The skeletal 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 of each patient were scanned and evaluated with the program Viewbox 3.1® (dHal software, Kifissia, Greece). The conventional cephalometric analysis for T1, T2, T3, and T4 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, and T4) on the first radiograph (T1), and the

Table 1. Random errors (si) in mm or degrees of the cephalometric variables.

Variable	si	Variable	si	Reference point	si (mm)	
					X	*Y*
SNA (°)	1.14	IiL–N–point B (°)	1.14	Incision sup.	0.48	0.21
SNB (°)	0.82	IiL–N–point B (mm)	0.24	Incision inf.	0.58	0.55
ANB (°)	0.48	IiL–A–Pg (°)	1.29	Apex inf.	0.54	0.18
NSL/NL (°)	0.86	IiL–A–Pg (mm)	0.49	Point B	0.28	0.45
NSL/ML′(°)	1.01	Holdaway ratio	0.47	Asab	0.35	0.25
NL/ML′ (°)	0.84	IsL/IiL (°)	1.63	Pogonion	0.37	1.19
Jarabak ratio	1.15	Overjet	0.36	Menton	0.89	0.45
IsL/NSL (°)	1.52	Overbite	0.53	Gonion′	2.48	1.14
IsL/NL (°)	1.31					
IiL/ML′ (°)	1.39					

Asab, alveolar surgical anterior base.

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[1]. 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 and the coordinates of the reference points (Table 1) 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 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 versus translation) of the lower anterior segment base in comparison to the lower incisors as ratio (Ii [x value; T3 − T2]/Asab [x value; T3 − T2]).

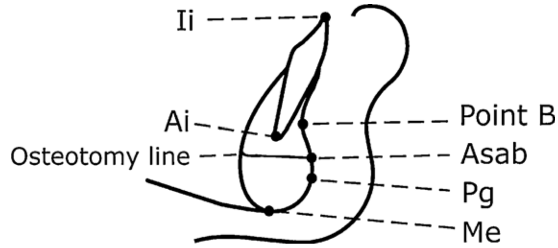

Fig. 2. Reference points used in the cephalometric analysis of the lower apical base in DOG patients. Ii, incision inferior; point B; Ai, apex inferior; Asab, apical surgical anterior base; Pg, pogonion; and Me, menton. Asab is the most anterior and inferior point of the lower anterior segment resulted by the surgical osteotomy. This cephalometric point was introduced to evaluate the movement (rotation versus translation) of the lower anterior segment base in comparison to the lower incisors (Ii) as the ratio Ii (x value)/Asab (x value).

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 obtained by superimposing the tracings of the different stages (T2, T3, and T4) on the first radiograph (T1). The error of the method (si) was 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[3].

The random errors are presented in Table 1. No systematic errors were found when the values were evaluated with a paired t test.

Statistical analysis

Statistical analyses were conducted using SPSS software (version 13.0, SPSS Inc., Chicago, IL, USA). Normal distribution was confirmed with the Kolmogorov–Smirnov test. The effect of treatment, determined as the differences between the variables and co-ordinates at T3 and T1 (T3 and T2 for Asab), T4 and T1 (T4 and T2 for Asab), T4 and T3 was tested with a paired t test. The relationships between skeletal variables, age, and gender were analysed with the Pearson's product moment correlation coefficient.

Results

Table 2 shows the selected variables before surgery (T1) and at 2-year follow-up (T4). The mean changes, standard deviations, and ranges for the selected cephalometric parameters 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. In the vertical plane, negative values imply an upward and positive values a downward movement of the point.

Table 2. Values of selected cephalometric variables at T1 (before surgery) and T4 (2.0 years after surgery).

	T1			T4		
	Mean	SD	Range	Mean	SD	Range
SNA (°)	80.5	3.7	73.1 to 88.0	80.2	4.0	72.8 to 92.1
SNB (°)	76.2	4.1	68.8 to 85.4	77.2	4.4	69.9 to 90.1
ANB (°)	4.3	2.0	0.3 to 8.0	3.0	2.2	−1.4 to 6.6
NSL/NL (°)	7.6	4.2	−1.9 to 15.0	7.9	4.1	0 to 14.6
NSL/ML′ (°)	33.7	7.3	16.3 to 53.7	34.8	7.3	13.9 to 53.2
NL/ML′ (°)	26.0	6.4	13.9 to 44.8	26.9	6.3	12.4 to 45.4
Gonion angle (°)	124.9	7.4	112.7 to 145.8	124.7	7.9	107.5 to 142.9
Jarabak ratio	64.8	6.3	49.2 to 80.9	63.9	6.1	50.2 to 83.8
IsL/NSL (°)	106.8	8.7	81.7 to 120.5	105.3	8.0	92.1 to 125.0
IsL/NL (°)	114.4	8.4	91.0 to 126.7	113.2	7.3	100.8 to 126.4
IiL/ML′(°)	91.1	7.3	77.2 to 104.6	95.4	8.2	78.3 to 111.3
IiL–N–point B (°)	20.9	7.5	6.2 to 36.3	27.5	7.1	14.5 to 46.8
IiL–N–point B (mm)	4.3	3.2	−1 to 12.9	7.1	3.4	2.7 to 16.7
IiL–A–Pg (°)	20.4	6.8	5.5 to 31.3	25.2	6.6	9.0 to 38.5
IiL–A–Pg (mm)	−0.4	3.5	−7.0 to 9.0	4.5	2.9	−0.1 to 13.7
Holdaway ratio	0.2	5.2	−10.2 to 13.6	6.0	4.5	−2.8 to 19.4
IsL/IiL (°)	128.5	12.4	106.9 to 157.3	124.5	10.6	100.1 to 145.6
Overjet (mm)	7.4	2.4	4.1 to 14.3	2.4	0.8	0.9 to 4.1
Overbite (mm)	4.0	2.0	0.7 to 7.5	1.7	1.6	−0.7 to 5.4

Horizontal changes

The mean advancement of the anterior alveolar process immediately following DOG (T3 − T1) was 4.2 mm at point B, 2.9 mm at Asab (T3 − T2), and 6.4 mm at incision inferior (all $p = 0.000$). Mean relapse (T4 − T3) was −0.8 mm or 19.0% at point B, −1.2 mm or 41.4% at Asab (T4 − T2), and −1.6 mm or 25.0% at incision inferior of the initial surgical advancement. Figures 3 and 4 show the surgical changes (T3 − T1) and the amount of relapse (T4 − T3) of point B and OJ.

Regarding the ratio Ii [*x* value; T3 − T2]/Asab [*x* value; T3 − T2], the alveolar segment moved as a result of the DOG in a rotational way in all but six patients if the ratio between 0.8 and 1.2 was taken as translational movement. That means, that in 27 patients the incisal edges of the lower incisors (Ii) were more advanced than their alveolar surgical anterior base (Asab). In five patients the ratio was negative; that means that point Asab was even set back whilst point Ii was advanced by the DOG.

Correlations

No significant correlations were found between relapse (T4 − T3, *x* value) of point B, Ii, or Asab with gender and age of the patients. No correlations were found for the amount of advancement (T3 − T1) and relapse (T4 − T3) at Ii, point B and Asab. The type of advancement (rotational versus translational; Ii [*x* value; T3 − T2]/Asab [*x* value; T3 − T2]) had no influence on relapse (T4 − T3) at point B (*x* value) and Asab (*x* value).

A larger gonial angle (T1) was significantly correlated with a smaller relapse (T4 − T3) at the *x* values of point B ($p = 0.042$; $R = 0.356$). A larger NL/ML′ angle (T1) showed significant correlations with a smaller relapse (T4 − T3) at the *x* values of point B ($p = 0.006$; $R = 0.470$)

Table 3. Changes (mm or degree) in the variables and coordinates of the mandible and lower incisors as the immediate (T3 − T1) and final (T4 − T1) result of DOG surgery.

	Variable or coordinate	T3 − T1†				T4 − T1‡			
		Mean	*p*	SD	Range	Mean	*p*	SD	Range
Horizontal (*x* value [mm])	Point B	4.2	***	2.4	−0.21 to 11.6	3.4	***	2.3	0.1 to 11.8
	Asab	2.9	***	2.3	−1.1 to 6.7	1.6	***	2.2	−2.1 to 7.1
	Pogonion	0.0	ns	1.1	−3.7 to 1.8	0.6	*	1.5	−3.2 to 4.5
	Go′	−0.5	ns	2.5	−4.6 to 5.3	0.3	ns	2.4	−5.5 to 5.9
	Incision sup.	1.3	***	1.6	−1.3 to 5.4	0.1	ns	2.1	−3.6 to 6.5
	Incision inf.	6.4	***	2.5	−0.5 to 13.1	4.8	***	2.9	−0.9 to 10.4
	Apex inf.	4.7	***	2.2	1.7 to 10.8	3.7	***	2.4	0.1 to 13.1
Vertical (*y* value [mm])	Point B	1.7	***	2.3	−1.6 to 6.6	0.6	ns	2.4	−5.2 to 6.0
	Asab	−0.5	ns	1.6	−5.4 to 2.3	0.2	ns	1.5	−3.6 to 3.3
	Pogonion	0.3	ns	2.0	−5.1 to 4.8	0.3	ns	2.5	−4.6 to 5.4
	Menton	0.1	ns	0.7	−0.7 to 2.7	0.0	ns	1.1	−3.4 to 3.3
	Go′	−0.4	ns	2.0	−6.6 to 4.7	−0.4	ns	1.7	−4.0 to 2.8
	Incision sup.	−1.7	***	1.6	−6.7 to 0.4	−0.7	**	1.4	−4.1 to 1.4
	Incision inf.	1.6	***	2.1	−2.3 to 5.7	1.3	**	2.3	−4.0 to 5.8
	Apex inf.	0.5	ns	1.7	−2.8 to 4.5	0.6	ns	1.7	−3.1 to 4.6
Angular (°), linear measurements (mm), and ratios	SNA (°)	−0.2	ns	1.0	−3.0 to 1.7	−0.3	ns	1.6	−3.9 to 4.1
	SNB (°)	1.4	***	1.4	−0.6 to 4.1	1.0	***	1.7	−2.3 to 4.7
	ANB (°)	−1.6	***	1.1	−4.0 to 0.9	−1.4	***	1.2	−3.9 to 0.5
	Wits (mm)	−3.7	***	2.0	−8.0 to 0.4	−3.1	***	2.3	−7.1 to 3.4
	NSL/NL (°)	0.2	ns	1.2	−2.4 to 2.9	0.2	ns	1.5	−2.8 to 3.6
	NSL/ML′ (°)	1.3	***	1.4	−1.0 to 4.8	1.1	**	1.9	−2.9 to 4.0
	NL/ML′ (°)	1.1	***	1.6	−2.0 to 4.7	0.9	***	1.3	−1.9 to 3.3
	Gonion angle (°)	−2.1	***	2.7	−8.0 to 1.9	−0.2	ns	3.8	−6.3 to 8.9
	Jarabak ratio	−0.7	*	1.6	−4.0 to 2.2	−0.9	*	2.0	−4.2 to 4.1
	IsL/NSL (°)	0.7	ns	4.8	−7.2 to 22.0	−1.5	ns	5.8	−16.3 to 11.5
	IsL/NL (°)	0.9	ns	4.4	−7.6 to 20.1	−1.2	ns	5.6	−14.2 to 10.5
	IiL/ML′ (°)	6.5	***	5.3	−6.5 to 15.7	4.3	***	7.1	11.8 to 19.2
	IiL–N–point B (°)	9.1	***	4.5	−4.2 to 17.1	6.5	***	6.7	−6.3 to 21.5
	IiL–N–point B (mm)	3.2	***	1.5	−1.7 to 5.2	2.8	***	2.7	−1.6 to 9.0
	IiL–A–Pg (°)	5.5	***	4.6	−4.9 to 15.6	4.8	***	6.8	−11.7 to 19.2
	IiL–A–Pg (mm)	6.4	***	1.9	0.5 to 11.5	4.8	***	2.8	−0.7 to 12.6
	Holdaway ratio	8.6	***	2.8	1.4 to 16.4	5.9	***	3.3	−0.9 to 13.7
	IsL/IiL (°)	−8.5	***	6.7	−31.4 to 4.9	−4.0	*	9.5	−28.3 to 10.5
	Overjet (mm)	−5.3	***	1.8	−9.4 to −1.1	−4.9	***	2.3	−11.8 to −1.5
	Overbite (mm)	−3.4	***	1.7	−7.1 to 0.1	−2.2	***	2.2	−6.8 to 2.2
	Ii/Asab	1.87		15.4	−66.2 to 42.3				

T1, before surgery; T3, 24.4 days after surgery; T4, 2.0 years after surgery.

*$p \leq 0.05$.

**$p \leq 0.01$.

***$p \leq 0.001$.

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

‡ T4 − T2 for Asab.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.

Table 4. Changes (mm, degree or ratio) in the variables and coordinates of the mandible and lower incisors as the relapse (T4 − T3) of DOG surgery.

	Variable or coordinate	T4 − T3			
		Mean	*p*	SD	Range
Horizontal (*x* value [mm])	Point B	−0.8	***	1.2	−3.2 to 1.7
	Asab	−1.2	***	1.5	−4.2 to 1.6
	Pogonion	0.7	***	1.0	−1.2 to 3.7
	Go′	0.8	ns	2.9	−6.4 to 4.9
	Incision sup.	−1.2	***	1.6	4.7 to 1.2
	Incision inf.	−1.6	***	2.1	−6.2 to 2.6
	Apex inf.	−1.1	***	1.6	−4.2 to 2.3
Vertical (*y* value [mm])	Point B	−1.1	*	2.4	−6.5 to 2.9
	Asab	0.7	*	1.6	−3.0 to 4.5
	Pogonion	−0.1	ns	2.3	−5.4 to 5.0
	Menton	−0.1	ns	1.0	−3.0 to 2.0
	Go′	0.0	ns	1.9	−3.9 to 3.9
	Incision sup.	1.0	***	1.3	−1.5 to 3.1
	Incision inf.	−0.3	ns	2.2	−4.7 to 4.5
	Apex inf.	−0.1	ns	2.2	−4.1 to 5.8
Angular (°), linear measurements (mm), and ratios	SNA (°)	−0.2	ns	1.4	−2.9 to 4.7
	SNB (°)	−0.4	ns	1.2	−2.7 to 3.2
	ANB (°)	0.2	ns	1.0	−2.1 to 1.6
	Wits (mm)	0.5	ns	2.0	−3.5 to 4.7
	NSL/NL (°)	0.0	ns	1.2	−2.5 to 2.0
	NSL/ML′ (°)	−0.2	ns	2.1	−5.4 to 3.6
	NL/ML′ (°)	−0.2	ns	1.7	−4.0 to 2.8
	Gonion angle (°)		1.9**	3.3	−5.4 to 9.5
	Jarabak ratio	−0.2	ns	2.2	−4.5 to 5.0
	IsL/NSL (°)	−2.2	*	5.9	−13.4 to 12.8
	IsL/NL (°)	−2.2	*	5.9	−12.2 to 11.3
	IiL/ML′ (°)	−2.1	ns	7.7	−17.0 to 22.2
	IiL–N–point B (°)	−2.6	*	7.1	−15.5 to 18.1
	IiL–N–point B (mm)	−0.4	ns	2.5	−4.6 to 5.1
	IiL–A–Pg (°)	−0.7	ns	7.5	−13.4 to 20.5
	IiL–A–Pg (mm)	−1.5	***	2.2	−5.1 to 4.5
	Holdaway ratio	−2.7	***	2.1	−6.7 to 1.8
	IsL/IiL (°)	4.5	**	9.3	−25.2 to 21.7
	Overjet (mm)	0.3	ns	2.1	−4.8 to 5.5
	Overbite (mm)	1.1	**	2.2	−3.1 to 6.7

T3, 24.4 days after surgery; T4, 2.0 years after surgery.
* $p \leq 0.05$.
** $p \leq 0.01$.
*** $p \leq 0.001$.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.

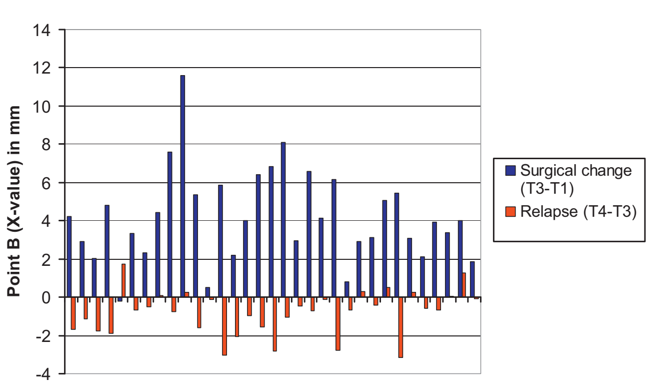

Fig. 3. Surgical change (T3 − T1) and amount of relapse (T4 − T3) of point B (*x* value in mm) in individual patients ($n = 33$).

and Abas ($p = 0.011$; $R = 0.438$). The same was seen for a larger NSL/ML′ angle (T1) and a smaller relapse (T4 − T3) at the *x* value of point B ($p = 0.041$; $R = 0.357$). A larger Jarabak ratio (T1) was significantly correlated with a larger relapse (T4 − T3) at the *x* values of point B ($p = 0.016$; $R = -0.418$).

Discussion

This study was undertaken to investigate the amount of skeletal relapse and remodelling in patients undergoing DOG of the mandibular anterior alveolar process. Additional surgical procedures on the mandible (e.g. genioplasty and BSSO)

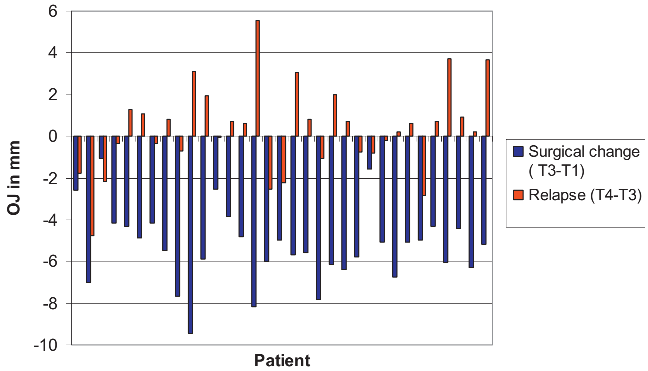

Fig. 4. Surgical change (T3 − T1) and amount of relapse (T4 − T3) of OJ (in mm) in individual patients ($n = 33$).

and maxilla were excluded to provide a uniform patient sample. This permits the examination of alveolar segmental DOG without the influence of other confounding surgical procedures.

About one quarter of this sample was male. This predominance of female over male patients (27 versus 6) is often found in maxillofacial surgery and adult orthodontics, because more females than males seek treatment. This meant that it was not possible to investigate possible gender differences.

The amount of advancement (T3 − T1) had no influence on the amount of relapse (T4 − T3) at point B, at Ii, and Asab. Smaller advancements with DOG did not show less relapse than larger advancements. In BSSO such a positive correlation was found between the amount of relapse and the amount of mandibular advancement. Advancements in the range of 6–7 mm or more predispose to horizontal relapse[6]. It was a surprising finding that a larger NL/ML′ and NSL/ML′ angles (T1) were significantly correlated with a smaller relapse (T4 − T3) for the x values of point B in this patient sample. This is in contrast to relapse patterns after a BSSO for mandibular advancement where a large mandibular plane angle (NL/ML′) is often correlated with increased horizontal relapse[6]. It is possible that patients with a hyperdivergent facial pattern have a lower perioral muscular tonus and thus fewer relapses.

7 patients had mandibular advancement due to DOG of more than 6.0 mm and the mean advancement at point B was 4.2 mm in this study. The amount of relapse at point B is 19% after 2.0 years. A reason for this amount of skeletal relapse could be the overcorrection achieved by the distraction where an edge-to-edge incisal position or negative OJ at T3 had to be corrected with Class III elastics in 11 patients. A systematic review on relapse rates in BSSO for mandibular advancement with bicortical screws shows a large variability from 2 to 50% in long-term relapse (>1.5 years) at point B[6]. Pseudarthrosis at the osteotomy sites occurred in none of the 33 patients examined.

The higher relapse rate at Ii of 25% could be due to the fact that the DOG creates space distally of the canines whilst crowding is still present in the incisor region. Incisor alignment is carried out in this newly generated space to prevent further proclination or round trips not until the distraction will be accomplished. For this reason, it is possible that Ii moves further posteriorly by orthodontic forces.

To the authors' knowledge, there are no published studies that evaluate skeletal stability of DOG of the mandibular anterior alveolar process, which makes a direct comparison of the present data impossible. Recently, Vos et al.[21] could not show retrospectively any significant difference in non-syndromic adult patients treated for mandibular advancement either with DOG (BSSO type) or BSSO 10–49 months after surgery. The mean lengthening of 7.23 mm in BSSO and 7.81 mm in DOG was comparable. Skeletal relapse was −0.5 mm (7%) in BSSO and −1.1 mm (14%) in DOG.

The movement of distraction (translation versus rotational) was defined by the type of distraction appliance chosen. The hinge plate allows a more rotational and the base-distractor a more translational movement of the anterior mandibular alveolar segment. The idea behind the introduction of two newly defined skeletal points (alveolar surgical anterior base and alveolar surgical prominence) was to evaluate the movement of the surgical base independently and to evaluate bone remodelling at the surgical site. A comparison between the movements of Ii, point B, and lower incisor apex makes it possible to study whether DOG created predominantly a rotation or translation of the alveolar process, especially when considering the ratio Ii (x value; T3 − T2)/Asab (x value; T3 − T2). A ratio of 1 signifies that a pure translation of the segment was taking place. The higher the ratio is above 1, the more the centre of rotation is located at the lower incisor apex or at Asab, respectively, and the contrary for values below 1. Five of the 33 patients had a negative ratio indicating a set back of point Asab whilst point Ii was advanced. Only six patients had a ratio between 0.8 and 1.2 which could be described as translation movement. That means that 27 patients had a more or less accentuated rotational movement of the distracted segment. Some proclination of the lower incisors however was certainly related to the orthodontic treatment which could have biassed the assessment of that ratio.

The interface of the surgical section of the anterior aspect of the symphysis is highly susceptible to resorption and bony remodelling. This has been confirmed by McDonnell et al.[8], when evaluating the surgical borders of advancement genioplasties where osseous remodelling was highest. In the present study, this was seen especially at point Asab. The border of the segment needs to be remodelled to smooth the contour and aspect of the anterior symphysis. This may explain why the relapse rate of 41% at Asab is so high.

Triaca et al.[18] noted that DOG of the mandibular alveolar process can be applied in specific cases: skeletal Class II patients with crowding to reduce the required sagittal distance to be achieved by an advancement BSSO; skeletal Class III patients to create space for decompensation of the lower incisor inclination; skeletal Class I with dental Class II patients to create space of one premolar width and overjet normalization; and in skeletal and dental Class I patients with crowding to avoid extraction and the often resulting unfavourable profile. It could also be argued that DOG of the mandibular anterior alveolar segment might be beneficial to prevent the biomechanical side effects on the mandibular condyle that can occur after BSSO or mandibular DOG[11]. This could prevent progressive condylar resorption which is related to long-term relapse and impaired mandibular function. The target groups for condylar resorption are young women with a high mandibular plane angle[5,13]. 7% of all BSSO advancement patients appear to undergo progressive condylar resorption[12]. Further research is needed to elucidate whether condylar resorption is less in cases treated with DOG of the mandibular alveolar process.

In conclusion, DOG of the mandibular anterior alveolar process resulted in a mainly rotational rather than translational advancement of the tooth-bearing alveolar segment. Two years after treatment, 19% of the original skeletal advancement and 26% of the dental advancement have vanished. Considering the amount of skeletal relapse, the procedure could be an alternative to BSSO for mandibular advancement in selected cases.

Competing interests

None declared.

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Ethical approval

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