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The effect of subspinal Le Fort I osteotomy and alar cinch suture on nasal widening

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A B S T R A C T

The aim of this retrospective study was to evaluate the relationships between upper jaw movements and nasal soft-tissue changes in patients who have undergone subspinal Le Fort I osteotomy combined with alar cinch suture.

Single and multivariate linear regression analyses were used to examine the relationships between greatest inter-alar width (GAW) and maxillary advancement, maxillary impaction, and rotational movements. The database of our referral hospital was searched for patients who had undergone upper jaw surgery with a subspinal LFI osteotomy to correct dentoskeletal deformities between April 2012 and June 2016.

Thirty-eight of the patients (15 men and 23 women) who were identified were eligible for inclusion. The average change in inter-alar width (ΔGAW) was $+1.7 \pm 1.2$ mm. GAW increased by 0.3 mm ($p < 0.0001$) for each millimetre of maxillary advancement, and increased by 0.5 mm ($p < 0.0001$) for each millimetre of maxillary impaction. GAW increased by 0.2 mm for each degree of counterclockwise rotation of the occlusal plane ($p < 0.0001$).

An analysis of our data compared with the current literature confirmed that subspinal Le Fort I combined with alar cinch suture reduced alar base widening.

1. Introduction

Le Fort I (LFI) osteotomy is a common surgical procedure that is used to correct facial dentoskeletal deformities. It can, however, lead to undesirable and unpredictable morphological changes of the nose; the most important and frequent ones are widening of the inter-alar width and the nasal base. Surgeons have attempted to limit this outcome by combining Le Fort I osteotomy with specific surgical techniques, such as the alar cinch and V–Y sutures: the former aims to preserve the normal inter-alar width by reconstructing the interrupted muscles, in order to prevent lateral nasal deviations and to reduce nasal enlargement after surgery (Mustafa et al., 2016). As far as V–Y sutures are concerned, no clear evidence has been produced demonstrating that they are effective in limiting inter-alar width enhancement. Another technique, subspinal LFI osteotomy, which was first described in 1997, seems to be effective in limiting inter-alar width and in preserving the anterior nasal spine and its muscular insertion (Mommaerts et al., 1997, 2000).

Although several studies have attempted to quantify and define the relationships between variations in the soft nasal tissues and maxillary movement, the data that are currently available in the literature seem to be conflicting (Jeong et al., 2017; Schendel and Carlotti, 1991), and there are still no reliable methods for predicting nasal changes after LFI osteotomy. For the most part, variations between patients can be explained by intra-patient preoperative differences, divergent treatment strategies, and poor reproducibility of the data collected. This study aimed to evaluate the efficacy of subspinal LFI osteotomy and alar cinch sutures in preserving preoperative inter-alar width in patients with dentoskeletal deformities.

2. Materials and methods

A retrospective study was designed to investigate changes in inter-alar nasal width in patients undergoing subspinal LFI osteotomy.

A database search was carried out to identify of all the patients who underwent orthognathic surgery between April 2012 and June

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2016 in the Department of Maxillofacial Surgery and Dentistry of Verona University Hospital.

The study's inclusion criteria were: having undergone upper jaw surgery with a subspinal LFI osteotomy to correct dentoskeletal deformity; having undergone one cone-beam computed tomography (CBCT) scan (NewTom VGI EVO, Qr Verona, Cefla) 15 days prior to surgery, another a few days immediately after the procedure, and a third at least 6 months after the procedure. The exclusion criteria were: having undergone orthognathic surgery; facial trauma or cleft.

The demographic features of the patients and details of the procedure that were recorded included: the sex and age of the patient, the date of surgery, and the type of upper jaw surgery (one-piece or multi-segment Le Fort I). All the procedures were performed by experienced surgeons (L.T. and A.D.). The clinical and radiological analyses were carried out by an external examiner not involved in planning and surgery (L.L.). Statistical analysis was performed by a member of the Statistical Department (A.P.) of Verona University.

The CBCTs were acquired with the patient standing while maintaining a natural head position and relaxed lips. Scans were obtained with a single rotation of the device; the absorbed dose in each scan was approximately 59 mSv.

The preoperative CBCT was performed approximately 1 week before surgery (considered baseline = T0). The postoperative CBCT (T1) was performed within 15 days of surgery. A third (T2), long-term CBCT was performed at least 6 months after surgery.

A specially designed software (Dolphin Imaging, release 12.0, Chatsworth, CA, USA) was used to carry out facial soft-tissue reconstruction using DICOM files; the linear measurements of the inter-alar nasal width at its widest point (greatest alar width, GAW) were recorded at the three timepoints. The measurements, rounded to a tenth of a millimeter, were recorded in a database; all the measurements were taken by the same surgeon (L.L.). This surgeon was not previously involved in planning or treatment.

Sagittal and vertical movements, taken at the level of the upper incisor margin, and the occlusal plane rotation values for the upper jaw were obtained from the preoperative cephalometric planning. Then the measurements were compared with alar width changes to see if any relationships emerged.

All data were analyzed using SPSS for Windows, version 11.4 (Chicago, IL, USA). The data were presented as means and standard deviations. The generalized linear model (GLM) was the repeated measure used to quantify the GAW pattern between the preoperative and six-month scans (T0 to T2). Student's t-test for paired samples was used to compare ΔGAW at the different timepoints in the sex and segmentation groups. Linear regression ($y = a + bx$) was used to verify and quantify the association between ΔGAW at the first and last timepoints and the movements of the upper maxilla. A GLM multivariate analysis was used to confirm the correlations found. A p-value of <0.001 was considered statistically significant.

2.1. Surgical technique

The maxillary mucosal incision was made vestibular from the right first premolar to the left first premolar. The maxillary bone was exposed to identify the zygomatic and nasal buttresses and the infraorbital nerve. The nasal mucosa was elevated with an Obwegeser elevator. The anterior nasal spine was never exposed as the surgeon aimed to preserve the periosteal and muscle attachments, as shown in Fig. 1.

An osteotomy was performed using a piezosurgical device at the base of the anterior nasal spine, which continued to be attached to the nasal septum (Fig. 2). Quadrangular cartilage and vomer were detached from the maxillary ridge with a chisel, engaging the previously prepared osteotomy (Fig. 3a and b). The surgeon then proceeded to perform a subspinal LFI osteotomy (Fig. 4). If the procedure was a segmented one, a three-piece Le Fort I was performed (interdental osteotomies between lateral incisor and canine, with an H-shaped design on the nasal floor).

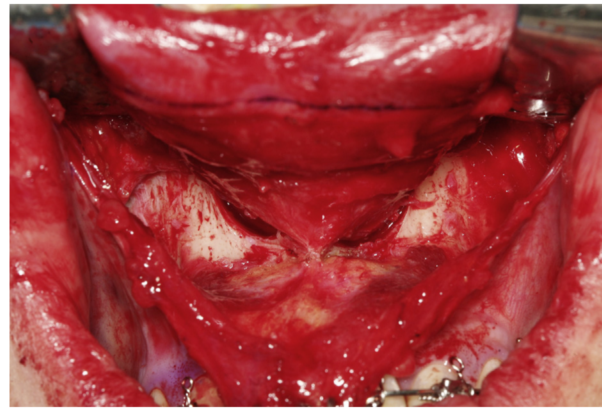

Fig. 1. Upper maxilla exposure and nasal floor exposure.

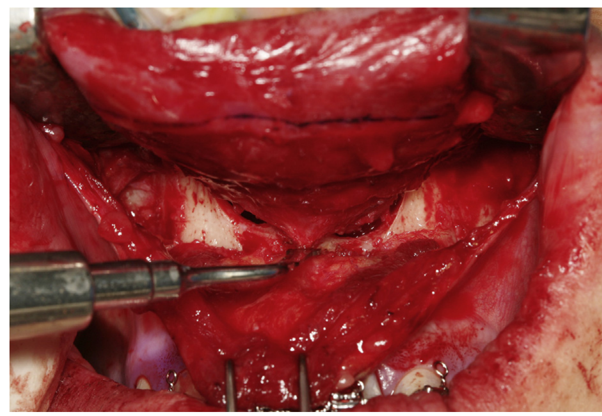

Fig. 2. Subspinal osteotomy using piezosurgery.

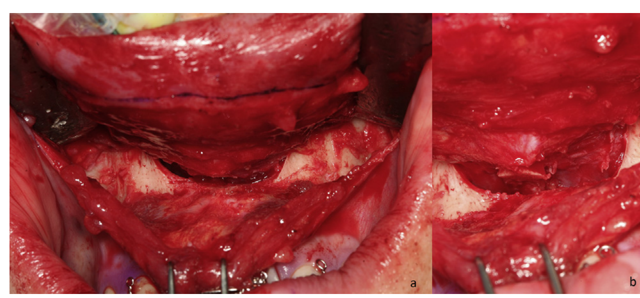

Fig. 3. Subspinal osteotomy (a), detail (b).

Whenever an upper jaw impaction was required, an osteoplasty of the maxillary crest and the floor of the nose was performed, as shown in Fig. 5. This osteoplasty was proportional to the entity of the vertical shortening to avoid excessive upper repositioning of the base of the piriformis and thus positional anomalies of the nasal base and upper lip.

At the end of surgery, the anterior nasal spine was fixed to the upper jaw in the midline by means of a slowly absorbable suture (Vicryl 4.0), as shown in Fig. 6. The alar cinch was performed as a single-loop suture with the same suture; it was placed before the

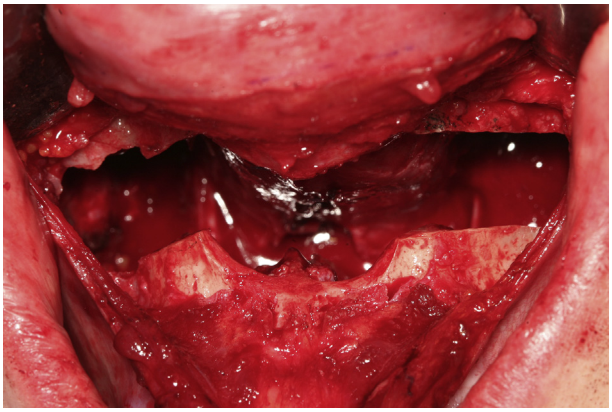

Fig. 4. Subspinal osteotomy, down fracture.

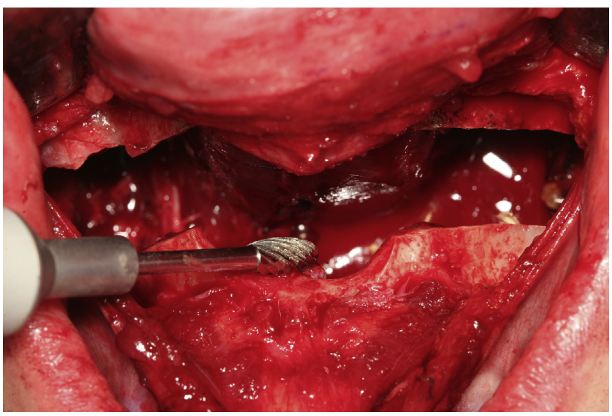

Fig. 5. Piriform osteoplasty.

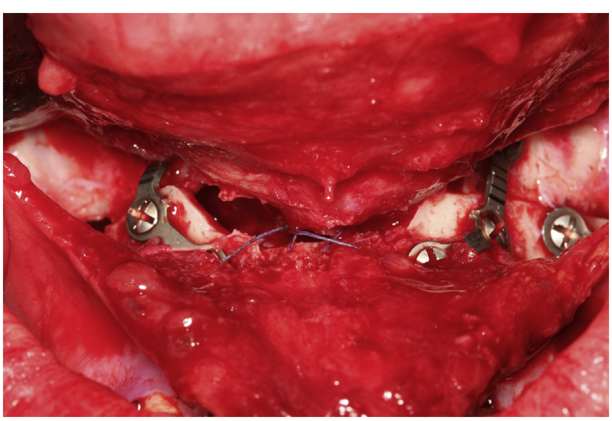

Fig. 6. ANS (anterior nasal spine) stabilization.

circumvestibular incision was closed on the upper jaw, taking one bite for each nasal ala. The knot was placed on the midline under the maxillary spine. No V–Y sutures were performed in any of the patients.

3. Results

Thirty-eight patients (23 women and 15 men; average age = 23.9 ± 5.7 years; range = 18–42 years) underwent subspinal LFI osteotomy between April 2012 and June 2016 in the Department of Maxillofacial Surgery of the University of Verona. Thirteen of the patients underwent subspinal LFI and 25 underwent multi-segmented subspinal Le Fort I (MSLFI), with the segmentation area placed between the lateral incisor and the canine (Table 1).

Table 1
Study variables — average and standard deviation (mm).

	Age	M/F	LFI/MSLFI	Mx+Md rot	Mx1 vertic	Mx1 sagit
Average	23.9	15/23	13/25	4.4°	−1.2	5.6
SD	5.7	–	–	5.3°	2.3	1.3

M: males; F: females; LFI: Le Fort I osteotomy; MSLFI: multi segmented Le Fort I; Mx+Md rot: occlusal plane rotation; Mx1 vertic: vertical movement of the maxilla; Mx1 sagit: sagittal movement of the maxilla.

Table 2
Primary outcome variables — averages, and standard deviations (mm).

	Pre (T0)	Post (T1)	>6 m (T2)	T1–T0	T2–T1	T2–T0
Average	34.7	36.9	36.4	2.2	−0.5	1.7
SD	3.1	3.5	3.2	1.3	1.4	1.2

Table 3
Repeated measurements at the three timepoints, $p < 0.0001$.

Dependent variable	Parameter	B	Standard error	t	p
Pre (T0)	Intercept	34.713	0.505	68.762	0.000
Post (T1)	Intercept	36.887	0.570	64.750	0.000
>6 m (T2)	Intercept	36.418	0.521	69.962	0.000

The mean modification of the occlusal plane was 4.4° ± 5.3° counterclockwise (minimum −3.6°, maximum 12.4°). The vertical movements of the upper jaw measured at the incisal edge were −1.2 ± 2.3 mm (minimum −6 mm, maximum 3 mm). The average sagittal advancement of the incisal edge was 5.6 ± 1.3 mm (minimum 4 mm, maximum 9.6 mm).

The mean GAW before surgery (at T0) was 34.7 ± 3.1 mm (minimum 28.8 mm, maximum 41.6 mm). The mean postoperative GAW (at T1) was 36.9 ± 3.5 mm (minimum 29.3 mm, maximum 43.5 mm). The mean GAW within 6 months of surgery (at T2) was 36.4 ± 3.2 mm (minimum 30.8 mm, maximum 42.6 mm). The first postoperative scan showed an average increase of 2.2 ± 1.3 mm (minimum −0.2 mm, maximum 5.1 mm) with respect to the preoperative scan. There was, on average, a difference of −0.5 ± 1.4 mm (minimum −3.1 mm, maximum 3 mm) between the first postoperative and the 6-month scans. At the final scan, the average GAW increase was 1.7 ± 1.2 mm (minimum −1.1 mm, maximum 5.3 mm) (Table 2).

These measurements were found to be statistically significant when the analysis was corrected for repeated measurements ($p < 0.0001$) (Table 3).

A comparison between the non-segmented and segmented groups did not reveal any statistically significant differences ($p = 0.950$) (Table 4).

The average increase in GAW between the two timepoints was 1.7 ± 1 mm in the non-segmented LFI group (13 patients) and 1.7 ± 1.3 mm in the MSLFI group (25 patients). The male patients showed a mean GAW increase between the T1 and T0 timepoints of 1.7 ± 1 mm; the female patients showed an average increase of 1.7 ± 1.4 mm. The differences between the two groups were not statistically significant ($p = 0.920$) (Table 5).

Statistically significant correlations were found in connection with the advancement, the impaction of the upper jaw, and the counterclockwise rotation of the occlusal plane. In particular, the GAW between the first and last timepoints increased by 0.3 mm ($B = 0.286$; $p < 0.0001$) for each millimeter of sagittal advancement of the Mx1 (Table 6). The GAW increased between the

Table 4
t-test for paired-sample repeated analysis to compare ΔGAW_{T2-T0} (greatest alar width) with segmentation.

			Sum of squares	Mean square	*F*	*p*
T1–T0 segmentation	Between groups	**(Combined)**	0.641	0.641	0.373	0.545
	Within groups		61.912	1.720		
T2–T1 segmentation	Between groups	**(Combined)**	0.521	0.521	0.275	0.603
	Within groups		68.261	1.896		
T2–T0 segmentation	Between groups	**(Combined)**	0.006	0.006	0.004	0.950
	Within groups		56.093	1.558		

Table 5
t-test for paired-sample repeated analysis to compare ΔGAW_{T2-T0} with sex.

			Sum of squares	Mean square	*F*	*p*
T1–T0 sex	Between groups	**(Combined)**	0.988	0.988	0.578	0.452
	Within groups		61.566	1.710		
T2–T1 sex	Between groups	**(Combined)**	1.254	1.254	0.668	0.419
	Within groups		67.528	1.876		
T2–T0 sex	Between groups	**(Combined)**	0.016	0.016	0.010	0.920
	Within groups		56.083	1.558		

Table 6
Linear regression correlating ΔGAW_{T2-T0} with Mx1 sagittal movements.

	Unstandardized coefficients		Standardized coefficients	*t*	*p*
	B	Standard error	Beta		
Mx1 sagit	0.286	0.038	0.779	7.560	0.000

Table 7
Linear regression correlating ΔGAW_{T2-T0} with Mx1 vertical movements.

	Unstandardized coefficients		Standardized coefficients	*t*	*p*
	B	Standard error	Beta	_	*B*
Mx1 vertic	−0.461	0.112	−0.560	−4.115	0.000

first and last timepoints by 0.5 mm for each millimeter of maxillary impaction ($B = 0.461$; $p < 0.0001$) (Table 7), but there was a 0.2 mm increase in GAW for that time period for each degree of counter-clockwise rotation of the occlusal plane ($p < 0.0001$).

Multivariate analysis confirmed that there were statistically significant differences in GAW between the first and last timepoints in both the vertical translation of Mx1 ($p < 0.030$) and the sagittal translation of Mx1 ($p < 0.018$) but not in the rotation movements of the occlusal plane. That latter result may have been due to non-predictable effects on the rotation of the anterior maxillary fragment caused by the MSLFI osteotomy ($p = 0.205$) (Table 8). The Mx + Md rotation variable appeared to be a potential confounding variable in the relationships between the T2 − T0 GAW and the surgical movements of the upper jaw.

The model explained 69% of the data variability: $R^2 = 0.694$ (Table 9).

A case is briefly described in Fig. 7.

4. Discussion

It is well established that LFI osteotomy can cause modifications in the overlying soft tissues, with changes in the nasal shape, the

Table 8
Multivariate linear regression — all variables.

	Unstandardized coefficients		Standardized coefficients	*t*	*p*
	B	Standard error	Beta		
Mx + Md rotation	−0.120	0.093	−0.389	−1.292	0.205
Mx1 Vertic	−0.225	0.099	−0.273	−2.271	0.030
Mx1 Sagit	0.446	0.179	1.215	2.488	0.018
ANS Sagit	−0.193	0.183	−0.386	−1.056	0.298

Table 9
Multivariate linear regression.

R	R^2	Adjusted R^2	Standard error of the estimate
0.833	0.694	0.658	1.225

projection of the nasal tip, and, in particular, the inter-alar flare reported in the literature (Altman and Oeltjen, 2007; Hellak et al., 2015; Jeong et al., 2017). The causes of these changes are uncertain, although three factors seem to be the most likely: edema, elevation of the periosteum of the anterior surface of the maxilla, and detachment of the muscles and ligaments stabilizing the alar region (Mommaerts et al., 1997, 2000). As far as maxillary movements are concerned, the advancement and impaction of the upper jaw appear to be the most important factors inducing changes in the nasal shape and in the projection of the nasal tip (Mommaerts et al., 2000; O'Ryan and Schendel, 1989).

The unpredictability of these variables and the heterogeneity of the outcome measures have been amply documented in the literature (Jeong et al., 2017; Rohrich et al., 2008). Several factors may be able to explain the heterogeneity, for example differences in the measurement techniques and in the statistical methods used, and even in the variables studied. Some studies, for example, have evaluated the maximum inter-alar dimension (GAW), and others the inter-alar dimension at the nasal base (ABW). Until recently, 2D analysis techniques were used to acquire measurements of 3D objects. Clearly, measuring radiographs or 2D photos of a patient in a supine or orthostatic position will not produce the same results as a 3D surface model reconstruction of CBCT scans (Muradin et al., 2011). The 3D surface model reconstruction used in our study ensured that accurate, reliable, and reproducible measurements were produced (Fourie et al., 2011; Liang et al., 2010; Naji et al., 2014; Oz et al., 2011; van Loon et al., 2015; Park et al. 2013).

The increases in GAW and ABW that have been reported following LFI osteotomy have led researchers to seek ancillary techniques to limit enlargement. Millard first described the cinch procedure to correct alar flare in patients not affected by cleft lip. The procedure, which uses skin incisions, has never been widely applied in orthognathic surgery (Millard, 1980). The alar base cinch, the technique, a described by Collins and Epker, and which was specifically designed to prevent enlargement of the nasal base linked to maxillary surgery, did indeed lead to a reduction (Collins and Epker, 1982), but the authors did not analyze any possible correlations between the type of maxillary movement and nasal modifications. The fact that there are few available data concerning the relationships between skeletal movements and nasal modifications has impeded the evaluation of the effectiveness of most of the methods discussed in the papers that have been published.

An important study on this subject was conducted by Van Loon, who reported a 1.8 mm increase in GAW after traditional LFI without alar cinch or V–Y suture, with an average advancement of 3.36 mm at Mx1 (van Loon et al., 2015). That result, in the absence of any containment procedure, could be explained by the limited

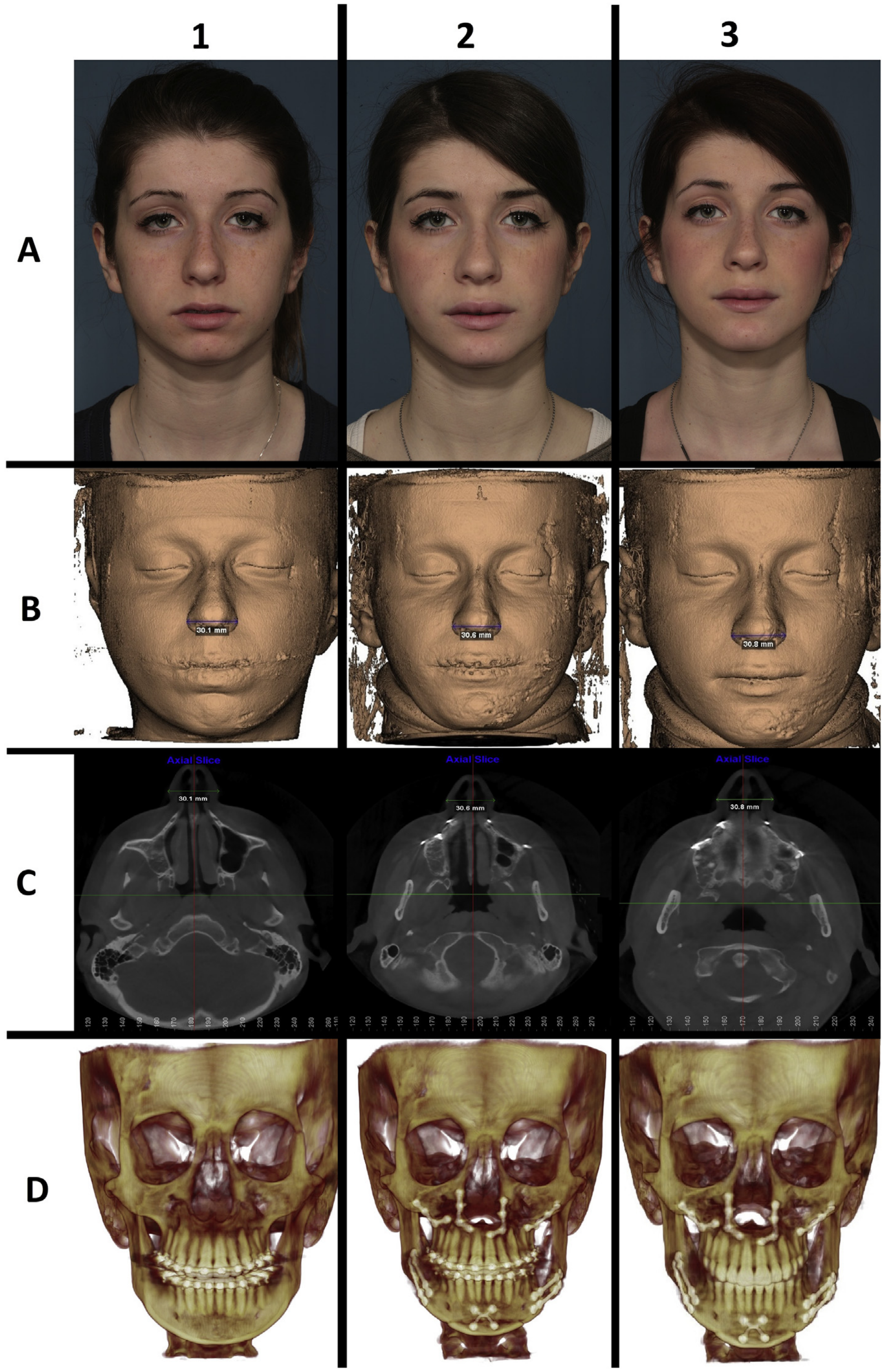

Fig. 7. (A) facial frontal image, (B) CBCT soft tissue, (C) CBCT axial, (D) CBCT 3D reconstruction, (1) preoperative, (2) postoperative short term, (3) postoperative long term. Class II patient. Surgery: Le Fort I and bimaxillary sagittal split osteotomy. Movements: maxillary advancement at incisor level, 5 mm; anterior nasal spine advancement, 1.2 mm; impaction, 3 mm. GAW: preop, 30.1 mm; postop short term, 30.6 mm; postop long term, 30.8 mm.

amount of skeletal movement. The study also revealed a statistically significant correlation between maxillary impaction and the ABW variation ($B = 0.15$).

Mommaerts analyzed the subspinal LFI technique and compared it with the classic LFI associated with V–Y and alar cinch sutures. The measurements, which were made using a caliper, showed GAW increases of 3 mm and 4.7 mm, respectively, but the relationship with skeletal movements was not investigated (Mommaerts et al., 1997).

Howley (Howley et al., 2011) demonstrated that, although the difference was minimal and not clinically significant, alar cinch suture led to greater control of the change in width of the alar base compared with that in a control group. The study used measurements of the ABW and a 3D imaging system. Unfortunately, a pre- and postoperative comparison of GAW measurements was not included. Although the patients underwent upper jaw movements with 'anterior or antero-superior vectors' the movements and the results were not analyzed. Khamashta and Naini's review on nasal changes following maxillary orthognathic surgery did not uncover any significant correlations between ΔGAW or ΔABW and advancement and impaction (Khamashta-Ledezma and Naini, 2015).

In another study, van Loon et al. reported a non-statistically significant difference in alar base width/nose volume between the patients who underwent alar cinch and those who did not. Using 3D stereophotogrammetry and CBCT scans, the authors uncovered an approximate 2 mm GAW increase in both patient groups (van Loon et al., 2016). When Peacock et al. examined a modified alar cinch including piriformis ligament, they found a 1.5 mm enlargement of the GAW at the 6-month postoperative measurement with respect to the preoperative one. However, the study was based on only 15 patients and no information was provided regarding the surgical movements used (Peacock and Susarla, 2015).

In a study comparing different alar cinch techniques, Rauso and Gherardini reported finding increases of 2.15 mm and 0.95 mm for a classic alar cinch and a modified one, respectively. However, they used angular measurements passing through the columella, which were acquired by means of a ruler (Rauso et al., 2010).

An increase in the inter-alar width was also found by Hellak and Kirsten, who performed classic Le Fort and alar cinch, and used 3D measurements. There were approximate average increases of 3 mm (GAW) and 2.5 mm (ABW) for this technique, respectively (Hellak et al., 2015). In their study, a predictive algorithm for the changes in GAW and ABW was elaborated, based on maxillary advancement. For example, an advancement of 5 mm of Mx1 led to an average GAW increase of 2.25 mm.

When Stewart and Edler used the alar cinch suture associated with V–Y on 36 patients they found an average 1.7 mm increase in GAW at the 1-year follow-up appointment. Ten of the patients underwent upper jaw impaction, but there is no information on the vertical movements of the other 26 patients. Those patients may have also undergone lengthening of the upper jaw, which could have contributed to the reduced increase in GAW (Stewart and Edler, 2011).

Shoji and Muto achieved a 0.28 mm increase in GAW by performing alar cinch and V–Y. Their measurements were made on patients in a supine position (Shoji et al., 2012).

Nirvikalpa and Narayanan reported 2.66 mm and 0.15 mm GAW increases for traditional and modified trans-septal alar cinch, respectively. It is important to remember, however, that maxillary setback was an inclusion criterion for that study (Nirvikalpa et al., 2013). Likewise, Ritto et al. reported a 1.4 mm increase in GAW for a modified alar cinch technique compared with 2.31 mm for a traditional alar cinch (Ritto et al., 2011).

Fernández Sanroman et al. reported no significant changes in nasal morphology after subspinal LeFort I osteotomy associated with alar cinch suture and V–Y closure. However, the study regarded only cases of maxillary advancement and elongation without impaction. The correlation between movements and GAW was not investigated (Fernández Sanromán et al., 2014).

A review of the studies examining this topic confirms that it is difficult, if not impossible, to compare the results published until now due to the heterogeneity of the outcomes evaluated and of the measurements, surgical techniques, as well as linear regression models used (Table 10). Our study set out to overcome these limitations and to validate the effectiveness of the subspinal LFI osteotomy and alar-chinch suture technique in a group of patients. This was done by considering all types of jaw movement, using accurate, reproducible 3D measurements, and applying single and multivariate linear regression models to evaluate the relationships between each variable (type of movement) and nasal enlargement.

Table 10
Review of the literature.

Authors	*n*	Measure	Follow-up	V–Y	Alar-Cinch	Subspinal	ΔGAW	ΔABW
Schendel, Williamson	8	Not defined	T0 = pre T1 = 4 m	Yes	Yes	No	0.9 ± 0.9	–
Howley, Ali	28	Scanner laser, 3D	T0 = pre T1 = 1 m T2 = 6 m	No	14/28	No	–	AC = 1.9 Non-AC = 2.7
Van Loon, Verhamne	26	CBCT, 3D	T0 = pre T1 = 1 y	13AC	13/26	No	AC = 2.02 Non-AC = 1.92	–
Hellak, Kirsten	33	CBCT	T0 = pre T1 = 14 m	No	Yes	No	3.17 ± 1.32	2.59 ± 1.26
Van Loon, van Heerbeck	36	CBCT, 3D	T0 = pre T1 = 1 y	No	No	No	1.81	–
Kamashta-Ledezma	31	Digital caliper	T0 = pre T1 = 6 m	10/31	16/31	No	2.62	3.09
Peacock, Susarla	15	Digital caliper	T0 = pre T1 = post T2 = 5 m	No	Yes	No	1.5	–
Mommaerts, Abeloos	31	Caliper	T0 = pre T1 = 6 m T2 = 15 m	19 yes 12 no	19 yes 12 no	19 no 12 yes	19 = 4.7 12 = 3	–
Stewart, Edler	36	Caliper	T0 = pre T1 = in T2 = 1 y	Yes	Yes	No	1.7 ± 1.0	2.3 ± 1.6
Rauso, Gherardini	40	Clinical	T1 = pre T2 = 6 m	No	AC vs AC IO–EO	No	AC = 2.15 ± 1.5 AC IO–EO = 0.95 ± 1.43	–
Shoji, Muto	30	Digital caliper	T1 = pre T2 = 1 y	Yes	Yes	No	0.28 ± 0.07	–
Nirvikalpa, Narayanan	62	Caliper	T1 = pre T2 = 6 m	No	AC vs AC trans–septal	No	–	AC = 2.66 ± 0.8 AC TS = 0.145 ± 2.05
Ritto, Medeiros	35	Photography	T1 = pre T2 = 3 m	No	AC vs AC IO–EO	No	AC = 2.31 ± 0.89 AC IO–EO = 1.40 ± 1.12	–
Fernández Sanroman	15	CBCT, 3D	T1 = pre T2 = 6 m T3 = 1 y	Yes	Yes	Yes	–	–

The results uncovered a mean GAW increase of 1.7 mm after subspinal LFI osteotomy associated with alar cinch, a result that can be considered quite favorable with respect to an average of 2.9 mm reported in the literature for a traditional LFI with alar cinch (Betts et al., 1993; Guymon et al., 1988; Peacock and Susarla, 2015; Rauso et al., 2010; Shoji et al., 2012; Stewart and Edler, 2011). It should be emphasized that our result was achieved despite an average Mx1 advancement of 5.6 mm.

Our study has also confirmed that the variables most associated with GAW enlargement are advancement and impaction of the upper jaw. A 0.3 mm GAW increase was found for each millimeter of advancement at Mx1 ($p < 0.0001$), and a 0.5 mm GAW increase was found for each millimeter of impaction of Mx1 ($p < 0.0001$).

The counterclockwise rotation of the occlusal plane also seems to be less involved in variations in the inter-alar width. Moreover, as demonstrated by univariate analysis, it plays a key role in containing nasal widening through posterior positioning of the perinasal region. The lack of significance uncovered by the multivariate analysis can be explained by the impossibility of accurately determining the modification in the premaxilla resulting from the segmentation of the maxilla, which was performed in nearly two-thirds of the patients.

As far as the limitations of this study are concerned, the most important one is the retrospective design of the study, which means that no control group was involved. An extensive review of the literature on this topic has hopefully addressed that gap.

5. Conclusion

The analysis of data presented here has demonstrated that subspinal LeFort I-type osteotomy and alar-cinch suture can effectively reduce GAW widening following upper jaw osteotomy, particularly in cases of marked advancement and impaction of the maxilla. The correlations outlined here will hopefully assist surgeons in making treatment decisions for these patients. In addition, our results showed that the counterclockwise rotation of the occlusal plane seemed to be a useful maneuver to contain nasal widening. Further studies are warranted to increase our understanding of the role maxillary segmentation plays in GAW widening.

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Declaration of Competing Interest

All the authors declare that they have no conflicts of interest to disclose.

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