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Nasal Airway Evaluation After Le Fort I Osteotomy Combined With Septoplasty in Patients With Cleft Lip and Palate

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Abstract: Septal deviation constitutes an important component of both esthetic deformity and airway compromise in patients with cleft lip and palate (CLP). The posterior parts of the nasal septum presented greater deviation than the anterior parts in patients with complete unilateral CLP. Le Fort I down-fracture provides better access to the nasal septum than intranasal incision during rhinoplasty, especially to the posterior part. This study objectively and subjectively evaluated the nasal function after Le Fort I osteotomy combined with septoplasty in patients with complete unilateral CLP. Twenty-three patients with complete unilateral CLP presenting with nasal obstruction and septum deviation were included (12—combined surgery group; 11—control group). Types of septum deviation in the patients were analyzed. Presurgical and 6-month-postoperative acoustic rhinometry (AR) was performed for objective assessment; and the nasal obstruction symptom evaluation (NOSE) scale was used for subjective assessment. The authors used SPSS to compare the baseline and follow-up results. Acoustic rhinometry assessment showed improvements in the nasal minimal cross-sectional area (MCA), nasal resistance, and nasal volumes in 12 patients who received combined surgery. For the 2 groups, significant improvements in nasal breathing were documented (by NOSE scores) at 6 months after surgery. Simultaneous management of the maxillary dysplasia (Le Fort I osteotomy) and intranasal pathology (septoplasty) were effective for relief of nasal airway obstruction in patients with complete unilateral CLP. The combination of objective (AR) and subjective (NOSE scale) assessments allowed better evaluation of the nasal function.

Key Words: Cleft lip and palate patients, Le Fort I osteotomy, nasal airway evaluation, septoplasty

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The average prevalence of cleft lip and palate (CLP) is 7.75 per 10,000 live births in the United States and 7.94 per 10,000 live births worldwide.¹ Patients with CLP often have associated nasal deformities such as septal deviation, nostril atresia, and deficiency of maxillary growth that alter the nasal floor.^{2,3} These deformities are partly due to the congenital defect itself and due to the prior surgeries performed. Both nasal septal deviation and maxillary hypoplasia constitute important components of the esthetic deformity and airway compromise in patients with CLP. Most patients with CLP would need subsequent orthognathic and rhinoplasty surgery to regain better facial appearance.

The human face develops during the first weeks of intrauterine life. The embryological development of maxilla involves fusion of medial nasal processes, which are centrally positioned on the face, in addition to bilateral maxillary processes that are laterally positioned.⁴ When these facial embryonic processes fail to fuse, cleft lip or CLP are established.⁴ The face of a patient with CLP becomes clinically asymmetric where the nasal septum is bent to one side because the muscles are attached only to that side.⁵ The nasal septum tends to present greater deviation in patients with alveolar clefts or cleft palates than in those without these clefts.⁶ The posterior parts of the nasal septum present greater deviation than the anterior parts in patients with complete unilateral CLP.⁷ Following completion of the maxillary down a fracture in orthognathic procedures, the subnasal approach provides excellent direct access to the nasal septum, especially the posterior part. Besides, maxillary surgical reposition affects the nasal airway size. Changes in the nasal airway in form and function are inevitable after Le Fort I osteotomy. For patients with CLP with nasal obstruction symptom, nasal evaluation and rhino surgery should be considered routinely. Improving the nasal airflow often enhances the patient's sense of smell, sinus drainage, sleep comfort, daytime alertness, and ability to perform exercise/sports.

Maxillofacial literature has traditionally addressed aspects of soft tissue and esthetic changes in patients undergoing orthognathic surgery.^{8,9} In patients with CLP, attention has been focused on their relapse rate and surgical technique. Few studies have discussed the management of nasal airway in patients with CLP by a subnasal approach through maxillary osteotomy. In Wolford's study, the effects of maxillary surgical repositioning on the esthetic changes of the nose and upper lip are presented in patients with a cleft.⁸ Posnick and Fantuzzo used a subjective method to evaluate the nasal airway function after Le Fort I osteotomy and septoplasty in noncleft patients.¹⁰

The aim of the present study was to compare the pre and postnasal airway functions with subjective and objective methods in patients with CLP following nasal septum correction and maxillary advancement.

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TABLE 1. Age, Cleft Side, Surgical Plan, and Septum Deviation Type of 12 Patients in Combined Surgery Group

	Age, y	Cleft Side	Surgical Plan, mm	Septum Deviation Type and Septum Shift From Midline, mm
1	21	Left	MA 5 + MI 3 + septoplasty	D + E, septum shift > 0.6
2	19	Left	MA 5 + BSSRO + septoplasty	C + E, septum shift > 0.6
3	21	Left	MA 5 + BSSRO + septoplasty	B + D, septum shift = 0.4
4	19	Left	MA 4 + septoplasty	A + C, septum shift = 0.5
5	22	Right	MA 6 + MI 3 + BSSRO + septoplasty	B + D, septum shift = 0.5
6	23	Right	MA 4 + MI 2 + BSSRO + septoplasty	B + C, septum shift > 0.6
7	19	Right	MA 3 + BSSRO + septoplasty	A + E, septum shift > 0.6
8	21	Left	MA 3 + MI 3 + BSSRO + septoplasty	C, septum shift = 0.5
9	21	Left	MA 5 + MI 2 + septoplasty	A + C, septum shift > 0.6
10	19	Left	MA 5 + MI 3 + septoplasty	C + E, septum shift > 0.6
11	20	Right	MA 5 + BSSRO + septoplasty	B + D, septum shift = 0.5
12	21	Right	MA 5 + MI 2 + BSSRO + septoplasty	C + E, septum shift > 0.6

BSSRO, bilateral sagittal split ramus osteotomy; MA, maxillary advancement; MI, maxillary inferior movement.

PATIENTS AND METHODS

Twenty-three patients with complete unilateral clefts of the lip and palate were included in this prospective study (13 men and 10 women, mean age 20.5 years, range 18–25 years). These patients, who had maxillary hypoplasia, also had nasal obstruction and septum deviation preoperatively. They were divided into 2 groups: a combined surgery group (12 patients underwent Le Fort I osteotomy and septoplasty) and a control group (11 patients did not undergo septoplasty). Patients in the control group would receive septoplasty and rhinoplasty in their later years. The patients’ information, surgical plan, and septum deviation type are presented in Tables 1 and 2. All patients underwent orthognathic surgery at the Department of Oral, Maxillofacial, and Plastic Surgery, the Ninth People’s Hospital in Shanghai, China. All patients had their lip and palate clefts repaired before 1 year of age and had their alveolar clefts repaired around the age of 13 years. All patients had received orthodontic treatment for several years before surgery.

None of the patients had a history of sinonasal malignancy, radiation therapy to the head or neck, or previous orthognathic surgery, septoplasty, or turbinoplasty.

Three days before surgery and 6 months after surgery, all patients underwent a standardized examination including anterior rhinological examination and acoustic rhinometry (AR) by an otorhinolaryngologist. They also completed the nasal obstruction symptom evaluation (NOSE) scale questionnaire on their own 3 days before surgery and 6 months after surgery.

Septum Deviation Type

For each patient, the shape of the nasal septum was classified into 5 types depending on its deviation pattern. The 5 types were described as follows:

- A. ridge opposite to the anterior part of the inferior turbinate;
- B. ridge opposite to the posterior part of the inferior turbinate;
- C. “C” shape deviation to the height of the middle turbinate and to the depth of the posterior part of the inferior turbinate;
- D. “S” shape deviation to the height of the superior turbinate and to the depth of the posterior part of the inferior turbinate; and
- E. spur opposite to the posterior part of the middle turbinate

The value of the nasal septum shift from the midline was also recorded. The severity of the septum deviation was graded into 3 levels according to the septum shift value: mild (<4 mm), moderate (4–6 mm), and severe (> 6 mm).

Surgical Techniques

The combined surgery group had maxillary advancement surgery and septoplasty, while the control group did not receive the nasal septum surgery. The metric maxillary movement was determined by lateral cephalometric radiographs and orthodontic treatment plans.

A horizontal incision was made in the maxillary vestibule extending between both the first molar regions. In all patients, a typical Le Fort I osteotomy was performed.

TABLE 2. Age, Cleft Side, Surgical Plan, and Septum Deviation Type of 11 Patients in Control Group

	Age, y	Cleft Side	Surgical Plan, mm	Septum Deviation Type and Septum Shift From Midline, mm
1	19	Right	MA 4 + BSSRO	A + E, septum shift = 0.5
2	19	Right	MA 5 + MI 3	C, septum shift > 0.6
3	22	Left	MA 6 + MI 3	B + D, septum shift = 0.4
4	18	Right	MA 5 + BSSRO	A + E, septum shift = 0.4
5	18	Left	MA 4 + MI 2	B + E, septum shift = 0.4
6	25	Right	MA 5 + MI 3 + BSSRO	A + C, septum shift > 0.6
7	21	Left	MA 3 + BSSRO	A + E, septum shift = 0.4
8	18	Left	MA 4 + MI 2 + BSSRO	C, septum shift > 0.6
9	19	Right	MA 4 + MI 2 + BSSRO	A + E, septum shift > 0.6
10	21	Left	MA 6 + MI 3	C + E, septum shift = 0.5
11	19	Left	MA 4	C + D, septum shift > 0.6

BSSRO, bilateral sagittal split ramus osteotomy; MA, maxillary advancement; MI, maxillary inferior movement.

TABLE 3. Results of Acoustic Rhinometry (Combined Surgery Group, n = 12)

	Pre		6 Months Post	
	Combined Surgery Group (n = 12)	Control Group (n = 11)	Combined Surgery Group (n = 12)	Control Group (n = 11)
RT, cm H ₂ O/L/Mi	1.52 ± 0.66	1.52 ± 0.59	1.24 ± 0.43 (P = 0.031)	1.34 ± 0.41 (P = 0.242)
NV, mL	13.29 ± 4.15	12.78 ± 2.84	14.73 ± 4.31 (P = 0.019)	13.49 ± 2.88 (P = 0.554)
MCA, cm ²	0.47 ± 0.09	0.47 ± 0.10	0.56 ± 0.12 (P = 0.048)	0.49 ± 0.08 (P = 0.168)

MCA, minimal cross-sectional area; NV, nasal volume; RT, total nasal resistance.

After disimpaction, a periosteal elevator was used to achieve submucosal exposure of all the buckled/deviated portions of the cartilaginous and bony septum on both sides, which were then removed (submucosal resection). A higher-level deviation was not easy to manage. We removed a small piece of the cartilage present inferior to the high deviated septum and made partial-thickness incisions (scoring) on the concave side of the high deviated cartilage. Even in very severe patients, we preserved the dorsal and columellar components of the cartilaginous septum that is necessary for structural support. Because a secondary rhinoplasty would be a future consideration for patients with CLP, preservation of as much useful septal cartilage as possible for spreader grafts and lower lateral batten grafts is very important. The deviated anterior nasal spine was dissected and osteotomized flush with the maxilla, and the leading edge of the nasal septum was then fixed to the midline maxillary bone. Additionally, an iatrogenic deviation of the septum was caused by the presence of the endotracheal tube. After disimpaction, an assistant held the tube to eliminate as much tension as possible. If the nasal mucosa was torn at down-fracture, suture repair was performed after septoplasty was accomplished.

Intranasal splints can be used to readapt the mucoperiosteum and mucoperichondrium into their proper positions, and to decrease the incidence of hematoma and maintain alignment of the septum.

Objective Assessment by Acoustic Rhinometry

To evaluate the nasal airway objectively, we used an Eccovision Acoustic Rhinometer (HOOD Laboratories, Pembroke, MA). The equipment consists of a pulse generator positioned at the distal end of a 24-cm tube that has a recording microphone positioned at its proximal end. The rhinometer tube is placed against one of the nostrils. The device generates sound waves that propagate through the tube, pass through the microphone, and enter the nasal cavity.¹¹

Nasal minimal cross-sectional area (MCA), nasal resistance (NAR), and nasal volumes (NV) were determined by using AR. Acoustic rhinometry determines the cross-sectional areas of the nose depending on the distance to the nostril. The software calculates the cross-sectional areas based on the reflection time, change in frequency, and amplitude of sound waves applied to the nose.

For each subject, an external nasal adapter was selected for proper fit, and a thin layer of ointment was applied to prevent any acoustic leakage between the nostril and adapter. Special care was taken not to distort the nasal valve anatomy and to position the nose adapter in light contact with the nostril during the assessment. Measurements were repeated 3 times in each nasal cavity before and 10 minutes after topical application of 5 drops of a nasal vasoconstrictor (0.1% xylometazoline hydrochloride) into each nostril.

Nasal resistance was determined for each side of the nose and the total resistance calculated using Ohm law equation for parallel resistors: $1/RT = 1/Rr + 1/RI$, where RT = total nasal resistance, Rr = nasal resistance on the right side, and RI = nasal resistance on the left side. Nasal volume was calculated using the equation: $NV = Vr + Vl$, where NV = total nasal volume, Vr = nasal volume

on the right side, and Vl = nasal volume on the left side. Minimal cross-sectional area was the mean figure of the 2 nasal cavities' MCA. $MCA = (MCAI + MCAr)/2$, $MCAI = MCA$ on the left side and $MCAr = MCA$ on the right side.

Subjective Assessment by Nasal Obstruction Symptom Evaluation Scale

Recently, a validated outcomes instrument, the NOSE scale, became available to assess the extent of patient-perceived clinical nasal obstruction both before and after either medical or surgical intervention. The NOSE scale is a brief, valid, reliable, and responsive questionnaire that provides a means of prospectively assessing the clinical outcome after nasal septoplasty and/or inferior turbinate reduction.^{12,13} The range of raw scores on the instrument is from 0 to 20. It is then scaled to a total score of 0 to 100 by multiplying the raw score by 5. A score of 0 means no nasal obstruction and a score of 100 means the most severe nasal obstruction.

Statistical Analysis

Nonparametric analysis (Wilcoxon signed-rank test) was used to compare the baseline and follow-up results. Results are presented as mean ± standard error of the mean. A P value < 0.05 was considered statistically significant.

RESULTS

Acoustic Rhinometry

The results of the nasal airway measurements by AR preoperatively and 6 months postoperatively are presented in Table 3. In order to eliminate the effect of the nasal mucosa swelling, we compared results after using a nasal vasoconstrictor. Results of the AR showed improvements in MCA, NAR, and NV.

The Nasal Obstruction Symptom Evaluation Scale

For the 2 groups, significant improvements in nasal breathing were documented by the NOSE scale at 6 months after surgery. The NOSE scale questionnaire was used in our study group to assess the disease-specific quality of life (QOL) with respect to symptomatic nasal obstruction. A numerical weighted score (raw score × 5) of 0 to 100 (with higher scores indicating more severe nasal obstruction) was recorded for each patient. For the combined surgery group, the baseline NOSE scores ($76.65 ± 8.05$) and those at 6 months after surgery ($8.75 ± 4.3$) were compared (P < 0.05). Similarly, for the control group, the baseline NOSE scores ($13.15 ± 8.45$) and those at 6 months after surgery ($7.75 ± 8.15$) were compared (P < 0.05).

DISCUSSION

Guenther et al¹⁴ reported a significant improvement in the NAR following maxillary repositioning by rhinomanometry. Kunkel and

Hochban recorded the nasal airway changes by AR. The changes were compared to the amount of skeletal movement by means of preoperative and 6-week postoperative lateral cephalography.¹⁵ Erbe evaluated the changes in the nasal airway following 1-piece Le Fort I osteotomy by AR and anterior active rhinomanometry. The interalar width and cross-sectional area at the Isthmus nasi increased significantly. Nasal volume decreased without increasing the nasal airway resistance.¹⁶

In their investigations, rhinoplasty surgery was not performed during Le Fort I osteotomy. Turvey described the potential adverse effects of Le Fort I osteotomy on nasal breathing; he suggested that septal deviation should be assessed preoperatively and recommended making corrections in the abnormal intranasal anatomy either before or during orthognathic surgery.¹⁷ Haarmann performed functional rhino surgery during Le Fort I osteotomy. He used AR and rhinomanometry to make an objective assessment, which showed reduction in the NAR after combined surgery.¹⁸

However, none of the studies mentioned above used subjective assessment to evaluate the nasal function-related QOL of patients by standard questionnaire. Posnick and Fantuzzo indicated that simultaneous Le Fort I osteotomy and intranasal pathology were effective for the symptomatic relief of nasal airway obstruction. The NOSE scale was used to assess the extent of clinical nasal obstruction before and after septoplasty and inferior turbinate reduction performed at the time of Le Fort I down fracture.¹⁰ They did not make an objective assessment of the nasal airway function.

Although the effects of Le Fort I osteotomy on the nasal airway have been reported for nonclefts, little information is available on patients with CLP. In our study, we evaluated the nasal function in patients with complete unilateral CLP after Le Fort I osteotomy combined with septoplasty both objectively and subjectively.

We used AR to assess the nasal airway function objectively. Compared to rhinomanometry, AR was easier to manipulate and more noninvasive. Especially in younger patients, their cooperation was not a problem. Our data suggested that patients with CLP with nasal obstruction showed improvements in the AR assessment 6 months after surgery. This finding corroborated other previous aerodynamic studies suggesting that maxillary repositioning opens the internal nose dimensions, thus reducing NAR. According to Götzfried et al's study, a Le Fort I osteotomy and ventral-caudal advancement of the maxilla would improve the nasal breathing in a cleft patient. They used rhinomanometric measurements and x-ray examination to confirm the results.¹⁹

The nasal valve area was the narrowest portion of the nasal passage accounting for most of the airflow resistance. Small changes in the nasal valve area produced significant changes in the nasal airflow.^{20,21}

Maxillary advancement tended to widen the basal portion of the nasal valve, which might reduce the nasal airway resistance by opening the nasal valve. Some authors observed a subjective improvement in nasal breathing after surgical advancement of the maxilla in patients with hypoplasia of the middle third of the face. They also explained that it was due to an increase in the volume of the nasal skeleton and/or in the nasolabial angle, which improved the nasal ventilation.²¹ In addition, surgical correction of a mechanical airway obstruction (deviated septum) was done by a septoplasty. It was shown by previous studies that a functional septoplasty could improve nasal breathing both objectively and subjectively in patients with nasal obstruction.²²⁻²⁴ These 2 major surgical procedures help to create an expanded nasal cavity, contributing to an increase in the NV and MCA, and a reduction in the NAR.

In our study, significant improvements in nasal breathing were documented (by the NOSE scale) 6 months after surgery in both

groups. Objectively, the nasal airway function improved after combined surgeries. Subjectively, patients with CLP regained their self-esteem because of their improved esthetics after the surgery. They are more likely to have a positive attitude and more self-esteem than before. Additionally, the nasal discomfort was also eliminated to a certain extent. For the control group, patients did not experience significant improvement in the objective assessment. However, they also showed improvements in their health-related QOL.

CONCLUSIONS

Our study showed that simultaneous management of a maxillary dysplasia (Le Fort I osteotomy) and an intranasal pathology (septoplasty) was effective for the relief of nasal airway obstruction. For patients with CLP, functional septoplasty should be considered routinely. The combination of an objective (AR) and a subjective (NOSE scale) assessment allowed a better evaluation of the nasal structure and function.

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