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Retrospective Study on Dentofacial Changes after Lefort I Advancement Surgery

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Abstract

Introduction: The main objective of our study is to assess the importance, direction, and predictability of dentofacial changes following LeFort I maxillary advancement while focusing on the extent of improvement of the soft and hard tissue profile of the face after surgery. ***Material and Method:*** This is a retrospective study carried out on patients treated in the dentofacial orthopedics unit at the Farhat Hached University Hospital of Soussa. The data of the study were obtained from a sample of 20 participants aged at least 18 years. Cephalometric measurements were performed on each patient and the collected data were analyzed with SPSS 22.0. Spearman's correlation test and simple linear regression test were used. The normality of the sample distribution was studied with the Shapiro-Wilk and Kolmogorov-Smirnov tests. The statistical significance level was set at 5%. ***Results:*** A negative and statistically insignificant correlation was found between patient age and the amount of maxillary advancement. The SNA and ANB angles were significantly and positively correlated with the amount of maxillary advancement. There was also a positive, statistically significant correlation between the amount of advancement and the thickness of the postoperative upper lip, which was confirmed by simple linear regression analysis, whereas the Z and nasolabial angles were negatively and significantly correlated with the amount of advancement. Also, a positive and statistically significant correlation was found between upper incisor exposure and upper lip thickness and length. ***Discussion****:* The results found in the literature have commonalities and differences with those found in our study, these comparisons will be discussed in our article. ***Conclusion:*** These variations should be taken into consideration and anticipated in our daily practice.

Keywords: Lefort I/Class III/upper lip/upper incisor/profile radiography.

1. INTRODUCTION

Class III skeletal anomalies are characterized by an excessively anterior position of the mandible relative to the maxilla, which can be in a normal or retrusive position.

In Class III cases with mild to moderate skeletal discrepancy, either compensatory treatment or orthosurgical treatment can be considered. [28,29]

However, unfortunately, there is no golden rule to definitively determine which case is more suitable for surgical intervention versus orthodontic camouflage. [25] Improving facial aesthetics is one of the main complaints of patients during orthognathic consultations, which leads us, in a combined treatment of orthodontics and orthognathic surgery, to correct not only the malocclusion, but also facial aesthetics.

Given the above, the objective of this study was to radiologically evaluate the extent, direction, and predictability of soft tissue changes associated with maxillary advancement.

2. MATERIALS AND METHODS

2.1. Study Type

This is a retrospective study conducted on patients treated in the Dentofacial Orthopedics Department at Farhat Hached University Hospital in Sousse.

2.2. Participants

- Approval from the Farhat Hached University Hospital Ethics Committee was obtained prior to the start of the study.
- The data for this study came from a sample of 20 participants (boys and girls) aged at least 18 years.

- All patients consulted the Dentofacial Orthopedics Department at Farhat Hached University Hospital in Sousse from August 2013 to April 2022.

2.3. Study Population

2.3.1. Inclusion Criteria

- This study included Tunisian male and female patients aged over 18 years.
- All patients included in the study had a Class III malocclusion and underwent maxillary advancement surgery alone or combined with mandibular surgery, with previous orthodontic decompensation.
- Good quality radiographs.

2.3.2. Exclusion criteria

- Patients without central incisors.
- Patients who underwent lip repositioning surgery.
- Patients who did not attend the postoperative follow-up.

3. METHODOLOGY

3.1. Radiological Technique

During the radiological examination, each patient was stabilized, using the ear olives of the cephalostat, in a horizontal position in which the Frankfurt plane was parallel to the ground and the midsagittal plane was parallel to the film.

The distance between the anode and the patient's midsagittal plane was 5 meters, while the distance between the midsagittal plane and the film was 20 cm, allowing images to be obtained with a very low magnification.

3.2. Criteria for the validity and acceptance of lateral lateral teleradiography:

- Good contrast
- Actual size
- Absence of double-sided image of the cervico-mental region
- Superposition of the orbital roofs
- Clarity of soft structures and the pharynx

3.3. Selected Cephalometric References

Pre-surgical and post-surgical lateral teleradiography were plotted and analyzed at two different time intervals to perform intra-examiner calibration.

On each lateral teleradiography, we performed a cephalometric tracing, determining various points and lines.

These angles and measurements were of interest to: The skeletal variables (SNA,SNB), the alveolar variables (Frankfurt plane; Plane parallel to the Frankfurt plane and passing through the incisal edge of the lower incisor; Plane parallel to the Frankfurt plane and passing through the incisal edge of the upper incisor) and the cutaneous variables (Measurement of upper lip thickness, Measurement of lip length, Measurement of nasolabial angle, Measurement of Z angle. ANS: Anterior nasal spine, PNS: Posterior nasal spine)

3.4. Statistical Analysis

All collected data were entered into a computer using SPSS 22 software.

The Spearman correlation test and the simple linear regression test were used to study the relationship between the extent of maxillary advancement, age, angular and linear variables in the sagittal and vertical directions.

The normal distribution of the sample was examined using the Shapiro-Wilk and Kolmogorov-Smirnov tests.

The statistical significance threshold was set at 5%.

3.5. Ethical Aspects

Our study was conducted with the approval of the Ethics Committee of the Farhat Hached University Hospital in Sousse.

4. RESULTS

4.1. Sample Description

Twenty patients, including 12 girls (60%) and 8 boys (40%), aged 18 to 31 years with a mean age of 21.75 +/- 3.37 years, were included in this study **(Fig. 1).**

The amount of maxillary advancement ranged from 2 to 8 mm, with a mean of 4.7 mm and a standard deviation of 1.593 **(Fig. 2).**

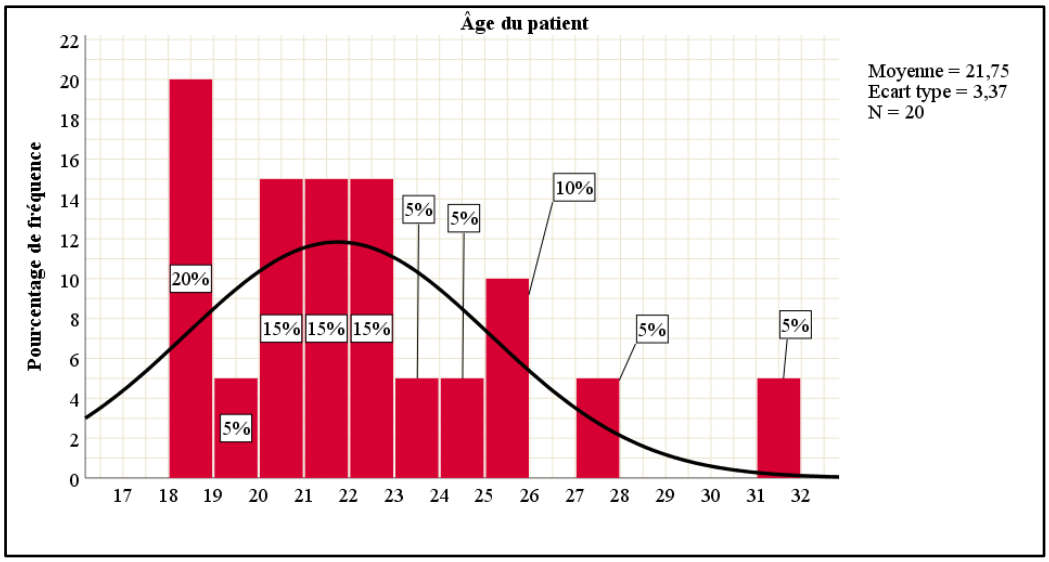

Figure 1: Sample distribution by age with percentages

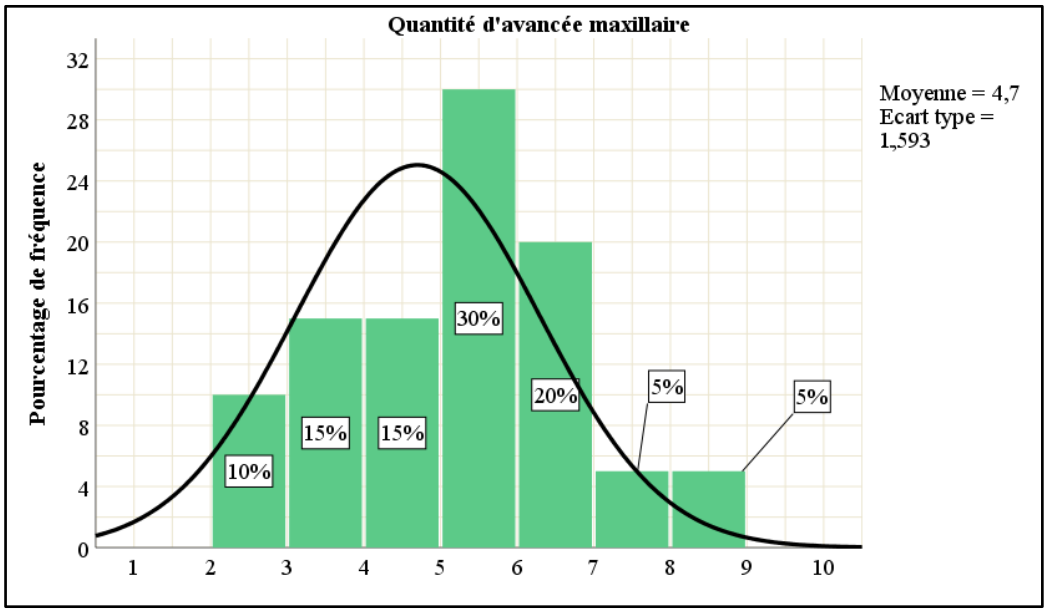

Figure 2: Sample distribution according to the amount of maxillary advancement with percentages

4.2. Analytical Results

4.2.1. khi 2 Test

There were weak and statistically insignificant associations between patient sex and the amount of maxillary advancement ($X^2 = 5.764$; df = 6; VC = 0.537; p = 0.450 > 0.05).

4.2.2. Comparative Analysis

The paired analysis test shows an increase in the SNA angle, which increased from a mean value of 76.60° to 80.75°.

An increase in the ANB angle was also noted, from -3.45° preoperatively to 1.55° postoperatively. The I/F angle, overjet, upper incisor exposure, and upper lip length and thickness improved significantly postoperatively. However, the I/i angle, nasolabial angle, and Z angle decreased postoperatively **(Table 1).**

4.2.3. Correlation Test

4.2.3.1. Correlation between age and the amount of maxillary advancement

A negative and statistically insignificant correlation was found between patient age and the amount of maxillary advancement **(Table 2).**

4.2.3.2. Correlation between the amount of maxillary advancement and cephalometric measurements in the sagittal and vertical direction (skeletal, dental and soft tissue).

There was no statistically significant correlation between the amount of maxillary advancement and the following parameters: post-operative SNB, post-operative I/F, post-operative I/i, post-operative upper incisor exposure and post-operative upper lip length.

A positive and statistically significant correlation between the amount of advancement and the post-operative SNA angles, post-operative ANB with respectively (r = 0.579**; p = 0.007 < 0.01) and (r = 0.501*; p = 0.025 > 0.01).

There was also a positive and statistically significant correlation between the amount of advancement, postoperative overjet and postoperative upper lip thickness with (r = 0.460*; p = 0.041 > 0.01).

The correlation between the amount of advancement, nasolabial angle and Z angle was negative and statistically significant with respectively (r = - 0.610**; p = 0.004 < 0.01) and (r = - 0.472* p = 0.036 > 0.01) **(Table 3).**

4.2.3.3. Correlation between upper incisor exposure and upper lip thickness and length.

A positive and statistically significant correlation was found between upper incisor exposure and upper lip thickness and length, with (r=603**, p=0.005<0.01) and (r=597**, p=0.005<0.01), respectively **(Table 3).**

4.2.4. Simple linear regression test

4.2.4.1. Regression of postoperative cephalometric measurements in the sagittal and vertical directions according to the amount of maxillary advancement

The simple regression model reveals that the amount of maxillary advancement has a statistically insignificant effect on the following variables:

Postoperative SNB, postoperative I/F, postoperative I/I, postoperative upper incisor exposure, and postoperative upper lip length.

4.2.4.2. Simple linear regression of postoperative upper lip thickness according to the amount of maxillary advancement

The simple linear regression model revealed that the amount of maxillary advancement (MA) had a significant effect on upper lip thickness (UL) (F = 4.823, R^2 = 0.211, p = 0.041).

The dependent variable (DV) explained up to 21.1% of the variance of the independent variable (UL) **(Figure 3).**

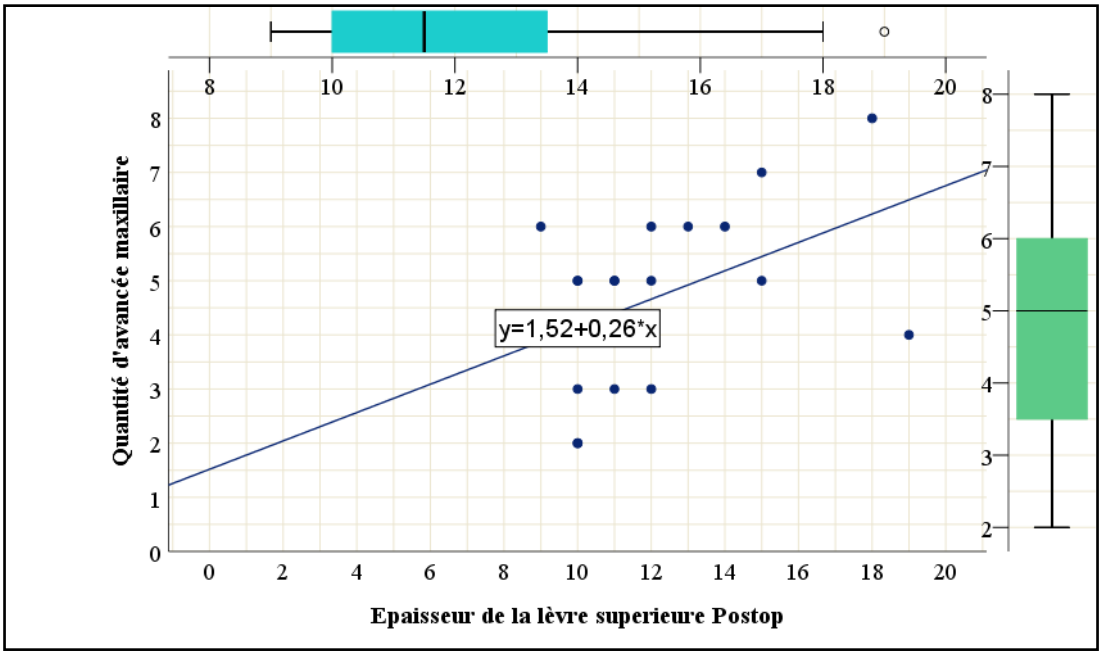

Figure 3: Simple linear regression of postoperative upper lip thickness according to the amount of maxillary advancement

4.2.4.3. Simple linear regression of postoperative nasolabial angle according to the amount of maxillary advancement

The simple linear regression model reveals that the amount of maxillary advancement (MA) has a significant effect on the nasolabial angle (MA) (F = 10.665, R^2 = 0.372, p = 0.004).

The dependent variable (MA) explains up to 37.2% of the variance in the independent variable (MA) **(Figure 4).**

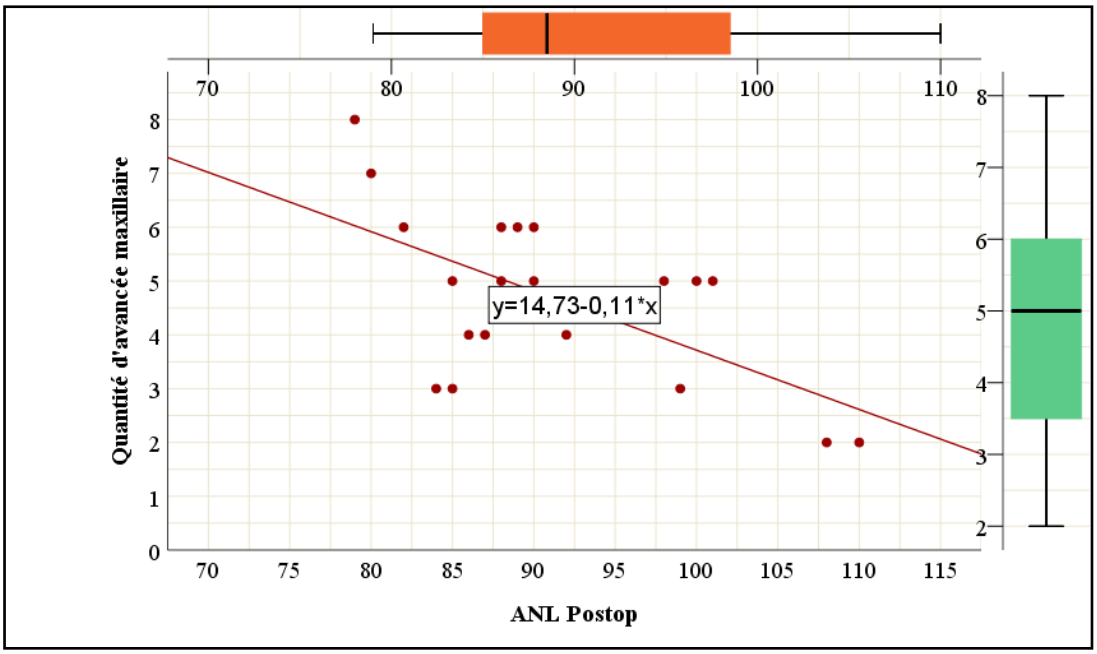

Figure 4: Simple linear regression of postoperative nasolabial angle according to the amount of maxillary advancement

4.2.4.4. Simple linear regression of upper lip thickness according to the amount of upper incisor exposure

The simple linear regression model reveals that upper incisor exposure (MA) has a significant effect on upper lip thickness (MA) (F = 10.289, R^2 = 0.364, p = 0.005). The dependent variable (DV) explains up to 36.4% of the variance in the independent variable (IV) **(Figure 5).**

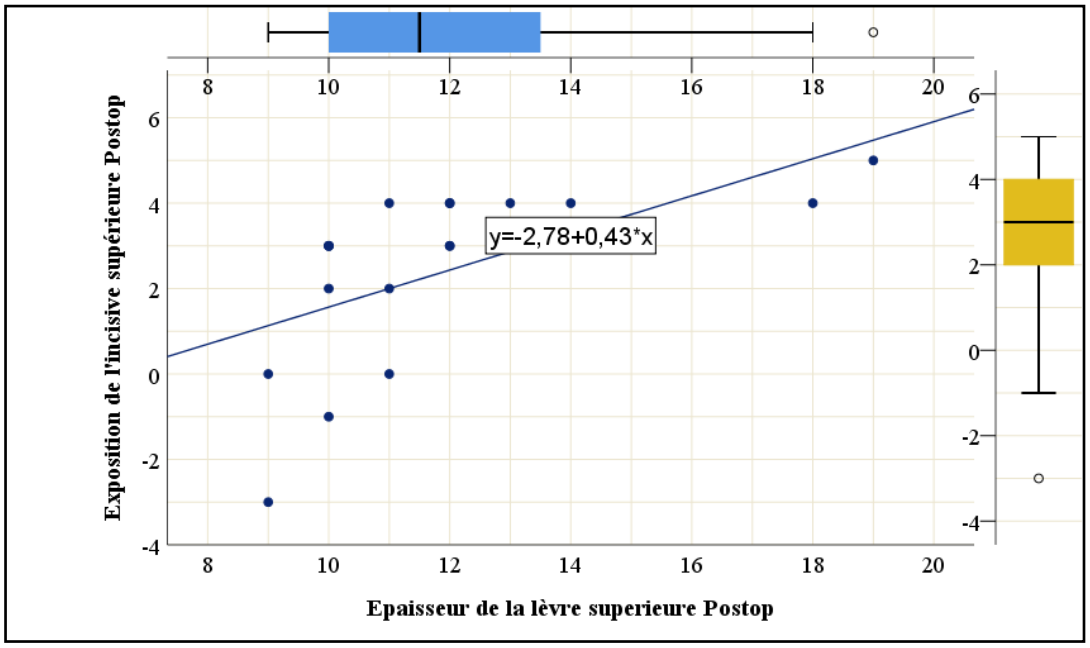

Figure 5: Simple linear regression of upper lip thickness versus upper incisor exposure

4.2.4.5. Simple linear regression of upper lip length according to the amount of upper incisor exposure

The simple regression model reveals that upper incisor exposure (DV) has a significant effect on upper lip length (IV) (F = 9.958, R^2 = 0.356, p = 0.005).

The dependent variable (DV) explains up to 35.6% of the variance in the independent variable (IV) **(Figure 6).**

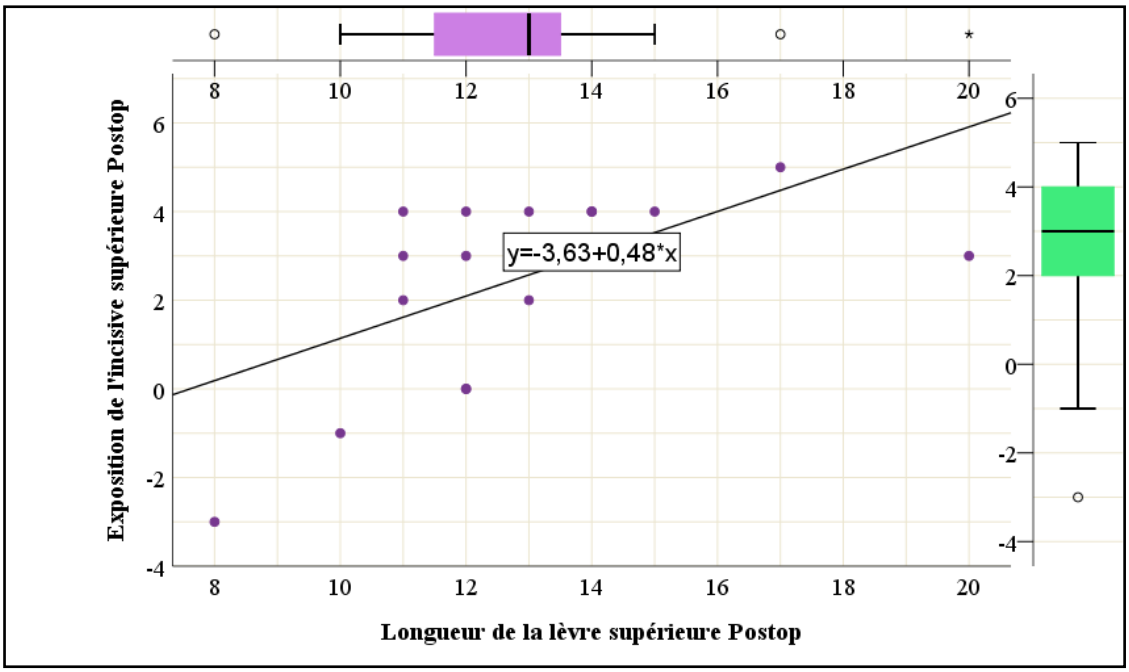

Figure 6: Simple linear regression of upper lip length according to the amount of upper incisor exposure

5. DISCUSSION

Successful surgical planning and accurate prediction of orthognathic surgery outcomes include not only occlusal correction and a balanced skeletal relationship, but also improvement of the patient's facial aesthetics. [1,38]

Indeed, Kerr *et al.,* suggested that surgery be performed in patients with an ANB and IMPA angle less than -4° and 83°, respectively. [9]

In this context, in cases of Class III malocclusion, maxillary advancement aims to correct the occlusion, improve facial aesthetics, and harmonize the facial profile.

Therefore, it is important for the clinician to be able to predict soft tissue changes resulting from hard tissue alterations. [18,27]

To this end, our study was conducted to compare and analyze soft tissue changes after orthognathic surgeries. Treatment outcomes were assessed by comparing cephalograms immediately before surgery, in which the dentoalveolar structures were decompensated, with cephalograms taken at the end of treatment.

5.1. Bone Structures

5.1.1. Maxillary Bone Position

A positive and statistically significant correlation was observed between the amount of advancement and the postoperative SNA angle ($r = 0.579^{**}$; $p = 0.007 < 0.01$). This is explained by the advancement of point A following maxillary advancement. The greater the amount of advancement, the more forward point A is.

This finding is consistent with previous observations by Ron Jacobson and David M. Sarver, who conducted a study confirming the predictability of improvement in maxillary position after LeFort I maxillary advancement surgery. [14]

5.1.2. Maxillo-mandibular relation

Following maxillary advancement, the SNA angle increases, and therefore the ANB angle increases, resulting in a correction of skeletal Class III and a tendency toward skeletal Class I, thereby achieving the surgical objective.

5.2. Dentoalveolar Structures

5.2.1. Upper Incisor Inclination

Comparative analysis of our sample showed a significant increase in the I/F angle of 4.8°.

Despite this increase, there was no statistically significant correlation between the amount of maxillary advancement and the inclination of the upper incisor.

As in other studies, it is important to keep in mind the limitations of postoperative orthodontics affecting the position of the maxillary incisor. In this study, we were unable to eliminate this variable because all patients were orthosurgical patients. However, in our sample, most orthodontic treatments were undertaken preoperatively to minimize the length of fixed appliances postoperatively. [16]

5.2.2. Upper Incisor Exposure

Sample analysis revealed an increase in maxillary incisor exposure postoperatively. This is consistent with the study by Guilherme dos Santos Trento and colleagues, who found that in most patients who underwent maxillary advancement alone or in combination with another mandibular procedure, the results indicated a 23.33% increase in radiographic exposure of the maxillary central incisors after orthognathic surgery. [27] Another commonality was present in both studies, manifested by the absence of a statistically significant correlation between the amount of maxillary advancement and postoperative upper incisor exposure **(Table 3).**

However, it is difficult to have a standard or universal method for measuring tooth exposure with relaxed lips due to the number of variables that can be associated with it, such as the degree of muscle activity, individual diversity factors, and age.[10]

5.2.3. Overjet

A positive and statistically significant correlation was found between the amount of maxillary advancement and postoperative overjet ($r = 0.885^{**}$; $p = 0.000 < 0.01$ **(Table 3).** This increase is the result of the improvement in overjet, which went from a negative value (reverse bite) to a positive value.

5.3. Soft Structures

5.3.1. Nasolabial Angle

The results of this study are consistent with those of previous studies in that soft tissues increasingly follow the movement of hard tissues, probably due to their close relationship with the underlying hard tissues. [2,8,20]

Indeed, the study by Burçin Akan and colleagues supports the same idea, as it also showed a decrease in the nasolabial angle. **(1)** Unlike our study, Louis et al. found no significant correlation between the degree of change in the nasolabial angle and the degree of maxillary advancement. [19]

However, there is no consensus on changes in the nasolabial angle in the literature. [25] While some studies report significant changes in the nasolabial angle (an average value of 0.65° for every 1 mm of advancement), [11,23] others report no significant change or even a reduction. [12, 13]

5.3.2. Upper Lip Thickness

Analysis of the results revealed a positive and statistically significant correlation between the amount of advancement and postoperative upper lip thickness ($r = 0.460$; $p = 0.041 > 0.01$) **(Table 3).** This correlation is confirmed by the simple linear regression model, which reveals that the amount of maxillary advancement (VD) has a significant effect on upper lip thickness (ULT) ($F = 4.823$, $R^2 = 0.211$, $p = 0.041$).

In contrast to our study, Stella et al. conducted a study to assess the predictability of changes in the soft tissues of the upper lip following maxillary advancement surgery using the LeFort I technique. They selected 20 adult patients with a six-month follow-up.

The patients were divided into two groups based on lip thickness:

- Group 1 with an upper lip thickness between 10 and 17 mm.
- Group 2 with a thickness greater than 17 mm.

The results showed that patients with thin lips experienced a reduction in upper lip thickness. [7,27] In this regard, Bays *et al.,* also reported compression and thinning of the upper lip following anterior maxillary repositioning. [2]

Studies describing the influence of surgical soft tissue corrections are limited. However, some studies have shown that soft tissue changes in the lips are influenced by the extent and direction of maxillary bone displacement during surgery, primarily by lip tone and thickness.[5]

Contrary to this work, Stella et al. reported, in another study, a dead space, which is more visible in patients with severe maxillary retrognathism, where a true air pocket exists between the maxillary dentoalveolar structures and the upper lip mucosa. The authors suggested that a maxilla advanced into this dead space would not show any change in soft tissue contours. [4,26]

On the other hand, when studying the correlation between upper incisor exposure and upper lip thickness, a positive and statistically significant correlation was found between these variables ($r = 603$, $p = 0.005 < 0.01$) **(Table 4).**

In the same context, Trento et al. showed that there is a statistically significant correlation between maxillary central incisor exposure and lip thickness after LeFort I advancement surgery by studying lateral cephalograms ($p = 0.002$ / $r = 0.696$ - 99% CI). However, they stated that these radiographic measurements depend on lip positioning during the radiographic procedure, which can lead to variation in the results. [19,27] In this context, some authors claim that thinner lips tend to expose more incisors after maxillary advancement, which can produce or worsen a gummy smile [3,8]**.**

5.3.3. Upper Lip Length

According to our results, the length of the upper lip increases by an average of 1.5 mm, but this is not influenced by the extent of maxillary advancement **(Table 1).**

Indeed, Conley and Boyd also reported that the upper lip increased in length, but not in a clinically significant manner. **[**20]

Contrary to our study, Van Butsele et al. concluded, in a retrospective cephalometric study, that for every millimeter of maxillary advancement, the upper lip moved upward by almost 30% of the amount of advancement. [10]

Overall, the literature presents a wide variability of results, ranging from a shortening of 0.8 mm to an increase in height of 2.48 mm. [15]

A positive and statistically significant correlation between upper incisor exposure and upper lip length was demonstrated (r=597, p=0.005 <0.01) **(Table 4).** This correlation was confirmed by the simple regression model revealing that upper incisor exposure (VD) has a significant effect on upper lip length (VI) (F =9.958, R^2=0.356, p=0.005) **(Table 5).**

Our results do not support those reported by Trento *et al.,* who did not find a statistically significant correlation between lip height and increased radiographic exposure of the teeth after surgery (Pearson correlation coefficient p = 0.357).

Table 1: Paired sample statistics

		Moyenne	N	Ecart type	Moyenne erreur standard
Paire 1	SNA pré-opératoire	76,60	20	2,963	,663
	SNA post-opératoire	80,75	20	2,881	,644
Paire 2	SNB pré-opératoire	80,20	20	3,002	,671
	SNB post-opératoire	80,25	20	3,385	,757
Paire 3	ANB pré-opératoire	-3,45	20	1,877	,420
	ANB post-opératoire	1,55	20	1,669	,373
Paire 4	I/F pré-opératoire	115,80	20	7,898	1,766
	I/F post-opératoire	120,60	20	9,213	2,060
Paire 5	I/i pré-opératoire	126,30	20	11,434	2,557
	I/i post-opératoire	124,45	20	10,344	2,313
Paire 6	Overjet pré-opératoire	-3,05	20	1,701	,380
	Overjet post-opératoire	1,95	20	,999	,223
Paire 7	Exposition de l'incisive supérieure pré-opératoire	2,40	20	2,542	,568
	Exposition de l'incisive supérieure post-opératoire	2,50	20	2,013	,450
Paire 8	Angle nasolabial pré-opératoire	97,90	20	9,711	2,171
	ANL post-opératoire	91,05	20	8,817	1,971
Paire 9	Epaisseur de la lèvre supérieure pré-opératoire	12,15	20	2,796	,625
	Epaisseur de la lèvre supérieure post-opératoire	13,25	20	3,385	,757
Paire 10	Longueur de la lèvre supérieure pré-opératoire	11,35	20	2,390	,534
	Longueur de la lèvre supérieure post-opératoire	12,85	20	2,519	,563
Paire 11	L'angle Z pré-opératoire	77,25	20	6,129	1,371
	L'angle Z post-opératoire	68,80	20	6,031	1,349

Table 2: Correlation between age and the amount of maxillary advancement

		Amount of maxillary advancement
Patient's age	Pearson correlation	-,142
	Sig. (bilateral)	,550
	N	20

Table 3: Pearson correlation results between the amount of maxillary advancement and postoperative cephalometric measurements in the vertical and sagittal direction

post-operative SNA	Pearson correlation	,579**
	Sig. (bilateral)	,007
	N	20
post-operative SNB	Pearson correlation	-,386
	Sig. (bilateral)	,093
	N	20
post-operative ANB	Pearson correlation	,501*
	Sig. (bilateral)	,025
	N	20

post-operative I/F	Pearson correlation	-,220
	Sig. (bilateral)	,351
	N	20
post-operative I/i	Pearson correlation	,152
	Sig. (bilateral)	,521
	N	20
post-operative Overjet	Pearson correlation	,885**
	Sig. (bilateral)	,000
	N	20
Exposition de l'incisive supérieure post-opératoire	Pearson correlation	,361
	Sig. (bilateral)	,118
	N	20
ANL post-opératoire	Pearson correlation	-,610**
	Sig. (bilateral)	,004
	N	20
Epaisseur de la lèvre supérieure post-opératoire	Pearson correlation	,460*
	Sig. (bilateral)	,041
	N	20
Longueur de la lèvre supérieure post-opératoire	Pearson correlation	,251
	Sig. (bilateral)	,287
	N	20
L'angle Z post-opératoire	Pearson correlation	-,472*
	Sig. (bilateral)	,036
	N	20

*The correlation is significant at the 0.05 level (bilateral)
**The correlation is significant at the 0.01 level (bilateral)

Table 4: Pearson correlation results between upper incisor exposure and upper lip thickness and length

		Postoperative upper lip thickness	Postoperative upper lip length
Postoperative upper incisor exposure	Pearson correlation	,603**	,597**
	Sig. (bilateral)	,005	,005
	N	20	20

**. The correlation is significant at the 0.01 level (bilateral)

Table 5: Simple linear regression of upper lip length as a function of upper incisor exposure.

Model	R	R²	R² adjusted	Standard error of estimation					
					Variation of R	Variation of F	ddl1	ddl2	Sig. Variation of F
1	,597[a]	,356	,320	1,660	,356	9,958	1	18	,005

a. Predictors: (Constant), Upper lip length Postop

6. LIMITATIONS

The relatively small sample size of the present study (20 individuals: 8 men and 12 women) is the result of the strict selection criteria applied to eliminate some of the drawbacks of the retrospective study design. This clearly highlights the need for further research in this area.

On the other hand, the limitation of this study is the use of two-dimensional recordings for soft tissue assessment.

However, soft tissues exhibit a 3D architecture that, in addition to length and width, describes the depth of structures. On lateral cephalometric radiographs, only a two-dimensional profile of the soft tissues can be observed, whereas on 3D photographs, clinicians and researchers can examine changes in every aspect of the face in all areas.

In addition, many factors influence the response of facial soft tissues, including local conditions (muscle tone, tissue thickness) and general conditions (weight change and aging). This is why it is not always possible to fully predict the changes that occur.

Finally, it is important to note the problems associated with cephalometric tracings and analyses, which in this case are performed by a single operator and monitored by a supervisor. The significant inter-variability between operators calls into question the need

for at least two operators to assess radiological structures.

7. CONCLUSION

Determining changes in the facial soft tissue profile after orthognathic surgery, assessing the potential effects of treatment on the stability of facial aesthetics, and assessing the predictability of these changes are essential elements in any therapeutic management procedure.

These results can thus help the orthodontist more accurately determine the expected changes and prevent adverse effects of surgery.

A synergy between the orthodontist and the maxillofacial surgeon is therefore essential to achieve results that meet the patient's expectations.

Conflict of Interest: The author declares that he has no conflict of interest concerning the data published in this article.

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