Can the Upper Vermilion and the Nasolabial Fold Be Changed With Orthognathic Surgery?

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Background: Retrusive profiles show an appearance of aging with an under-projected vermilion and pronounced nasolabial folds due to deficient bone support.

Purpose: A study was made of the association between orthognathic surgery and changes in the nasolabial and vermilion areas in patients with retrusive profiles.

Study Design, Setting, Sample: A retrospective cohort study evaluated patients subjected to bimaxillary surgery according to the Barcelona Line (BL) protocol during 2021 at Teknon Medical Center (Barcelona, Spain). Subjects with craniofacial syndromes, facial esthetic procedures, and dental rehabilitations involving lip changes, were excluded.

Predictor Variable: The predictor variable was the timing of cephalometric measures, reported as T0 (preoperatively), T1 (1 month after surgery), and T2 (after 1 year of follow-up).

Main Outcome Variable: The outcome variable corresponded to the soft tissue changes of the nasolabial and vermilion area, reported as the nasolabial fold length and angle, nasolabial angle, upper lip concavity, vermilion length, and upper lip sagittal distance from BL.

Covariates: The covariates comprised patient demographic data, the surgical-orthodontic protocol, and the magnitude and direction of the skeletal movements.

Analyses: Descriptive and inferential analyses were performed based on analysis of variance, the Bonferroni test, Pearson's linear coefficient, the nonparametric Mann-Whitney U-test, Kruskal-Wallis test, and multiple linear regression models. Statistical significance was considered for $P < .05$.

Results: The sample comprised 27 subjects with a mean age of 32.5 ± 11.2 years. A mean decrease in nasolabial angle of $5.5 \pm 6^\circ$ was recorded ($P < .001$), with a shortening of the nasolabial fold length of 4.4 ± 7.6 mm ($P = .019$). An increase in upper lip concavity angle of $14.4 \pm 12^\circ$ was recorded ($P < .001$), along with a vermilion lengthening of 1.6 ± 1.3 mm ($P < .001$) and an increase in upper lip sagittal distance to BL of 5.7 ± 7.3 mm ($P = .001$), indicating a more projected and everted upper vermilion.

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Conclusions and Relevance: When adequate dentoskeletal support is provided by specific positional changes of the jaws planned through orthognathic surgery, the length of the nasolabial fold decreases, and the upper vermilion lengthens and becomes slightly everted.
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Upper lip youthful signs comprise smooth nasolabial folds accompanied by dentally supported lips.[1] Contrarily, the facial aging process is characterized by soft tissue (ST) descent, fat deflation and muscle traction attached to the dermis, resulting in deepening of the nasolabial and labiomental folds, and a thin and elongated upper lip vermilion.[2-4]

The nasolabial folds separate the cheeks and the upper lip, and are described as cutaneous areas in which several muscles converge: while the upper area of the folds is influenced by the levator labii superioris, levator anguli oris and zygomatic minor and major muscles, the paracommissural area is influenced by the modiolus, the zygomaticus major and the depressor anguli oris muscles. The lower part of the nasolabial fold in turn is influenced by the platysma. In the aging process, the adjacent malar and perioral fat compartments deflate, and the nasolabial fold therefore deepens.[2-6] Additionally, Pessa et al[7] reported bone loss with aging in the pyriform area, with consequent nasal base posterior displacement, deepening of the nasolabial folds, and loss of projection of the upper lip.

On the other hand, when a dentofacial deformity (DFD) involves midfacial-third hypoplasia, the following unaesthetic facial features may appear even in young patients: flat cheekbones with a sunken midface, a prominent nose, and a lack of support to the nasal tip, poor perinasal projection, scant dental exposure, a prominent appearing chin, and hypotonic lips.[8] Thus, a facial appearance of premature aging develops secondary to deepening of the nasolabial folds and poor projection of the upper lip.

Although several techniques such as fat grafts, fillers or face-lift procedures have been described to improve upper lip projection and reduce nasolabial fold deepening, thereby affording a youthful appearance,[9] patients with an underlying DFD with or without an aged facial appearance require management with orthognathic surgery (OS). In this context, an anatomical reference has been described for DFD diagnosis and treatment planning, based on a proper sagittal dentoskeletal support of the upper lip: the upper incisor to ST line,[10] which has been updated as the Barcelona Line (BL) as Figure 1 show.[11] When using this protocol, forward maxillomandibular movement is usually carried out, and consequently, a reverse facelift effect is obtained since the facial ST mask is tightened.[12] This antiaging effect depends not only on vectors and the quantity of skeletal movements but also on ST quality.[13]

Most studies on the impact of OS upon ST focus on the two-dimensional facial profile line of nose, lips and chin.[13-15] The purpose of this retrospective cohort study was to three-dimensionally (3D) evaluate other upper lip areas directly impacted after OS. In this regard, to our knowledge, no studies have evaluated changes of the nasolabial folds after OS, and only a few articles have evaluated upper lip vermilion eversion and changes in length.[16,17] The investigators hypothesize that some OS movements would change nasolabial fold shape and length, and projection of the vermilion. Accordingly, measurement was made of the 3D ST changes of the nasolabial folds and upper lip vermilion areas of patients with retrusive profiles that underwent bone positional changes through OS.

Material and Methods

STUDY DESIGN/SAMPLE

A retrospective cohort study was carried out involving subjects with an underlying DFD (Class II or III occlusion) with lack of upper lip support (upper incisal border behind the BL) who underwent bimaxillary OS according to the BL protocol during 2021 at the Maxillofacial Institute of Teknon Medical Center (Barcelona, Spain).

The inclusion criteria were patients who underwent bimaxillary surgery according to the BL protocol, over 18 years of age, and with maxillomandibular growth cessation at the time of surgery. The exclusion criteria were smokers, subjects with craniofacial syndromes or a history of disease conditions that could affect bone healing or ST quality, patients with previous or concomitant facial or lip aesthetic procedures (both medical and surgical), dental implants or dental rehabilitations that could change the upper lip position during the evaluated period, and failure to sign the informed consent or complete the 1-year postoperative clinical and radiological follow-up period.

The study was carried out in accordance with the ethical standards laid down in the Declaration of Helsinki (1964 and its later amendments), and was approved by the Teknon Medical Center Institutional Review Board (Ref.: 2020/92-MAX-CMT).

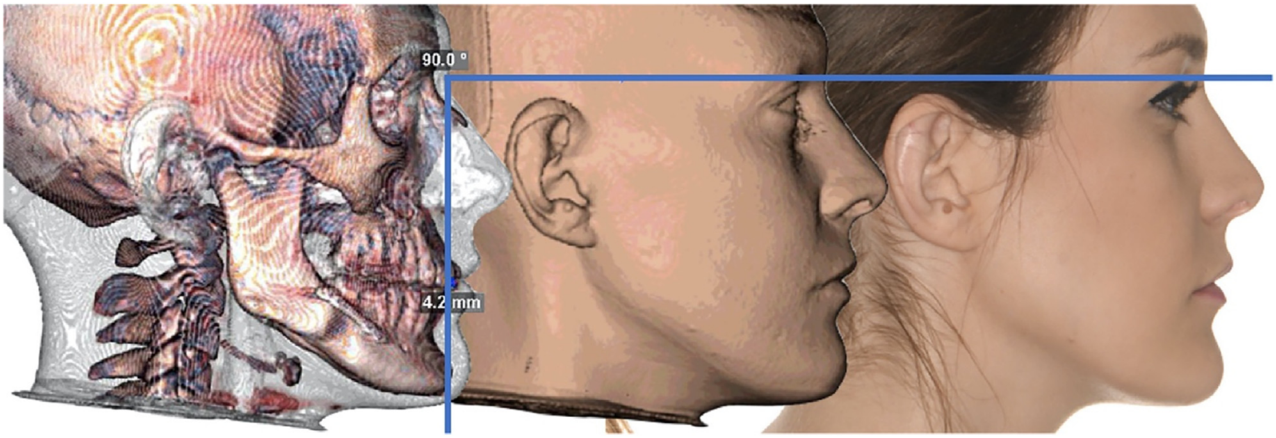

FIGURE 1. Barcelona line protocol on cone beam computed tomography (CBCT) scan (Dolphin 3D software). CBCT - 3D software image of a postoperative bimaxillary OS case, the blue line represents the BL. Note that in this case the upper incisor lies in front of the BL by 4.2 mm, and the pogonion lies on the BL. The BL protocol comprises a sequence of reproducible steps. 1) A 3D set-up is applied for DICOM positioning. 2) The photography is oriented in NHO matching up the (CBCT) 'virtual patient' ('ST layer'), in which a true horizontal line (THL) is drawn on the photograph, passing through the eye and at a determined point of the helix or over it; this photographic THL is transferred to the same point at the CBCT 'soft tissue virtual patient' in NHO, resulting in a reoriented CBCT 'virtual patient'.3) On the DICOM, the BL is traced perpendicular to the THL, crossing ST-Nasion. 4) Independently of the DFD, the cases are positioned in Class I occlusion. 5) The UI is translated (in bimaxillary cases the complex is moved as a block) virtually in or in front of the BL. The UI must have an appropriate angulation or a well-orthodontically planned position with the maxillary plane. The Pogonion must be in or ahead of the BL. 6) The dental and facial midline must be coincidental. 7) The yaw must be symmetrically corrected. 8) The vertical maxillary positioning is defined intraoperatively according to the clinical internal cantus/lateral incisor or orthodontic arch vertical measures, applying 2–3 mm of UI exposure with a relaxed upper lip (UL). Abbreviations: CBCT = cone beam computed tomography; OS = orthognathic surgery; BL = Barcelona line; NHO = natural head orientation; ST layer = soft tissue layer; THL = true horizontal line. Images published with the patient's consent.

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STUDY VARIABLES

The primary predictor variable was the timing of cephalometric measures, reported as T0 (preoperatively), T1 (1 month after surgery), and T2 (after 1 year of follow-up). Three time intervals were established for assessment of the outcomes: T1-T0 (ΔT1 = immediate changes after surgery), T2-T1 (ΔT2 = postoperative relapse) and T2-T0 (ΔT3 = global changes).

To analyze the ST changes resulting from bimaxillary surgery planned according to the BL protocol, the main outcome variable was the 3D study of the upper lip and vermilion ST changes using cephalometric measures such as the nasolabial fold length (mm) and angle (°), nasolabial angle, upper lip concavity, upper lip vermilion length, and upper lip sagittal distance from the BL (Fig 2 details the determination of each cephalometric measure).

As covariates, we recorded basic demographic data (sex, age, classification of DFD), the type of surgical-orthodontic protocol (surgery late, early or first) and the direction and magnitude of skeletal movements based on conventional angular and millimetric measurements.

Three dimensional landmarks for bone and STs are summarized in Figure 2. From these landmarks, linear and angular measurements were obtained to evaluate nasolabial fold and upper lip changes after OS, and their stability over the follow up period (Fig 3, A and B).

DATA COLLECTION

All patients had a cone-beam computed tomography (CBCT) study (iCAT, Imaging Sciences International, Hatfield, PA, USA) at three different time points: preoperatively (T0) and 1 month (T1) and 12 months after surgery (T2). The patients were instructed to breathe calmly, sitting in natural head orientation, with the tongue in a relaxed position, and the mandible in centric relation with a 2-mm wax bite in place to avoid direct contact between teeth.[18]

Three-dimensional surgical planning was performed with Dolphin Imaging Software (version 11.0, Chatsworth, CA, USA) according to the BL protocol[11] by the same surgeon (F.H.A). Surgical splints were printed in-house.[19] Patients were operated upon under general anesthesia. The mandible first protocol with Obwegeser bilateral sagittal split osteotomy[20] settled with the hybrid technique was applied.[21] Then, Le Fort I osteotomy with or without segmentation was performed through a minimally invasive approach, using the twist technique.[22] Finally, after maxillary repositioning and fixation, modified alar cinch suturing and V-Y closure were performed.[23,24]

Patients were extubated in the operating room and wore a closed-circuit cold mask at 17 °C. Twenty-4 hours after surgery, they were discharged with standard medication. Functional training with light guiding elastics and a soft diet for 1 month were prescribed.

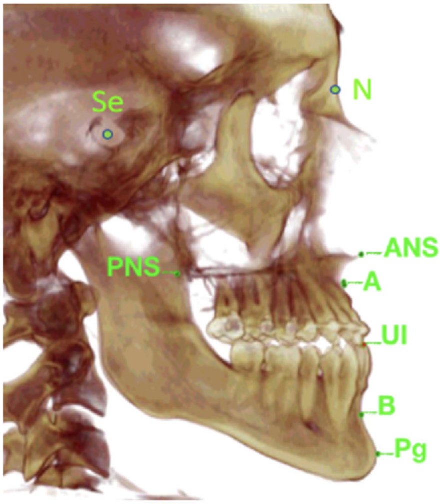
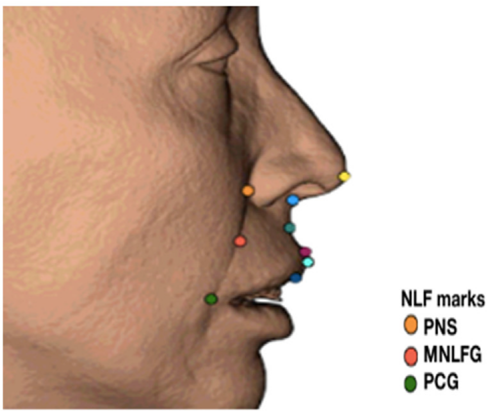
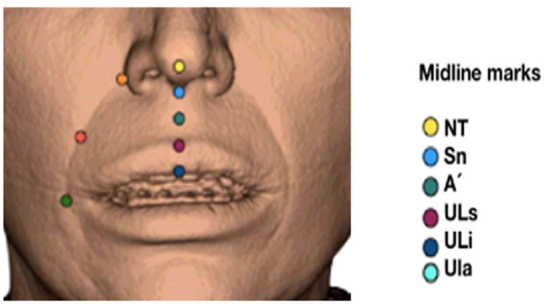
Measured on	Landmarks	3D Line	3D Angle
Hard tissue 	Sella (Se) Nasion (N) A point Upper Incisor (UI) B point Pogonion (Pg) Anterior nasal spine (ANS) Posterior nasal spine (PNS)		Se-N-A (SNA) Se-N-B (SNB) Se-N-Pg. (SNPg)
Soft tissue  	Paranasal (PN) Medium paracommissural groove (MPCG) paracommissural groove (PCG) Upper lip most superior border (Uls) Upper lip most inferior borderr (ULi) Upper lip anterior (Ula) Nasal Tip (NT) Subnasale (Sn) A soft tissue. (A´) Nasion ST. (N´)	**NLF length** PN - MPCG – PCG	**NLF Angle** PN – MPCG - PCG
		Vermillion length Vertical UL length (ULs to ULi)	**Nasolabial angle** NT - Sn – ULs
		ULa-BL Horizontal distance from ULa to BL	**UL concavity** SN - A´- ULs
		Barcelona Line (BL) True vertical line passing through ST nasion	

FIGURE 2. Measurements taken in hard and soft tissues from the 3D CBCT reconstructions.

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Two examiners (JVV and AVO) evaluated the imaging data using a landmark-based method and 3D voxel-based superimposition to ensure that all three virtual images (T0, T1, T2) were in the same position, and to avoid time-consuming measurements.[25] The examiners took two consecutive measurements and

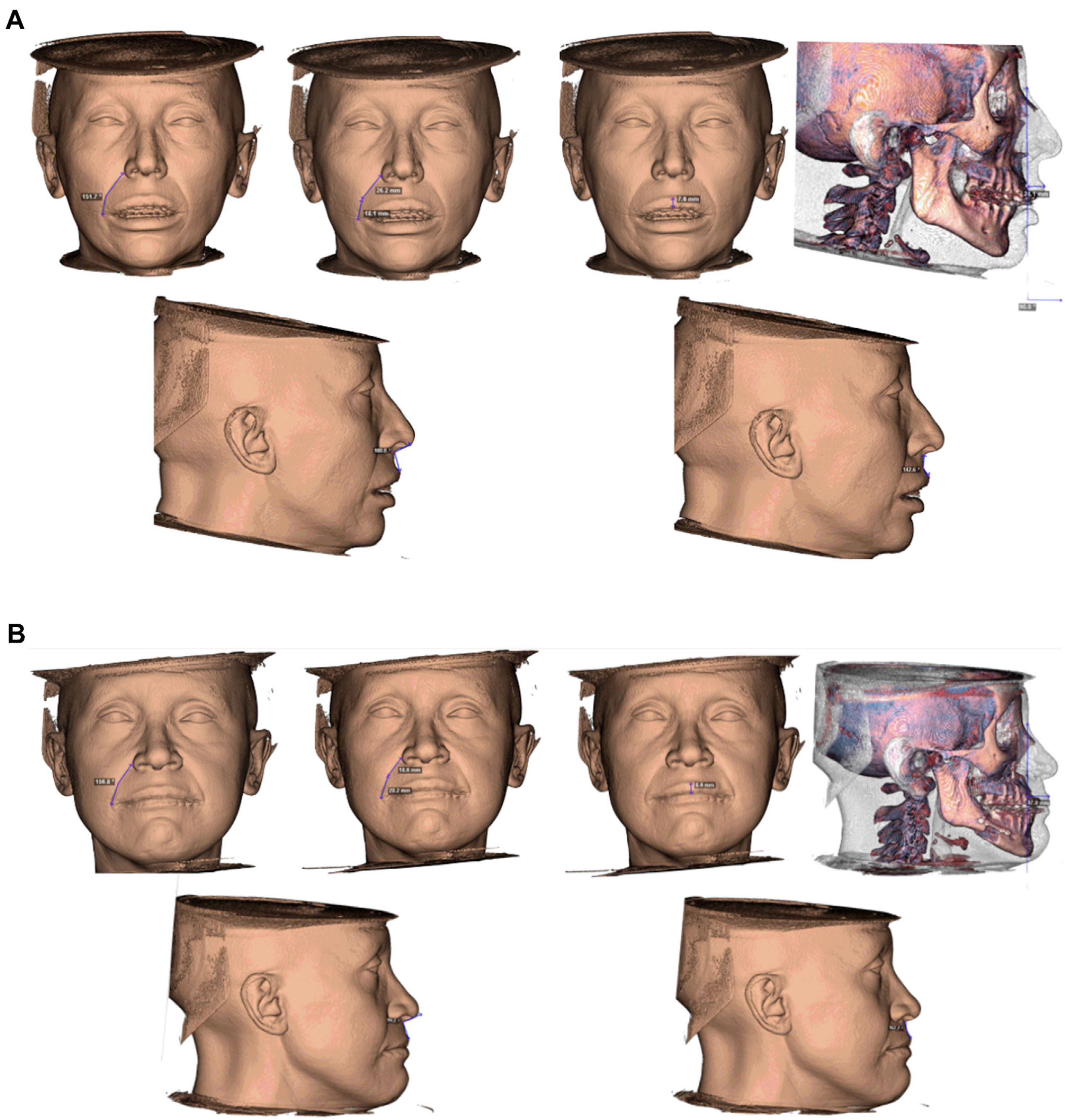

FIGURE 3. *A,* Clinical case. ST measurements from 3D-ST reconstruction at T0 (presurgical). Preoperative measurements: A: NLF angle (151.7°); B: NLF length (44.3 mm); C: vermillion length (7.6 mm); D: ULa- BL (24.1 mm); E: nasolabial angle (100.8°) F: Upper lip concavity (142.6°). *B,* Clinical case. ST measurements from 3D-ST reconstruction at T2 (after 12 months of surgery). Postoperative measurements: G: NLF angle (156.8°); H: NLF length (38.8 mm); I: vermillion length (8.6 mm); J: ULa-BL (37.8 mm); K: nasolabial angle (94.2°); L: Upper Lip concavity (162.7°).

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compared them against new measurements obtained after an interval of 2 weeks, to ensure accuracy and reproducibility.

DATA ANALYSIS

The study sample size was 27 patients and the statistical power was 80% with a 95% level of confidence. For sample size calculations, Jensen's reference[26] was used from which the standard deviation (SD) estimates. The size of the difference considered for the changes was 1.1 mm for the upper labrale variable, 0.4 mm for inferior nasal tip, 1.85 mm for inferior stomion, and 1.9 mm for lower lip stomion. These differences, in relation to the SD, correspond to the medium effect sizes (Cohen's d = 0.5). The calculations were carried out for a 1-tailed t-test.

Descriptive analyses were made, with a calculation of the mean, SD, minimum and maximum, and median for continuous variables, and absolute and relative frequencies (percentages) for qualitative variables. Absolute displacement of the X, Y, Z parameters in space was calculated using the formula:

The inferential analysis to assess nasolabial folds and upper lip projection included: 1) An analysis of variance (repeated measures analysis of variance) general linear model for comparing changes over time. The Bonferroni test was used to evaluate the ST changes at short term (T1-T0), stability (T2-T1), and global movement at long term (T2-T0); 2) Pearson's linear coefficient to correlate skeletal movements with ST changes in different periods; 3) The nonparametric Mann-Whitney U-test and Kruskal-Wallis test to assess whether changes in the skeletal and ST parameters depended upon the specific jaw movements and facial profile of the patient; and 4) Multiple linear regression models have been estimated for different outcomes (changes in parameters T2-T0) including all the independent variables detected as significant in the bivariate.

Results

After evaluating the total sample of patients (n:82) who underwent OS during the study period, n = 53 (64.6%) had bimaxillary surgery, following the exclusion criteria it was found that n = 12 (14.6%) had a septorhinoplasty before the OS, n = 6 (7%) had fillers before or during the OS, n = 4 (5%) had dental implants at the same OS surgical time and finally n = 3 (4%) did not have a complete set of CBCT data. Then, twenty-seven patients who met the inclusion criteria and none of the exclusion criteria were evaluated. There were 18 women (66.7%) and 9 men (33.3%), with a mean age of 32.5 ± 11.2 years (range: 18–57 years). Thirteen patients (48.1%) presented with initial DFD class II, while n = 14 (51.9%) presented with DFD class III. The surgery late protocol represented n = 15 (55.6%) of the cases, followed by surgery early in n = 7 (25.9%), and surgery first in n = 5 (18.5%) of the studied sample (Table 1).

The type and magnitude of the surgical skeletal movements are summarized in Table 2. All the skeletal measurements increased significantly after the operation, since all patients received an overall forwarding and widening movement of the maxilla-mandibular complex according to the BL, regardless of the initial dental class (Table 3). Only two patients received a slight mandibular setback with maxilla forwards and mandibular counterclockwise (CCW) rotation.

Table 1. DESCRIPTIVE STATISTICS

Demographic Characteristics	n = 27	%
Age (years)		100%
Mean ± SD	32.5 ± 11.2	
Range	17-60	
Sex		
Female	18	67%
Male	9	33%
Malocclusion class		
Class III	14	52%
Class II	13	48%
Maxillary segmentation		
Nonsegmented	14	52%
Segmented	13	48%
Maxillary rotation		
Counterclockwise	12	44%
None	11	41%
Clockwise	4	15%
Maxillary sagittal		
Forward	24	89%
None	3	11%
Maxillary centering		
None	18	67%
Centered	9	33%
Vertical maxilla		
None	11	41%
Downward	8	30%
Upward	8	30%
Mandibular sagittal		
Forward	18	67%
None	7	26%
Backward	2	7%
Mandibular centering		
Centered	16	60%
None	11	41%
Mandibular rotation		
Counterclockwise	14	52%
None	12	44%
Clockwise	1	4%
Chin sagittal		
None	18	67%
Forward	9	33%
Chin vertical		
None	26	96%
Downward	1	4%
Surgical timing		
Surgery late	15	56%
Surgery early	7	26%
Surgery first	5	19%

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The correlations between ST changes and the covariates are summarized in Table 4 and 5. The length of the nasolabial fold decreased more in patients undergoing segmented maxillary surgery

Table 2. LINEAR AND ANGULAR SKELETAL CHANGES AFTER BIMAXILLARY SURGERY IN THE STUDIED PERIODS. VALUES ARE REPORTED AS THE MEAN ± SD AND T-TEST WITH BONFERRONI CORRECTION OF REPEATED MEASURES ANOVA. THE CEPHALOMETRIC POINTS A, B, PG, PNS, UI DISTANCES ARE GIVEN IN MM AND WERE CALCULATED AS THE ABSOLUTE DISPLACEMENT OF THE PARAMETER IN THE SPACE OR REFERENCE SYSTEM (X,Y,Z DURING THE 3 TIME INTERVALS); THIS IS WHY THERE ARE MISSING DATA IN THE THREE FIRST COLUMNS. THE ANGLES SNA, SNB, SNPG AND NA-OP ARE GIVEN IN DEGREES

Skeletal Movements	T0	T1	T2	T1-T0	T2-T1	T2-T0
SNA	81 ± 3.3	86 ± 3.6	85.5 ± 3.8	5.1 ± 2.7 *P* < .001	−0.6 ± 1 *P* = .025	4.5 ± 3 *P* < .001
SNB	79 ± 7.1	85 ± 3.7	84.7 ± 3.5	5.9 ± 4.3 *P* < .001	−0.13 ± 0.9 *P* = 1.000	5.7 ± 4.3 *P* < .001
SNPG	80 ± 8.4	86.4 ± 4.3	86.6 ± 4.3	6.7 ± 5.5 *P* < .001	0.2 ± 1.4 *P* = 1.000	6.9 ± 5.6 *P* < .001
NA - OP	80 ± 4.6	85 ± 3.5	85.1 ± 3.8	5.4 ± 5.4 *P* < .001	0.13 ± 1.1 *P* = 1.000	5.6 ± 5.5 *P* < .001
A POINT	-	-	-	5 ± 2.4 *P* < .001	1.3 ± 0.7 *P* < .001	4.8 ± 2.03 *P* < .001
UI	-	-	-	7.1 ± 3 *P* < .001	1.8 ± 1.4 *P* < .001	7.4 ± 2.7 *P* < .001
PNS	-	-	-	5.7 ± 3.3 *P* < .001	1.3 ± 1.1 *P* < .001	5.9 ± 3.1 *P* < .001
B POINT	-	-	-	11.2 ± 7.5 *P* < .001	1.9 ± 2.3 *P* = .105	11.1 ± 7.4 *P* < .001
PG	-	-	-	13.5 ± 9.56 *P* < .001	1.4 ± 1.13 *P* < .001	13.5 ± 9.3 *P* < .001

Abbreviation: ANOVA, analysis of variance.

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(*P* = −0.03 MW), as well as in older patients (r = −0.7, *P* < .001). The lip parameters were correlated as follows: the upper lip concavity increased more in older patients (r = 0.5, *P* = .01); a greater gain in the labial projection (ULa-BL) was observed in segmented maxillary surgeries (*P* = −0.03 MW) and in older individuals (r = −0.6, *P* < .001); the changes in the length of the upper vermilion were more stable with the upward vertical movement of the maxilla (*P* = −0.004 KW), and the CCW mandibular rotation (*P* = −0.02 MW).

The ST changes in the nasolabial folds and upper lip vermilion projection measurements found after bony changes planned using the BL OS protocol over time are summarized in Table 6.

- The nasolabial fold length decreased immediately after surgery, with a further decrease at T2. Thus, a final mean decrease of −4.4 ± 7.6 mm (−12.5%; 95%CI -8.1 to-0.6 mm: *P* = .019) was observed. Older patients showed a more reduced nasolabial fold length immediately after surgery (r = −0.519, *P* = .005) and at 12 months of follow-up (r = −0.71, *P* < .001), which was related to stronger posterior nasal spine forwarding (r = −0.53; *P* = .005). Likewise, transverse maxillary gains

Table 3. BONE MOVEMENT DISTRIBUTION IN THE STUDY SAMPLE

Maxilla			Mandible			Chin		
Movement	Sample	%	Movement	Sample	%	Movement	Sample	%
Segmented	13	48.1						
Nonsegmented	14	51.9.						
Forward	24	88.9	Forward	18	66.7	Forward	9	33.3
Nonmov	3	11.1	Setback	2	7.4	Setback	0	0
			Nonmov	7	25.9	Nonmov	18	66.7
Impaction	8	29.6				Impactation	0	0
Descend	8	29.6				Descend	1	3.7
Nonmov	11	40.7				Nonmov	26	96.3
Centering	9	33.3	Centering	16	59.3			
Nonmov	18	66.7	Nonmov	11	40.7			
CW	4	14.18	CW	1	3.7			
CCW	12	44.4	CCW	14	51.9			
Nonrotation	11	40.7	Nonrotation	12	44.4			

Abbreviations: CCW, counterclockwise rotation; CW, clockwise rotation; Nonmov, no-movement.

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Table 4. BIVARIATE ANALYSES OF AGE, SEX, MALOCCLUSION CLASS AND SURGICAL TIMING VERSUS SOFT TISSUE CHANGES OF THE NASOLABIAL FOLD AND UPPER VERMILLION. THE TABLE REPORTS THE MEAN AND STANDARD DEVIATION, USING THE MANN-WHITNEY U-TEST AND KRUSKAL-WALLIS TEST

Variable	Subclassification	n = 27 (100%) Mean n ±SD	Nasolabial Angle Mean° ±SD	Upper Lip Concavity Mean°± SD	NLF Angle Mean°±SD	NLF Length Mean mm ±SD	ULa-BL Mean mm±SD	Vermillion Length Mean mm ±SD
Age	Total	32.5 ± 11.2	−5.5 ± 6	14.3 ± 12	−1 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			r = 0.1	r = 0.5	r = 0.2	r = −0.7	r = 0.6	r = −0.2
			P = .5	*P* = .01	*P* = .3	*P* < .001	*P* = .001	*P* = .4
	Less 25	9 (33%)	−5.4 ± 6	12 ± 8.7	−5 ± 7.5	0.9 ± 3.7	2.1 ± 5.1	1.3 ± 1.1
	25-40	10 (37%)	−7.3 ± 6.8	12.5 ± 9.5	1.2 ± 7.2	−3.9 ± 4	6.5 ± 8	2 ± 1.4
	Plus 40	8 (30%)	−3.3 ± 5.1	20 ± 17	1 ± 10.3	−11 ± 9	9 ± 7.4	1.3 ± 1.3
Sex	Total	27 (100%)	−5.5 ± 6	14.3 ± 12	−1 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.1 (MW)	0.7 (MW)	0.9 (MW)	0.2 (MW)	0.9 (MW)	0.4 (MW)
	Male	9 (33%)	−7.5 ± 5.4	16.6 ± 9	−1.7 ± 10	−1.7 ± 4.5	6.6 ± 7.6	1.8 ± 1.1
	Female	18/67%)	−4.4 ± 6	13.2 ± 13	−0.7 ± 8	−5.7 ± 88.5	5.2 ± 7.2	1.4 ± 1.4
Maloclussion	Total	27 (100%)	−5.5 ± 6	14.3 ± 12	−1 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.5 (MW)	0.3 (MW)	0.7 (MW)	0.3 (MW)	0.3 (MW)	0.5 (MW)
	Class II	13 (48%)	−6.7 ± 5.8	11.5 ± 13	−1.7 ± 8.6	−7.1 ± 9.3	7.7 ± 8	1.4 ± 1.3
	Class III	14 (52%)	−4.3 ± 6	17 ± 10.3	−0.4 ± 8.8	−1.8 ± 4.4	3.8 ± 6.1	1,7 ± 1.2
Surgical time	Total	27 (100%)	−5.5 ± 6	14.3 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			1 (KW)	0.1 (KW)	0.3 (KW)	0.4 (KW)	0.7 (KW)	0.9 (MW)
	Surgery first	5 (19%)	−4.8 ± 7	11.6 ± 20.4	3.6 ± 7.5	−6.3 ± 10.4	6.3 ± 6.9	1.5 ± 1.1
	Surgery early	7 (26%)	−5.8 ± 5.6	8.1 ± 9.1	0-03 ± 5.6	−1.1 ± 4.3	3.6 ± 7	1.7 ± 1.3
	Surgery late	15 (56%)	−5.5 ± 6.1	18.1 ± 8.6	−3.1 ± 9.7	−5.2 ± 7.7	6.5 ± 7.8	1.5 ± 1.4

Note: The blue color indicates significant changes, the green color indicates the most favorable changes in each group, while the red numbers indicate the detrimental effect on the areas studied.

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Table 5. BIVARIATE ANALYSES OF BONE MOVEMENT DIRECTION VS SOFT TISSUE CHANGES IN THE NASOLABIAL FOLD AND UPPER VERMILLION. THE TABLE EXPOSE MEAN, STANDARD DEVIATION USING THE MANN-WHITNEY AND KRUSKAL-WALLIS TEST

Variable	Subclassification	n = 27 (100%) Mean n ± SD	Nasolabial Angle Mean° ± SD	Upper Lip Concavity Mean°± SD	NLF Angle Mean°± SD	NLF Length Mean mm ± SD	ULa-BL Mean mm ± SD	Vermillion Length Mean mm ± SD
Maxillary segmentation	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.8 (MW)	0.7 (MW)	0.4 (MW)	0.03 (MW)	0.03 (MW)	0.8 (MW)
	Nonsegmented	14 (52%)	−5.1 ± 5.2	14.1 ± 8.7	0.2 ± 9.1	−1.1 ± 4.4	3.5 ± 6.3	1.5 ± 1.1
	Segmented	13 (48%)	−5.8 ± 6.8	14.7 ± 15.2	−2.3 ± 8.1	−7.9 ± 8.9	8.2 ± 7.6	1.6 ± 1.5
Maxillary rotation	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.5 (KW)	0.6 (MW)	0.5 (KW)	0.8 (KW)	0.1 (KW)	0.2 (KW)
	None	11 (41%)	−5.2 ± 8	15.8 ± 11	−3 ± 7	−2.3 ± 4.5	6.5 ± 7.5	1.5 ± 1.4
	Clockwise	4 (15%)	−8.6 ± 1.8	10.7 ± 8.7	1.5 ± 14	−3.3 ± 3.7	0.7 ± 0.6	2.3 ± 1
	Counterclockwise	12 (44%)	−4.7 ± 4.4	14.2 ± 14.5	−0.1 ± 8.4	−6.6 ± 10	6.7 ± 7.8	1.3 ± 1.2
Maxillary saggital	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
	None	3 (11%)	−6.7 ± 6	8.8 ± 9.6	−1.4 ± 5.6	0.6 ± 3.7	1.1 ± 1	1.3 ± 0.9
	Forward	24 (89%)	−5.3 ± 6	15 ± 12.2	−1 ± 9	−4.8 ± 7.9	6.3 ± 7.5	1.6 ± 0
Maxillary centering	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.05 (MW)	0.2 (MW)	0.6 (MW)	0.2 (MW)	0.2 (MW)	0.2 (MW)
	None	18 (67%)	−6.7 ± 4.5	12.7 ± 11.5	−1.2 ± 9	−3.9 ± 8.6	4.8 ± 6.6	1.8 ± 1.2
	Centered	9 (33%)	−2.9 ± 7.8	17.6 ± 12.9	−0.6 ± 7.2	−5,3 ± 5.3	7.5 ± 8.6	1.1 ± 1.3
Vertical maxillary	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.1 (KW)	0.9 (KW)	0.1 (KW)	0.5 (KW)	0.2 (KW)	0.004 (KW)
	None	11 (41%)	−2.9 ± 5.2	15.6 ± 10.4	−1 ± 16.8	−3.2 ± 8.6	5.6 ± 7.2	2 ± 1.3
	Downward	8 (30%)	−9.5 ± 5.7	14.5 ± 10.4	−0.5 ± 9.5	−4.1 ± 3.7	3.7 ± 7.7	2.1 ± 1.2
	Upward	8 (30%)	−5 ± 5.5	12.5 ± 16.1	−1.4 ± 10.9	−6.2 ± 9.5	7.9 ± 7.2	0.5 ± 0.7
Mandibular saggital	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.8 (MW)	0.6 (MW)	0.3 (MW)	0.6 (MW)	0.1 (MW)	0.2 (MW)
	None	7 (26%)	−5 ± 6.2	12.1 ± 13.7	2 ± 10.6	−3.2 ± 3.5	1.9 ± 1.8	2.2 ± 1.1
	Forward	18 (67%)	−6,2 ± 5.8	14.3 ± 12	−1.8 ± 8.2	−5.6 ± 8.6	7.1 ± 7.6	1.4 ± 1.3
	Backward	2 (7%)	−0.3 ± 7.4	22 ± 0.4	−5.1 ± 0.4	2.3 ± 6.3	6.4 ± 15	0.9 ± 0.3
Mandibular centering	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.6 (MW)	0.5 (MW)	0.7 (MW)	0.6 (MW)	0.3 (MW)	0.3 (MW)
	None	11 (41%)	−6.8 ± 6.6	15.3 ± 14.9	−1.7 ± 8.2	−5.4 ± 8.3	8.4 ± 9.5	1.3 ± 1.2
	Centered	16 (60%)	−4.6 ± 5.5	13.7 ± 10	−0.6 ± 9.1	−3.6 ± 7.3	3.9 ± 4.7	1.8 ± 1.3
Mandibular rotation	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3
			0.1 (MW)	0.3 (MW)	0.3 (MW)	0.3 (MW)	0.5 (MW)	0.020(MW)
	None	2 (44%)	−7.7 ± 6.9	11.6 ± 9	-3-0 ± 9	−2.1 ± 4.5	5.3 ± 7.7	2.1 ± 1.2
	Clockwise	1 (4%	0.2 ± 0.4	22.3 ± 7	5.1 ± 0	−3.6 ± 0	4.1 ± 0	0.1 ± 0
	Counterclockwise	14 (52%)	−3.9 ± 4.5	16.2 ± 14.2	0.3 ± 8.4	−6.3 ± 9.5	6.2 ± 7.4	1.2 ± 1.2
Menton sagittal	Total	27 (100%)	−5.5 ± 6	14.4 ± 12	−1.03 ± 9	−4.4 ± 7.6	5.7 ± 7.2	1.6 ± 1.3

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Table 5. Cont'd

Variable	Subclassification	n = 27 (100%) Mean n ± SD	Nasolabial Angle Mean° ± SD	Upper Lip Concavity Mean°± SD	NLF Angle Mean°± SD	NLF Length Mean mm ± SD	ULa-BL Mean mm ± SD	Vermillion Length Mean mm ± SD
			0.4 (MW)	0.5 (MW)	0.7 (MW)	0.2 (MW)	0.3 (MW)	0.3 (MW)
	None	18 (67%)	−4.5 ± 5.5	16 ± 10.1	−1.4 ± 8.6	−2.9 ± 7.1	4.3 ± 5.9	1.7 ± 1.2
	Forward	9 (33%)	−7.4 ± 6	11 ± 15	−0.4 ± 9.1	−7.3 ± 8.2	8.6 ± 9.1	1.2 ± 1.3

Note: The blue color indicates significant changes, the green color indicates the most favorable changes in each group, while the red numbers indicate the detrimental effect on the areas studied.

after expansion were related to a decreased nasolabial fold length (r = −0.60; *P* = .001).

- The nasolabial fold angle remained constant. No relevant skeletal movement correlations were detected.
- The nasolabial angle showed an immediate postoperative decrease and a further decrease at 1 year of follow-up. A final mean decrease of −5.5° ± 6 (−4.9%; 95% CI -8 to-2.5°: *P* < .001) was recorded.
- The upper lip concavity was significantly corrected after surgery, with a small relapse at T2. A final upper lip angle gain with projection/rectification of +14.4° ± 12 (10.5%; 95% CI 8.5 to 20°; *P* < .001) was obtained. Greater advancement of the A point was correlated with a greater increase in upper lip projection (r = 0.65, *P* = .001). In this context, older patients received greater A-point advancement and thus presented greater UL concavity correction (r = 0.458, *P* = .016).
- The Upper Lip Anterior - BL sagittal mean distance increased after surgery, with a minor relapse at T2, and a global mean increase of +5.7 ± 7 mm (16.4%; 95% CI 2.2 to 9.3 mm; *P* = .001)
- Vermilion length increased vertically after surgery with a nonrelevant relapse at T2. A final global vermilion mean length gain of 1.6 ± 1.3 mm (22.3%; 95%CI 0.9 to 2.2 mm; *P* < .001) was observed. Maxilla-mandibular CCW rotation had a favorable effect on vermilion length at both the short (*P* = .036) and long-term (*P* = .020) time points.

A multiple linear regression model was estimated including all the covariates detected as significant in the bivariate analysis (NLF length, Ula-BL and vermilion length) (Table 7). In the case of NLF length, the older the patient and in the presence of segmentation of the maxilla, the shorter the NLF length was found to be (*P* < .001 and *P* = .065, respectively). In the case of Ula-BL, older patients obtained greater lip eversion (*P* = .054). Lastly, in the case of upper vermilion length, maxillary upwards movement produced more positive changes (*P* = .037).

Discussion

The aim of this study was to measure the 3D ST changes of the nasolabial folds and upper lip vermilion areas of patients with retrusive profiles that underwent bone positional changes through OS according to the BL protocol. The results evidence 3D aesthetic improvement of the nasolabial folds and upper lip vermilion, afforded by appropriate dentoskeletal

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Table 6. CHANGES IN ST MEASUREMENTS AT TIMEPOINTS T0, T1, T2, AND BETWEEN PERIODS

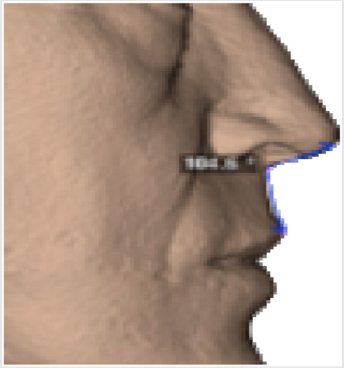
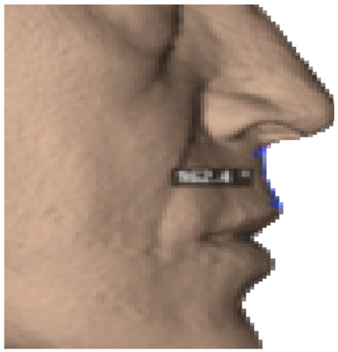
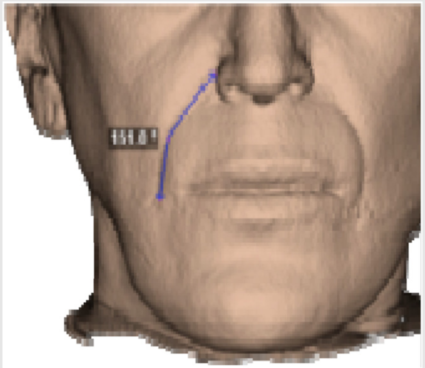
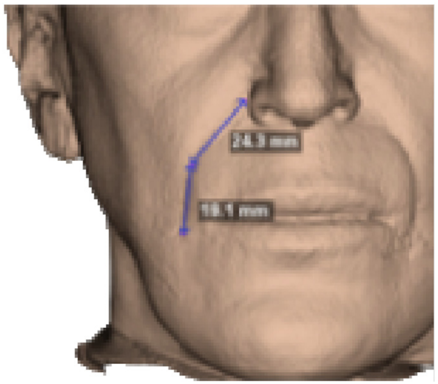
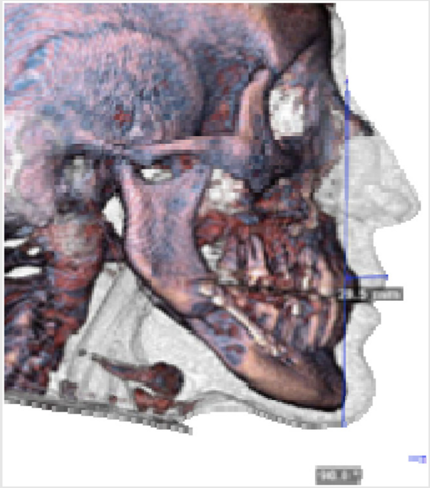
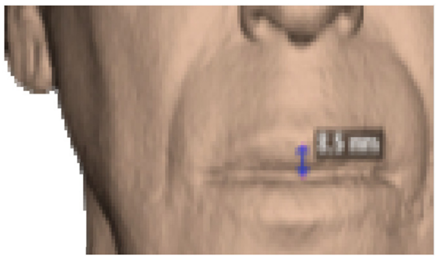
ST Measurements	T0	T1	T2	T1-T0	T2-T1	T2-T0	95% CI
Nasolabial angle 	112.4 ± 8.4	109.7 ± 9.4	107.0 ± 8.2	−2.8 ± 7 *P* = .143	−2.7 ± 5 *P* = .028	−5.5 ± 6 *P* < .001 −4.9%	−8.4/-2.5
UL concavity 	136.8 ± 12.4	151.5 ± 11.5	151.1 ± 12.4	14.7± 10.2 *P* < .001	−0.3 ± 9.4 *P* = 1.000	14.4 ± 12 *P* < .001 +10.5%	8.5/20.3

Table 6. Cont'd

ST Measurements	T0	T1	T2	T1-T0	T2-T1	T2-T0	95% CI
NLF angle 	157.8 ± 9.1	157.2 ± 6.2	156.8 ± 6.1	−0.61 ± 10.8 *P* = 1.000	−0.4 ± 6.2 *P* = 1.000	−1 ± 8.6 *P* = 1.000 −0.65%	−5.3/3.2
NLF length 	34.8 ± 8.3	31.8 ± 3.6	30.4 ± 3.6	−3.01 ± 8.8 *P* = .260	−1.4 ± 3.8 *P* = .233	−4.4 ± 7.6 *P* = .019 −12.5%	−8.1/−0.6

ULa – BL 	34.8 ± 8.5	42.4 ± 8.1	40.5 ± 9	7.6 ± 7.6 $P < .001$	−1.8 ± 4.6 $P = .138$	5.7 ± 7.3 $P = .001$ +16.4%	2.15/9.3
Vermillion length 	7.00 ± 1.5	8.5 ± 1.4	8.6 ± 1.5	1.5 ± 1.4 $P < .001$	0.1 ± 0.8 $P = 1.000$	1.6 ± 1.3 $P < .001$ +22.3%	0.9/2.2

Note: Values are reported as the mean ± SD. Lengths are given in mm. Angles are given in degrees.
The blue color indicates significant changes.
$P < .05$.

Table 7. CHANGES OF NLF LENGTH, ULA-BL AND VERMILLION LENGTH BY INDEPENDENT FACTORS AND COVARIATES: RESULTS OF THE MULTIPLE LINEAR REGRESSION MODEL

Change of		B Coefficient (95% CI)	*P* Value
NLF Length			
	Intercept	12.0 (5.85-18.2)	.001†
	Age	−0.45 (−0.64-0.26)	<.001‡
	Max. segmentation		
	No (ref.)	0	
	Yes	−3.89 (−8.04-0.26)	.065
Ula-BL			
	Intercept	−3.72 (−11.9-4.45)	.356
	Age	0.25 (−0.01-0.49)	.054
	Max. segmentation		
	No (ref.)	0	
	Yes	3.12 (−2.37-8.60)	.252
Vermillion length			
	Intercept	2.30 (1.30-3.31)	<.001‡
	Vertical max		
	No (ref.)	0	
	Downward	−0.18 (−1.41-1.05)	.760
	Upward	−1.23 (−2.39-0.08)	.037*
	Man rotation		
	No (ref.)		
	Counterclockwise	−0.55 (−1.67-0.58)	.327

Note: The blue color indicates the significant changes.
* $P < 0.5$.
† $P < 0.1$.
‡ $P < .01$.

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support according to the type of bone movement planned in OS.

The results of the study reported an important decrease in the nasolabial fold length, resulting in a less perceptible groove. Likewise, an increase was observed in the upper lip vermilion length and sagittal projection of the lip area, with improvement of the upper lip concavity. Most variables showed minor recurrences related to skeletal relapse, though this proved insignificant in relation to the initial changes recorded. On the other hand, the mean nasolabial fold length and nasolabial angle further improved from T1 to T2, perhaps secondary to accommodation of the upper lip ST during the 12-month postoperative period.

In the context of OS, the BL is a functional and aesthetic guide that conducts the maxillomandibular complex three-dimensionally to a protruded position according to individual aesthetic requirements.[27,28] A reverse facelift effect (12) is added, because the forward repositioning of the skeletal structure tightens the ST. Similarly, adequate occlusal plane rotation through maxilla-mandibular CCW rotation adds a more defined jawline. It has been widely reported that forward and CCW rotation movements - most on which BL planning is based - afford better antiaging effects, improving the perioral lines, nasal tip support, and skin tightening[12]

When an ST midface aged appearance is observed, a thin and flaccid upper lip with a deep and elongated nasolabial fold will be noted - suggesting that individualized sagittal maxillomandibular advancements, as well as the necessity for an anterioposterior maxillary widthening, could decrease the length of the nasolabial fold. Additionally, when an upper lip flattening exists, additional upper lip filler or lipofilling could be indicated, though these cases were excluded from our study to avoid adding bias.[27] Similarly, when deepening and lengthening of the nasolabial folds arise secondary to aging process, its management with fillers or facelift could be assessed.

According to Baudoin et al,[27] an ideal vermilion vertical length has not been defined, though 7-9 mm is the average in young subjects. Shorter lengths therefore could be regarded as unaesthetic. Likewise, the present study evidenced aesthetic improvement of the vermilion, since a vertical length increase of 1.56 mm ± 1.26 was recorded associated with maxillary vertical movements and CCW rotations ($P = -0.004$ KW and $P = -0.02$ MW, respectively). Moreover, this was accompanied by increased upper lip projection and correction of its concavity. It is also important to highlight the relevance of the applied modified alar cinch technique and V-Y closure to avoid nasolabial ST widening and preserve the upper lip thickness, as well as upper lip vermilion projection and length.[16,17,24] Both techniques were applied in the sample studied.

In the same context, the nasolabial angle was reduced due to increased upper lip projection. However, the subspinal Le Fort I osteotomy provides maintenance or improvement of nasal tip support, which *a priori* would increase the nasolabial angle. This means that improved upper lip projection was more relevant than nasal tip support improvement.

No changes were observed in relation to the nasolabial fold angle since our sample included mostly young adults (mean age 32.5 ± 11.2 years), and nasolabial fold deflection mainly appears in older people, where the malar fat descends and the nasolabial fold angulations become accentuated. However, our results evidenced an overall decrease in nasolabial length (-4.36 ± 7.61, $P = .01$) more accentuated in older patients ($r = -0.7$, $P < .001$).) and mostly associated with posterior nasal spine advancements and CCW rotation ($r = -0.53$, $P = .005$) as well the maxillary segmentation play an association with the NLF length change ($P = -0.03$ MW). In other words, stronger maxillomandibular forward and CCW rotation movements were required in older people, since they presented thinner and limper upper lip ST. Lastly, although it could not be measured objectively, all of the patients subjectively resulted with less perceptible nasolabial fold grooves, probably because of skin stretching in the nasolabial fold area, related to the overall ST facemask reverse lift effect. This is in line with the data found in the literature.[28]

The limitations of this study comprise its retrospective design, with the usual biases this implies. In addition, patient weight or body mass index was not measured – these being data that could influence ST volume and quality. On the other hand, the impact of orthodontic devices upon ST projection preoperatively and at 1 month of follow-up, and the ST measurements made on CBCT scans analyzed with 3D software, could add some measurement bias and should be considered in future studies. Since BL was the planning tool used, the outcomes must be interpreted with caution when generalizing them to cases planned with other methodologies. Furthermore, comparative groups to test the advantages of using the BL planning protocol over other protocols in different genders and races measuring ST thickness could be useful for assessing their behavior after OS. Lastly, mention should be made of the variability that characterizes any form of reference measurement, and emphasis must be placed on the need for accurate clinical judgment to guide diagnosis and planning in OS.

In conclusion, when adequate dentoskeletal support is provided as a function of the kind of movement planned in the context of OS, a more youthful appearance of the upper vermilion and nasolabial fold is obtained: the nasolabial angle is reduced, the nasolabial folds decrease in length, and the upper lip vermilion becomes slightly elongated and everted.

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