Soft Tissue Changes after Maxillary Advancement in Patients with Cleft Lip and Palate

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ABSTRACT

Objectives: The purpose of this retrospective observational study was to analyse the soft tissue response in patients with cleft lip and palate undergoing maxillary advancement and its correlation with hard tissue changes.
Material and Methods: A cephalometric analysis and comparison of pre- and postoperative lateral cephalometric radiographs was performed using Dolphin Imaging software (Dolphin Imaging & Management Solutions). A total of 261 lateral cephalometric radiographs (preoperative, immediate postoperative and 6 months postoperative) from 87 patients with cleft lip and palate who underwent maxillary advancement (Le Fort I osteotomy) were analysed. Maxillary advancement was measured and patients were categorized by advancement magnitude. Statistical analysis involved comparison of soft tissue changes across different advancement groups.
Results: Overall, significant increases were observed in overjet, overbite, upper lip length, and facial harmony, while nose size decreased. The highest soft/hard tissue ratios were observed with advancements ≤ 5.0 mm. Soft tissue changes were minimal for advancements ≤ 5.0 mm but more pronounced for larger advancements. No significant correlation was found between cephalometric variables and maxillary advancement.
Conclusions: Maxillary advancement significantly influences soft tissue changes in patients with cleft lip and palate. Smaller advancements result in minimal soft tissue changes, while larger advancements impact lip thickness and incisor exposure.

Keywords: cephalometry; cleft lip; cleft palate; LeFort Osteotomy; maxillary osteotomy; orthognathic surgery.

Accepted for publication: 24 January 2026
To cite this article:
De Oliveira Tanaka AK, Marinho Barcellos B, Medrano Gutiérrez A, de Paula Oliveira Gringo C, Toledo Teixeira da Silveira I, Reis de Araújo Carvalho L, Yassutaka Faria Yaedú R.
Soft Tissue Changes after Maxillary Advancement in Patients with Cleft Lip and Palate
J Oral Maxillofac Res 2026;17(1):e5
URL: http://www.ejomr.org/JOMR/archives/2026/1/e5/v17n1e5.pdf
doi: 10.5037/jomr.2026.17105

INTRODUCTION

Individuals with cleft lip and palate (CLP) commonly present with a concave facial profile, due to skeletal abnormalities and soft tissue features. The cleft rehabilitative process results in midfacial growth deficiency, facial aesthetic compromise, and velopharyngeal dysfunction, impacting both the functional and psychosocial aspects of affected individuals [1-3]. These patients also typically exhibit a lack of cheek contour, nasolabial imbalance, insufficient projection of the nasal tip, inadequate support for the upper lip, reduced upper incisor exposure, and anterior and posterior cross bite, alongside compromised alveolar and dental structures [4-7].

Around 25% of patients require surgical correction due to severe maxillary deficiency and the failure of conservative treatments with orthodontics and maxillary orthopaedics [7]. Therefore, orthognathic surgery seeks to correct maxillary skeletal anomalies through advancement, thereby improving function, facial profile, and dentoskeletal harmony, with Le Fort I osteotomy being the most commonly used approach [8,9].

In soft tissue management, changes in dental-skeletal positioning and its repercussions should be anticipated during preoperative orthodontic-surgical planning, given the close relationship between soft and hard tissues and the need to enhance the facial profile, which represents the primary aesthetic concern for these patients. The goal is to establish a predictable soft-to-hard tissue advancement ratio to optimize postsurgical outcomes. In patients without clefts, this ratio typically ranges from 0.4 : 1 to 0.6 : 1, however, its application in patients with CLP remains incompletely understood [10].

Maxillary advancement in patients with CLP is a well-established approach for correcting skeletal deformities and improving the facial profile. However, there is a lack of detailed, quantified assessments of soft tissue changes associated with this procedure. Most studies primarily focus on the impact of maxillary advancement on bone and dental structures, with limited insight into the relationship between skeletal movement and soft tissue alterations. Furthermore, no clear consensus exists regarding the ideal soft-to-hard tissue advancement ratio, which complicates the prediction of consistent aesthetic outcomes. Therefore, this retrospective observational study aims to evaluate and quantify the soft tissue changes associated with maxillary advancement in patients with cleft lip and palate, by analysing the soft tissue response and its correlation with hard tissue changes.

MATERIAL AND METHODS

The study was conducted at the Department of Oral and Maxillofacial Surgery of the Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo (HRAC-USP), Brazil.

The study was carried out between May 1 and December 31, 2020, using archived patient records and lateral cephalometric radiographs obtained from the HRAC-USP image archive. This study follows the STROBE guidelines for observational studies [11]. The sample consisted of patients with CLP who underwent orthognathic surgery for maxillary advancement through Le Fort I osteotomy between January 1, 2005 and December 31, 2013 (Figure 1).

The study protocol was approved by the Ethics Committee of HRAC-USP (CAAE: 16616413.7.0000.5441; report No. 841.966). All data were anonymized prior to the analysis. All patients had previously signed an informed consent form authorizing the use of their clinical data for the research purposes.

Inclusion criteria

The inclusion criteria were patients with unilateral or bilateral complete or incomplete clefts, who underwent maxillary advancement using Le Fort I osteotomy, fixation with plates and screws. The patients had to have lateral cephalometric radiographs with adequate visibility in the preoperative, immediate postoperative periods and at least 6 months postoperative.

Exclusion criteria

The exclusion criteria comprised patients less than 15 years of age, those who underwent maxillary expansion, individuals with a history of previous orthognathic surgery, edentulous patients, those with interference from devices, syndromic conditions, imaging issues, or a lack of required radiographs.

Definitions of cephalometric variables

The following cephalometric variables were used for this study.

Dentoskeletal measurements:

- Maxillary incisor-maxillary occlusal plane angle (Ang Mx1), (°): angle between the long axis of the upper incisor and the maxillary occlusal plane.

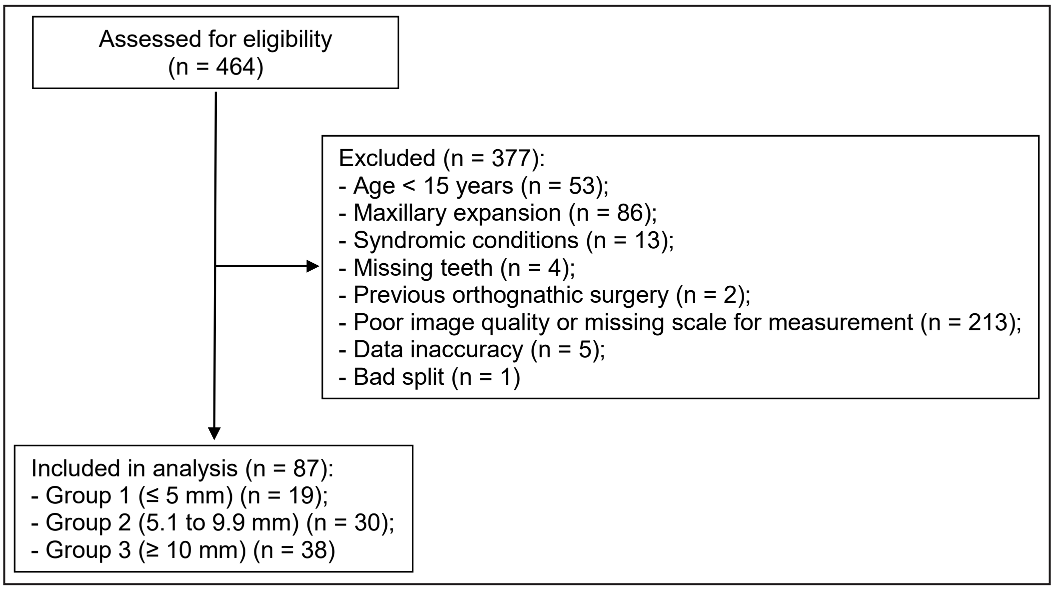

Figure 1. STROBE flow diagram.

- Overjet (OJ), mm: horizontal distance from the incisal surface of the upper incisor to the incisal surface of the lower incisor.
- Overbite (OB), mm: vertical distance from the incisal surface of the upper incisor to the incisal surface of the lower incisor.

Soft tissue structures:

- Upper lip thickness (Tck UL), mm: distance between the internal upper lip point and the anterior upper lip.
- Upper lip angle (Ang UL), (°): angle formed by the anterior upper lip line to the subnasal point and a vertical line passing through the subnasal point.
- Nasolabial angle (Ang NasoLip), (°): angle formed by the line of the columella (cartilaginous base of the nasal septum) to the subnasal point,
- extending to the anterior upper lip point (Figure 2).

Facial length:

- Upper lip length (Sn-ULI), mm: distance between the subnasal point and the lower margin of the upper lip.
- Upper incisor exposure (Exp Mx1), mm: distance between the lower boundary of the upper lip and the incisal edge of the upper incisor (Figure 3).

Facial harmony:

- Glabella to A’ point (G’-A’): horizontal distance from the glabella point to the A’ tegumentary point.
- Upper lip-lower lip (ULA-LLA): horizontal distance between the most anterior point of the upper lip and the most anterior point of the lower lip (Figure 4).

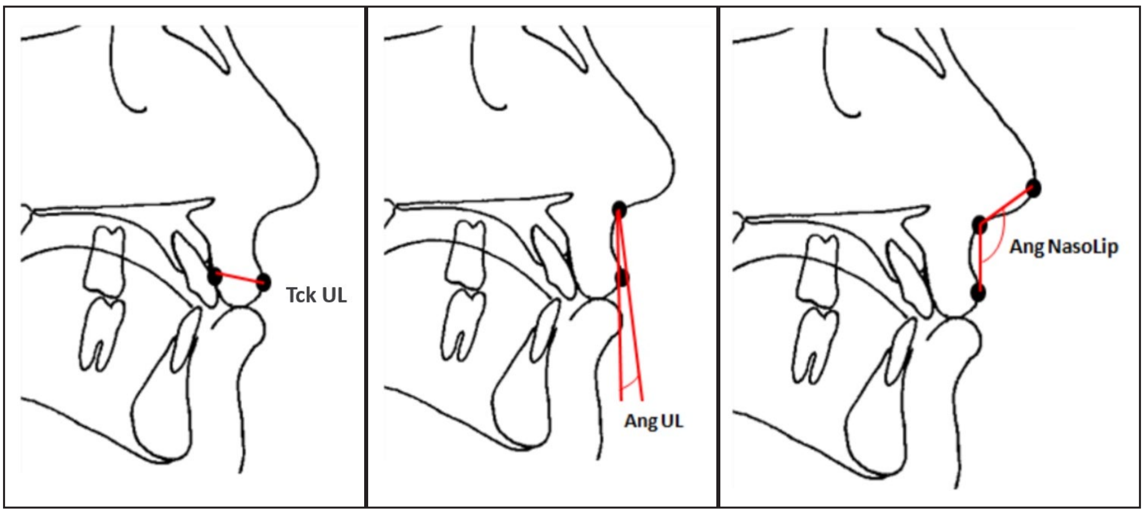

Figure 2. Soft tissue measurements.
Tck UL = upper lip thickness; Ang UL = upper lip angle; Ang NasoLip = nasolabial angle.

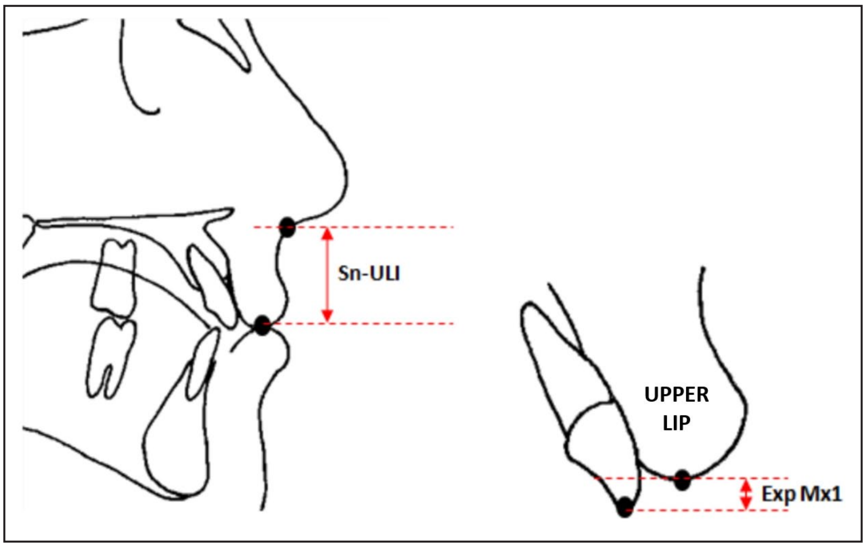

Figure 3. Facial length measurements.
Sn = subnasale; Sn-ULI = upper lip length; Exp Mx1 = upper incisor exposure.

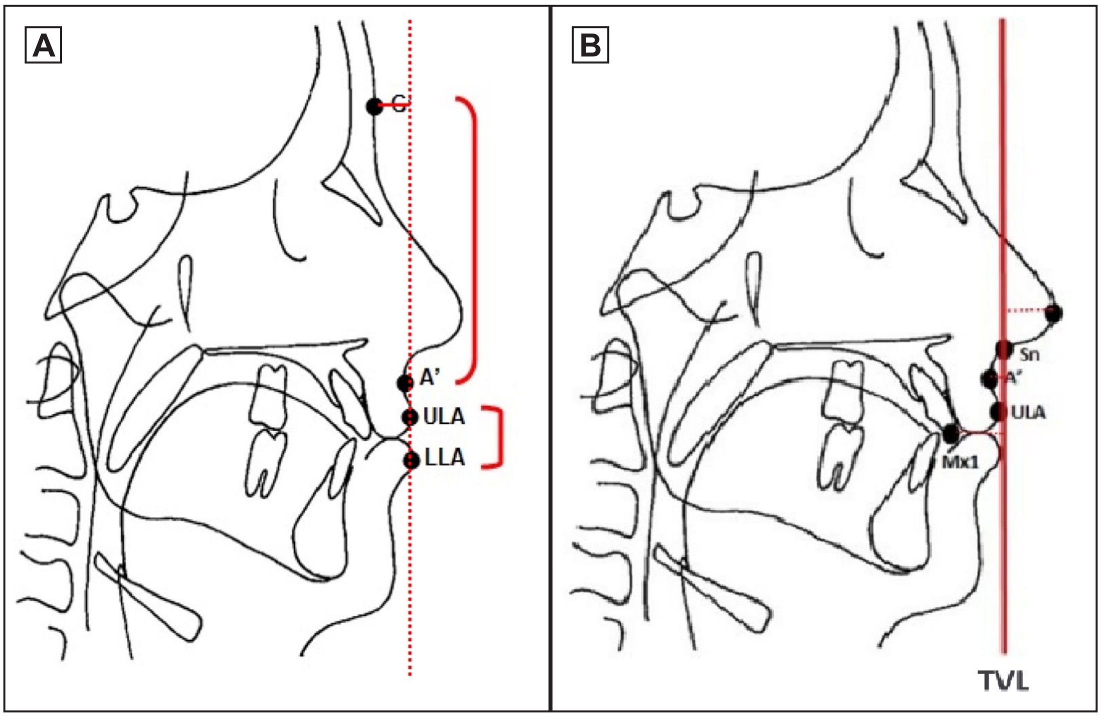

Figure 4. A = facial harmony measurements; B = projection to the TVL.
Sn = subnasale; Mx1 = maxillary incisor to the TVL; A' = A' point; TVL = true vertical line; ULA = anterior upper lip; LLA = anterior lower lip; G' = glabella.

Projection to true vertical line (TVL):

- Nasal apex (Nose), mm: horizontal distance from the nasal projection point to the TVL.
- A' point (A'), mm: horizontal distance from the A' tegumentary point to TVL.
- Anterior upper lip (ULA), mm: horizontal distance from the anterior upper lip point to TVL (Figure 4).
- Anterior lower lip (LLA), mm: horizontal distance from the most anterior point of the lower lip to the TVL.
- Maxillary incisor to TVL (Mx1), mm: horizontal distance from the upper incisor incisal point to TVL.

Data analysis

The images were processed using Adobe® Photoshop® CS5 (Adobe Systems Inc.; San Jose, California, USA). All images were saved in .tiff format, 16-bit greyscale, maintaining original resolution and contrast and subsequently indexed in Dolphin Imaging

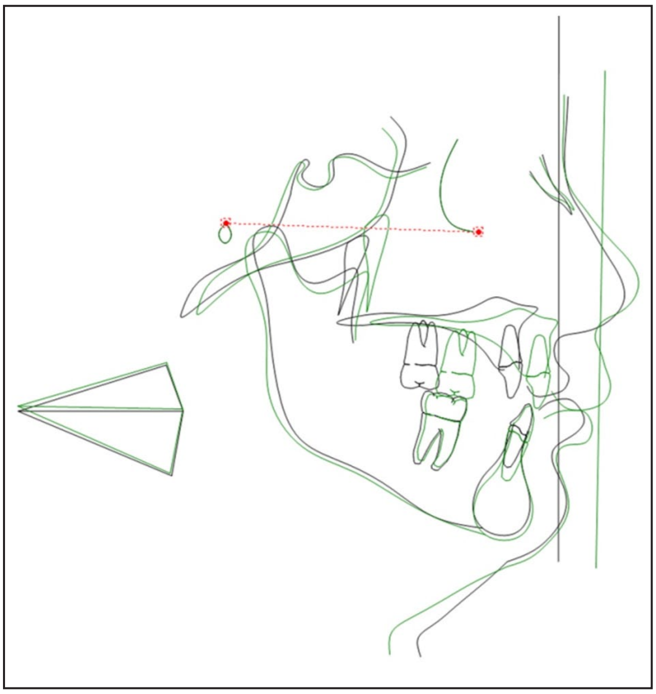

Figure 5. Cephalometric superimposition.

version 11.5 (Dolphin Imaging & Management Solutions; Chatsworth, California, USA). This software was used to mark reference points and generate cephalograms based on 52 landmarks for cephalometric analysis. A 10 cm ruler was employed for calibration to ensure measurement accuracy.

All cephalometric tracings and measurements were performed by a single experienced examiner (A.K.O.T.). A total of 27% of the sample was re-measured after a 15-day interval to assess intra-examiner reliability. Random error was calculated using Dahlberg's formula. Intra-examiner reliability was further assessed using intraclass correlation coefficients (ICC), showing good agreement (ICC > 0.75).

Various cephalometric variables were measured, including dental-skeletal angles, lip thickness, nasolabial angles, facial harmony indicators, and projections relative to the TVL (Figures 2, 3 and 4).

In all cephalometric tracings, the TVL was fixed at the subnasal point across all time points, serving as the reference for horizontal displacement of the evaluated landmarks. After completion of all tracings, the mean values of each variable were recorded for the preoperative (T1), immediate postoperative (T2), and late postoperative (T3) periods.

All lateral cephalometric images were obtained in digital format from the institutional image archive and analysed in grayscale. Cephalometric tracings were performed under controlled lighting conditions in a darkened room, using a dedicated workstation. A 24-inch Dell 2408 LCD monitor (Dell Inc.; Round Rock, Texas, USA) at 1920 x 1200 pixel resolution was used for image analysis.

For a more detailed analysis, the sample was categorized based on the amount of maxillary advancement. The magnitude of maxillary movement was assessed by superimposing cephalometric tracings from T1 and T2 (Figure 5). Superimposition was performed along the Frankfurt horizontal plane, defined by the porion and orbitale points, which provides enhanced reliability for skeletal measurements. This method allowed for exclusive assessment of hard tissue changes. Based on the degree of advancement, the sample was divided into three groups:

- Group 1 (≤ 5 mm);
- Group 2 (5.1 to 9.9 mm);
- Group 3 (≥ 10 mm).

Statistical analysis

The data were tabulated in a spreadsheet using Microsoft Excel® version 2016 (Microsoft Corp., Redmond, Washington, USA) for subsequent statistical analysis. To assess differences between the analysed periods, repeated measures ANOVA was performed using SigmaPlot version 14.0 (Systat Software Inc., San Jose, California, USA), with a significance level set at $P < 0.05$. The reliability of the measurements was assessed by calculating the intraclass correlation coefficient (ICC), with values ≥ 0.75 considered excellent. Intra-examiner error was evaluated using the Dahlberg formula and paired t-test, with 27% of the sample re-measured by the same examiner (A.K.O.T.) after a 15-day interval.

RESULTS

In total, 87 patients met the criteria (50 males and 37 females, age range 17 to 37 years), and 261 lateral cephalometric radiographs were analysed. All measurements were performed by a single experienced examiner (A.K.O.T.). All surgeries were performed by a single surgeon (R.Y.F.Y) following a standardized protocol under the same conditions. No postoperative complications were observed in any of the patients. The sample distribution based on maxillary advancement revealed 19 patients in Group 1, 30 patients in Group 2, and 38 patients in Group 3. The average movement was 9.58 mm, with a minimum of 0.2 mm and a maximum of 23.5 mm. Table 1 presents the overall variable analysis, excluding the postoperative T2 period,

Table 1. Mean, standard deviation (SD) and P-values of the measurements in the preoperative (T1) and late postoperative (T3) periods calculated on the total sample (n = 87)

Measure	T1		T3		P-value
	Mean	SD	Mean	SD	
Ang Mx1 (°)	59.929	7.595	60.259	7.085	0.6762
Overjet (mm)	-3.967	4.599	2.575	1.152	< 0.0001[a]
Overbite (mm)	-0.386	2.328	1.614	1.245	< 0.0001[a]
Tck UL (mm)	11.597	2.664	11.264	2.184	0.2057
Ang UL (°)	20.116	13.794	18.541	10.751	0.0282
Ang NasoLip (°)	85.489	14.867	88.89	13.528	< 0.0001[a]
Sn-ULI (mm)	19.289	3.695	20.932	3.48	0.0001[a]
Exp Mx1 (mm)	3.199	2.981	1.799	2.387	< 0.0001[a]
Nose (mm)	18.757	4.207	16.594	3.597	< 0.0001[a]
A' (mm)	1.307	2.25	1.998	2.267	0.0054[a]
ULA (mm)	4.393	3.117	4.645	2.934	0.4396
Mx1 (mm)	-10.015	4.789	-9.047	3.637	0.0366[a]
G'-A' (mm)	-1.076	6.548	-0.9	6.789	0.8062[a]
ULA-LLA (mm)	-5.377	4.481	0.69	3.313	< 0.0001[a]

[a]P-values < 0.05 were considered statistically significant (repeated measures ANOVA).
Ang Mx1 = maxillary incisor-maxillary occlusal plane angle; Mx1 = maxillary incisor to true vertical line; Tck UL = upper lip thickness; Ang UL = upper lip angle; Ang NasoLip = nasolabial angle; Sn-ULI = upper lip length; Exp Mx1 = upper incisor exposure; Nose = nasal apex; A' = A' point; ULA = anterior upper lip; G'-A' = glabella to A' point; ULA-LLA = upper lip-lower lip.

which was used solely for measuring movement magnitude through cephalometric tracing superimposition (Figure 5). Analysis of the entire sample showed notable increases in overjet, overbite, nasolabial angle, Sn-ULI, A‘ soft tissue point, upper incisor, and facial harmony measures, while upper incisor exposure and nose size decreased. P-values reported in Table 1 were obtained exclusively using repeated measures ANOVA to compare measurements between the preoperative (T1) and late postoperative (T3) periods. No significant changes occurred in upper incisor inclination, upper lip thickness, upper lip angle, or upper lip to TVL distance. Despite being statistically insignificant, there was an increase in the angle between the long axis of the upper incisor and the occlusal plane, suggesting that the incisor became more inclined after maxillary advancement.

Table 2 presents the average advancement for each measure studied and the ratio between hard and soft tissue movements. The average hard tissue advancement was calculated based on the mean movement of the upper central incisor (9.58 mm) across the entire sample. The relationships for the upper lip were minimal, with Sn-ULI accounting for 17% of the hard tissue advancement, the nose showing -23% relationship, and upper incisor exposure

Table 2. Mean advancement values and soft-to-hard tissue ratios relative to maxillary incisor movement in the total sample (n = 87)

Measures	Mean advance[a] (mm)	Relation with upper central incisor (%)
Tck UL	-0.3	-3
Sn-ULI	1.6	17
Exp Mx1	-1.4	-15
Nose	-2.1	-23
A'	0.6	7
ULA	0.2	3

[a]Mean advance = 9.58 mm, corresponding to the average sagittal displacement of the maxillary incisor (Mx1) in the total sample.
Tck UL = upper lip thickness; Sn-ULI = upper lip length; Exp Mx1 = upper incisor exposure; Nose = nasal apex; A' = A' point; ULA = anterior upper lip.

showing -15% relationship.

When subdivided by movement magnitude, the Sn-ULI, nose size, and facial harmony measures remained consistent across all groups, while soft tissue changes became more pronounced with larger advancements. In advancements up to 5.0 mm, soft tissue changes were minimal, with about a 2.0 mm reduction in nose size and a 2.5 mm increase in lip length. For advancements greater than 5.0 mm, there was a significant reduction in Tck UL (approximately 1.0 mm) between 5.1 to 9.9 mm, with no significant changes in lip thickness for smaller advancements. Lip thinning began at advances greater than 5.0 mm, but no significant change was seen in advancements ≥ 10 mm. Table 3 presents the relationship between soft tissue changes and upper incisor movement specifically for the group with advancements ≤ 5 mm. The highest correlations between hard and soft tissue movements were observed in this group, particularly for Sn-ULI and the projection of point A‘.

Regarding soft tissue movements and upper incisor movement across different groups based on movement magnitude, in advancements ≤ 5.0 mm, the strongest relationships were found for Sn-ULI, thickness, and the A‘ soft tissue point, which accounted for 74%, 18%, and 15% of hard tissue advancement, respectively.

The nose showed -62% relationship, and upper incisor exposure had -31% relationship (Table 3). The largest relationships were found in the group with advancements ≤ 5.0 mm. Groups with advancements ≥ 5.1 mm showed weaker relationships, particularly in advancements ≥ 10 mm. The upper lip demonstrated minimal variation across all groups, with no statistically significant differences, although slightly higher values were observed in the 5.1 to 9.9 mm group.

Table 3. Mean advancement values and soft-to-hard tissue ratios relative to maxillary incisor movement in patients with advancements ≤ 5 mm (n = 19)

Measures	Mean advance[a] (mm)	Relation with upper central incisor (%)
Ang Mx1	1.92	58
Overjet	7.22	0.02
Overbite	1.73	52
Tck UL	0.58	18
Sn-ULI	2.47	74
Exp Mx1	-1.02	-31
Nose	-2.04	-62
A'	0.5	15
ULA	0.11	3
G'-A'	-0.43	-13
ULA-LLA	7.47	0.02

[a]Total mean advance = 3.31 mm, corresponding to the average sagittal displacement of the maxillary incisor (Mx1) in patients with advancements ≤ 5 mm

Ang Mx1 = maxillary incisor-maxillary occlusal plane angle; Tck UL = upper lip thickness; Sn-ULI = upper lip length; Exp Mx1 = upper incisor exposure; Nose = nasal apex; A' = A' point; ULA = anterior upper lip; G'-A' = glabella to A' point; ULA-LLA = upper lip-lower lip.

In this sample, no significant correlations were found between upper lip cephalometric measurements and the degree of maxillary advancement. However, trends in soft tissue behaviour were observed: upper lip position and thickness remained relatively stable, while Sn-ULI showed a slight decreasing trend (Figure 6). Nasal variation also remained stable in relation to maxillary advancement. Additionally, the A' point and upper incisor exposure demonstrated stability with increasing maxillary advancement, as supported by the data analysis.

DISCUSSION

Given that postsurgical orthodontic and prosthetic rehabilitation may influence skeletal movement references, treatments in this study were performed six months after maxillary advancement surgery, with the lateral cephalogram obtained at this time for late postoperative evaluation. The timing of the postoperative period is crucial for reliable soft tissue profile studies in patients with clefts. Previous studies with shorter postoperative periods or no reported timing have shown higher soft-to-hard tissue ratios (0.78 : 1 to 1 : 1) [12-16]. Two-thirds of the labial profile and one-third of the nose undergo changes from 4 to 6 months post-surgery [17], with subtle, minimal changes potentially continuing for up to a year [18,19]. Based on these observations, this study considers postoperative periods of 6 months or longer, when soft tissue changes have stabilized, ensuring more reliable results.

The relationship between upper lip and hard tissue advancement in this study was only 3%, much lower than the 28 to 66% range reported by other authors [17,18,20,21-26]. Despite advancing the upper incisor, the upper lip did not follow the bone movement, likely due to scar tissue fibrosis and reduced flexibility. Additionally, the altered anatomy of the middle third and maxillomandibular discrepancy in patients with clefts creates a gap between the upper lip and anterior maxilla, requiring significant bone advancement to affect the lip.

A possible influencing factor is the initial thickness of the upper lip, as the literature shows divergent results for thin and thick lips. Freihofer [17] found higher lip advancement with thin lips (90%)

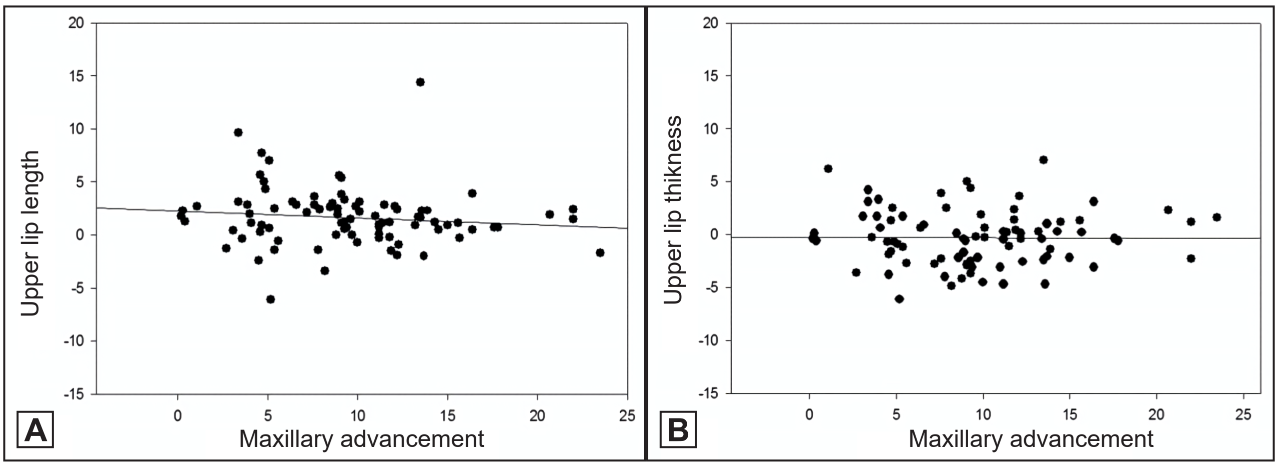

Figure 6. Scatter plots illustrating the relationship between maxillary advancement (mm) and upper lip soft tissue changes: A = upper lip length; B = upper lip thickness.

Each point represents an individual patient. The fitted regression lines demonstrate no significant correlation between maxillary advancement and upper lip measurements, with only a slight decreasing trend observed for upper lip length.

compared to thick lips (50%), but no correlation was observed in this study. The initial lip thickness was similar across all groups, and no correlation with maxillary advancement could be established. Regarding surgical technique, preserving the anterior nasal spine could improve soft-to-hard tissue relationships, as Freihofer [17] found a better ratio (4 : 7) when the nasal spine was preserved. However, no significant correlation between lip and maxillary advancement was found in this study, consistent with findings from other research [18,24].

Previous studies in both cleft and non-cleft individuals have shown a decrease in Tck UL after maxillary advancement surgery [27-29]. Similarly, this study observed a 3% reduction in upper lip thickness, which is lower than the 17 to 30% decrease found in other studies [22,30]. Lip thinning was most pronounced in the group with movements between 5.1 and 9.9 mm, likely because patients with oral clefts typically have a negative overjet and deep bite, with the upper lip positioned forward and upward. For advancements greater than 5 mm, the upper lip makes contact with the maxilla, leading to thinning due to the lip's limited flexibility in following the maxillary advancement.

In addition to thinning, advancements greater than 5 mm resulted in an increase in lip length and a decrease in incisor exposure, suggesting the lip became flatter and lost its natural curvature. The type of suture used may also influence lip thickness. The V/Y suture, known to increase lip thickness and improve aesthetics, was employed in this study. For advancements up to 5 mm, an 18% increase in lip thickness was observed, likely due to the eversion caused by the suture. This technique helps prevent lip fibrosis from limiting forward movement, thus mitigating further thinning, especially for smaller advancements [19].

The average relationship between Sn-ULI and hard tissue movement was 17%, consistent with previous studies, which reported ranges from 10 to 33% [17,18]. In patients with oral clefts, the relationship between lip length and maxillary advancement is generally more pronounced due to pre-existing soft tissue contraction. While lip length increases with anterior maxillary repositioning, the effect was less significant in cleft patients, as shown by the low correlation between the variables in this study.

In this study, nasal area and volume showed no significant changes, consistent Freihofer [17], which found minimal impact of anterior maxillary movement on the nasal cavity. This contrasts with other research that reported a significant increase in nasal airway after maxillary advancement, particularly in patients with cleft palate. This discrepancy may stem from different measurement techniques and sample sizes - this study used three-dimensional computed tomography scans, offering more accuracy [19]. However, other studies have also reported minimal changes, while improvements in nasal area and volume were observed in advancements greater than 10 mm, likely due to increased soft tissue displacement and airway expansion [18].

Despite the upper incisor showing only a slight increase in inclination (Ang Mx1), overjet and overbite were significantly increased, reflecting correction from a Class III open bite toward normal occlusion. Soft tissue measurements revealed that Sn-ULI increased by ~1.6 mm, whereas Exp Mx1 decreased slightly (-1.0 to -1.4 mm) and nasal measurements decreased by approximately 2 mm. These findings indicate that soft tissues partially follow skeletal advancement, with variations depending on the anatomical region. This is consistent with Chaisiri et al. [31], who reported partial adaptation of the upper lip to maxillary advancement, and with Seo et al. [32], which showed differential soft-to-hard tissue movement ratios (ΔPoint A'/ΔPoint A = 1.08, ΔLs'/ΔIs = 0.72) in patients with CLP. The movement of soft tissues does not appear to uniformly follow skeletal movement, particularly in the lower part of the upper lip, which may be influenced by scar tissue and alterations in the underlying muscles. In addition, the heterogeneous movement observed across nasal and upper lip landmarks could be related to anatomical variability and scarring inherent to CLP.

Maxillary advancement surgery plays a key role improving functional outcomes, especially in patients with oral clefts. This study highlighted correlations between maxillary movement and lip dimensions, as well as upper airway changes, which are important for assessing both functional and aesthetic results. Our findings align with and expand upon those reported by Susarla et al. [33], who observed relatively consistent soft tissue adaptations after larger Le Fort I advancements (6.2 [SD 1.7] mm) in patients with CLP, with soft-to-hard tissue ratios around 0.89 to 0.97 for the subnasal, upper lip, and stomion. In contrast, in our cohort, smaller maxillary advancements (≤ 5 mm) showed the most pronounced correlations, particularly at the Sn-ULI and the A' soft tissue point, while larger advancements demonstrated less predictable soft tissue responses, including reductions in Tck UL and minimal changes in nasal projection. It comes again with the idea that soft tissue adaptation is highly variable and may depend on the magnitude of skeletal movement, individual anatomical characteristics, and the presence of scar tissue. For instance, certain parameters, such as overjet and lower lip-upper lip distance, showed minimal correspondence with incisor movement, indicating that skeletal advancement does not uniformly translate into soft tissue or occlusal changes. Understanding the relationship between hard and soft tissue movements is therefore crucial for predicting postoperative outcomes and guiding individualized planning to optimize both functional and aesthetic results in orthognathic surgery.

Limitations

This study has some limitations that should be considered when interpreting the findings. Its retrospective design may introduce selection bias, and the use of two-dimensional cephalometric analysis may not fully capture three-dimensional soft tissue changes. In addition, variability in landmark identification, particularly in patients with CLP, may have influenced measurement precision. Furthermore, the absence of a control group may limit the generalizability of the findings.

CONCLUSIONS

Maxillary advancement in individuals with cleft lip and palate resulted in notable soft tissue changes, with the most pronounced correlations observed in smaller advancements (≤ 5.0 mm), particularly for upper lip length and the A' soft tissue point. Larger advancements showed less predictable soft tissue responses, including a decrease in upper lip thickness without significant changes beyond 10 mm. While no significant correlations were found between maxillary advancement and cephalometric measurements, trends indicated stability in upper lip position, minimal nasal projection changes, and reduced upper incisor exposure. These findings emphasize the variability of soft tissue adaptation and the need for individualized planning to optimize aesthetic and functional outcomes in orthognathic surgery.

ACKNOWLEDGMENTS AND DISCLOSURE STATEMENTS

The authors report no conflicts of interest related to this study.

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To cite this article:
De Oliveira Tanaka AK, Marinho Barcellos B, Medrano Gutiérrez A, de Paula Oliveira Gringo C, Toledo Teixeira da Silveira I, Reis de Araújo Carvalho L, Yassutaka Faria Yaedú R.
Soft Tissue Changes after Maxillary Advancement in Patients with Cleft Lip and Palate
J Oral Maxillofac Res 2026;17(1):e5
URL: http://www.ejomr.org/JOMR/archives/2026/1/e5/v17n1e5.pdf
doi: 10.5037/jomr.2026.17105