Original Article

Does Le Fort I Osteotomy Have an Influence on Nasal Cavity and Septum Deviation?

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ABSTRACT

Aims: Le Fort I (LI) osteotomy has been used for the correction of dento-facial deformities of the midface. The aim of this study was to determine the effects of advancement and impaction of the maxilla with LI osteotomy on the nasal cavity and septum. **Patients and Methods:** In this study, 40 adult patients, 23 females and 17 males (mean age 20.52 ± 4.4 years), who underwent single-piece LI advancement and impaction surgery combined with a bilateral sagittal split osteotomy (BSSO) were included. Posterior-anterior (PA) and lateral cephalometric radiographs taken before surgery (T0) and at least three months after surgery (T1) were evaluated. The superior and anterior movements of maxilla, changes of the nasal cavity, nasal septum and maxillo-mandibular parameter were measured on the cephalometric radiographs. Treatment changes were statistically analyzed using paired sample *t*-test, and Pearson correlation analysis was applied for the determination of the relationship between variables. **Results:** There was no statistically significant change in the deviation parameters ($P > 0,05$). However, a statistically significant decrease was found for left and right nasal cavity heights after LI osteotomy ($P < 0.05$). Furthermore, no significant correlation was found between septal deviation angle and extent of maxillary movement ($P > 0.05$). Positive correlation was found between nasal cavity width and amount of maxillary impaction. ($P < 0.05$). **Conclusion:** The influence of maxillary impaction with LI osteotomy on nasal septum deviation was not found significant but maxillary impaction with LI osteotomy significantly increased the nasal cavity width.

KEYWORDS: *Le Fort I osteotomy, maxillofacial surgery, nasal septum, nasal cavity, orthognathic surgery*

INTRODUCTION

The nasal septum is an important part of the form of the nose. It symmetrically divides the nasal airway and determines the position and height of the nasal apex. Moreover, deflection of the nasal septum will inhibit the function of the nasal airway.[1] Therefore, any damage to the nasal septum can affect both aesthetics and function.

Le Fort I (LI) osteotomy has been used for the correction of dento-facial deformities of the midface for years.[2,3] As a very close relationship exists between the maxilla and the nose, L1 osteotomies, which are frequently used during orthognathic surgery and have been shown to have a very significant on nasal aesthetics.[4] Besides the advantages of this surgical technique, there are also some adverse effects like widening of alar bases, increase in the nasolabial angle, thinning and shortening of the upper lip.[5-7]

Perforation or deviation of the nasal septum is one of the complications of Le Fort I osteotomy.[8,9] In these cases, septum deviation is corrected by surgery.[10,11] To improve the nasal airway and deal with any asymmetry

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that occurs, septoplasty can be performed to correct the septum after maxillary surgery. Columellar retraction resulting from excessive shortening of the caudal septum and anterior nasal spine (ANS) can be corrected using septal grafts. After maxillary advancement, where there is already a saddle deformation, improvement can be achieved by using chopped cartilage wrapped around the temporalis fascia in the dorsal profile.[12]

Different movements of the maxilla with LI osteotomies have various effects on the nasal cavity and septum.[13] Although there are many studies about changes in the nasal function and nasal form after LI osteotomies, there are few reports on the nasal septum changes after LI surgery. Ghoreishian *et al*.[14] reported that while the advancement of maxilla with LI osteotomy can increase the respiratory function, impaction can decrease the nasal respiration. On the contrary, Erbe *et al.*[8] concluded that there was no significant nasal airway changes after LI impaction or advancement. Furthermore, Turvey *et al.*[15] found that impaction of the maxilla often results with a decrease in the nasal resistance.

The aim of this retrospective study was to evaluate the effects of advancement and impaction of the maxilla via LI osteotomy on the nasal cavity and the nasal septum.

Patients and Methods

This retrospective study comprised of records of 40 adult patients who underwent orthodontic treatment and bimaxillary orthognathic surgery for skeletal Class 3 malocclusion at Baskent University between December 2008 and January 2017. Patients who underwent single-piece Le Fort I advancement and impaction surgery with alar base cinch suture combined with a BSSO were included in this study. Patients were excluded if they had congenital craniofacial deformity, craniofacial syndromes, previous facial trauma, naso-maxillary surgery and orthognathic surgery with inferior positioning of maxilla. All of the patients were Caucasian. Informed consents were obtained from all patients before the treatment and an ethics committee approval of ……. University Institutional Review Board (protocol number: D-KA 17/17) was attained before the study. Research was performed in accordance with the principles laid down in the Helsinki Declaration.

Surgical procedure

After nasotracheal intubation, conventional LI osteotomy procedure was initiated with a bilateral horizontal incision in the gingivobuccal sulcus above the attached gingival margin from the central incisor to the second premolars including mucosa, muscle and periosteum. The subperiosteal tissue was reflected superiorly. Piriformis aperture, infraorbital foramen, inferior of the pterygoid plate, palatine bone junction and nasal floor were exposed, respectively. After the dissection, reference points were marked and measured. Bilateral horizontal osteotomies, nasal septum osteotomy, separation of pterygoid plates from the maxillary tuberosity, and bilateral lateral nasal wall osteotomies were performed, respectively. Down fracture of the maxilla was achieved by downward pressure on the anterior maxilla. Following the complete mobilization of the maxilla, the maxilla was fixed with a 1.5 mm mini plates system (KLS Martin Group, Tuttlingen, Germany) according to the planned reference measurements and guidance of the surgical wafer. Alar cinch suture with 2.0 proline to control the alar base width and V-Y closure with 4.0 vicryl to control upper lip changes were accomplished. All patients gained Class I canine relationship and positive overjet after the orthognathic surgery. There were no nasal complications during or after surgical operations in our study group.

Lateral and posteroanterior cephalometric measurements

PA and lateral cephalometric radiographs were taken with a Morita X-ray device (Morita Veraviewpocs, CA, USA) before surgery (T0) and at least three months after surgery (T1). All of the radiographs were taken with the same cephalostat and calibration rule. Rradiographs were digitized and evaluated with Dolphin Imaging Software (Vers 11.5 Premium, Patterson Dental, CA, USA). The lateral cephalometric radiographs were superimposed on sella-nasion (SN) plane, and one of the investigators (A.A.) precisely established the direction and amount of the maxillary movement in the vertical and sagittal plane. In the cephalometric radiographs, the criteria sought was a Frankfort horizontal plane parallel to the floor, teeth at centric occlusion, lips in a resting position and the presence of calibration rulers through which calibration could be controlled. All radiographic images were taken by the same experienced radiology technician team who were educated about the dental radiography.

Horizontal reference plane (HR) was constructed with seven degrees from the SN plane and a vertical reference plane (VR) was formed perpendicular to HR [Figure 1]. The lateral cephalometric landmarks and measurements used in this study are presented in Figure 1.

The A point, ANS and posterior nasal spine (PNS) were used to represent the position of maxilla. Palatal plane (PP) was constructed between ANS and PNS reference points. The superior and anterior movement of the maxilla was measured in mm and degrees from each demonstrative reference point.

The list of the landmarks marked on each PA radiographs is given in Figure 2. Nasal cavity width, nasal cavity height, nasal base angle and nasal septum deviation angle were measured on PA cephalometric radiographs for the T0 and T1 periods [Figure 3]. Deviation of the nasal septum was assessed by angular measurements and linear measurements were used for the assessment of nasal transversal changes [Figure 3].

Statically analysis

The statistical evaluation of the changes between T0 and T1 measurements were analyzed with a paired sample *t*-test using SPSS statistical software package (version 21, SPSS, IBM Corporation, New York, USA) and Pearson correlation analysis was used to calculate the relationship between variables. All of the results were reported as mean ± standard deviation and the level of significance was 0.05.

Error of the method

Twenty days after the initial assessment of the radiographs, 10 patients were chosen randomly. A total of 20 radiographs were reanalyzed by the same author for intraexaminer reliability. Intraclass correlation coefficients at 95 per cent confidence interval for PA cephalometric measurements ranged from 0.964 to 1 [Supplementary Table 1].

Results

In total, 40 adult patients (23 females and 17 males) with a mean age 20.52 ± 4.4 years were evaluated. Table 1 demonstrates the means and standard deviations of the differences between pre- and postsurgical measurements. The nasal septum deviation angle did not show any significant change (P = 0.496) after L1 surgery.There was also no statistically significant difference between T0 and T1 for nasal base angle (P = 0.964). However, a statistically significant decrease was found for left and right nasal cavity heights after surgery (P < 0.05).

Table 2 shows the results of correlation analysis

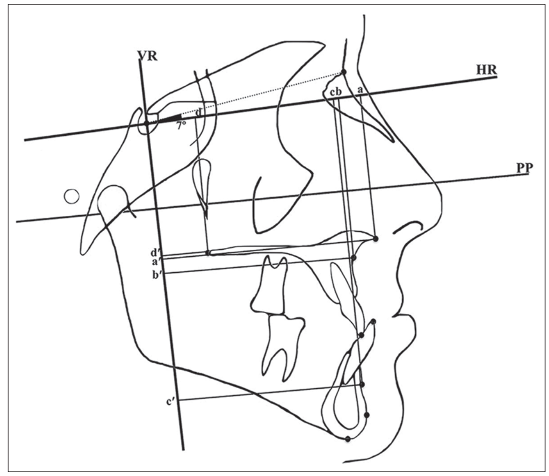

Figure 1: Reference planes and cephalometric measurements used in the study: HR, horizontal plane angulated 7° clockwise to SN plane at Sella; VR, perpendicular plane to HR passing through Sella; SN plane. Cephalometric measurements: (a) perpendicular distance of ANS point to HR, (a') perpendicular distance of ANS point to VR, (b) perpendicular distance of A point to HR, (b') perpendicular distance of A point to VR, (c) perpendicular distance of B point to HR, (c') perpendicular distance of B point to VR, (d) perpendicular distance of PNS point to HR, (d') perpendicular distance of PNS point to VR

Table 1: Differences between pre- and postsurgical measurements (T1-T0) (Paired sample *t*-test)*P<0.05

	Paired Differences					*t*	df	*P*
	Mean	Std. deviation	Mean std. error	95% Confidence Interval of the Difference				
				Lower	Upper			
SNA (degree)	4.48	3.04	0.48	3.51	5.45	9.33	39.00	0.000*
A-HR (mm)	−0.17	3.11	0.49	−1.16	0.83	−0.33	39.00	0.74
A−VR (mm)	4.25	3.74	0.59	3.06	5.45	7.21	39.00	0.000*
ANS-HR (mm)	−0.30	2.74	0.43	−1.18	0.56	−0.71	39.00	0.48
ANS-VR (mm)	4.42	4.42	0.70	3.01	5.83	6.33	39.00	0.000*
PNS-HR (mm)	−0.89	2.00	0.32	−1.53	−0.25	−2.82	39.00	0.008*
PNS-VR (mm)	2.35	3.64	0.58	1.19	3.51	4.09	39.00	0.000*
PP-HR (degree)	0.09	2.59	0.41	−0.74	0.91	0.22	39.00	0.83
ANB (degree)	6.77	4.08	0.65	5.46	8.07	10.40	39.00	0.000*
Wits (mm)	7.20	6.08	0.96	5.25	9.14	7.49	39.00	0.000*
Upper Ant. Facial Height (mm)	−0.14	2.75	0.43	−1.02	0.74	−0.32	39.00	0.75
Septal dev. Angle (degree)	0.26	2.39	0.38	−0.51	1.02	0.69	39.00	0.50
Nasal cavity width (degree)	0.30	2.72	0.43	−0.56	1.17	0.70	39.00	0.43
Nasal cavity width (mm)	−0.13	1.02	0.16	−0.46	0.19	−0.81	39.00	0.76
Right nasal cavity height (mm)	−2.04	3.13	0.49	−3.05	−1.04	−4.14	39.00	0.000*
Left nasal cavity height (mm)	−1.99	3.21	0.51	−3.02	−0.96	−3.92	39.00	0.000*
Nasal base angle (degree)	0.02	2.77	0.44	−0.87	0.90	0.04	39.00	0.96

Table 2: Results of correlation analysis between surgical measurements and nasal variables. *$P<0.05$

Parameters	Correlation coefficient	Septal Dev. Angle (degree)	Nasal cavity width (degree)	Nasal cavity width (mm)	Nasal cavity height (mm)	Nasal base angle (degree)
SNA (degree)	*r*	0.119	−0.161	0.074	0.108	−0.034
	p	0.466	0.321	0.649	0.508	0.833
A-HR (mm)	*r*	−0.045	0.055	0.142	0.388*	0.227
	p	0.783	0.734	0.382	0.013*	0.159
A-VR (mm)	*r*	0.036	−0.035	0.178	0.233	−0.085
	p	0.826	0.829	0.272	0.149	0.601
ANS-HR (mm)	*r*	−0.043	−0.11	−0.013	0.381*	0.084
	p	0.793	0.499	0.936	0.015*	0.604
ANS-VR (mm)	*r*	−0.017	−0.064	0.232	0.198	−0.056
	p	0.915	0.695	0.15	0.221	0.733
PNS-HR (mm)	*r*	−0.088	0.188	0.248	0.385*	0.238
	p	0.59	0.246	0.123	0.014*	0.138
PNS-VR (mm)	*r*	−0.052	0.1	0.064	0.2	−0.059
	p	0.748	0.539	0.696	0.217	0.718
PP-HR (degree)	*r*	0.098	0.182	0.494*	0.243	0.088
	p	0.548	0.262	0.001*	0.131	0.591
Upper Ant. Facial Height (mm)	*r*	−0.071	−0.046	−0.02	0.339*	−0.033
	p	0.662	0.778	0.904	0.032*	0.838

Table 3: Results of correlation analysis between septal deviation angle and nasal cavity measurements. *$P<0.05$

	Correlations		
	Nasal cavity width (degree)	Nasal cavity width (mm)	Nasal cavity height (mm)
Septal deviation angle (degree)			
r	−0.243	−0.19	−0.139
p	0.132	0.24	0.393
n	40	40	40

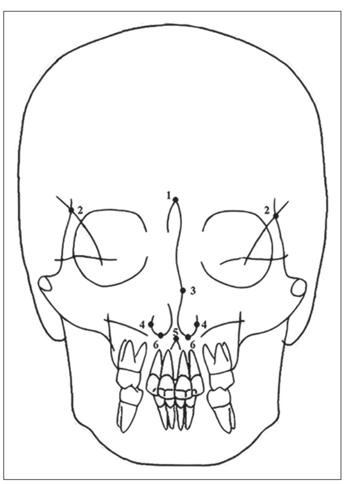

Figure 2: Posteroanterior cephalometric landmarks: (1) geometric center of crista galli, (2) intersection of the superior border of the greater wing of the sphenoid bone and the lateral orbital margin, (3) the most deviated point of the nasal septum, (4) the most lateral point on the nasal cavity, (5) anterior nasal spine, (6) the lowest point on the nasal cavity

between surgical measurements and nasal parameters. A negative correlation (r = −0.494) was found between

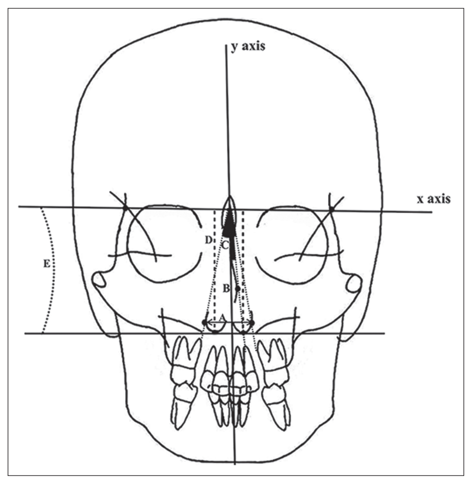

Figure 3: (A) Nasal width angle was measured between the y-axis and the line connecting the crista galli to the most prominent point of the lateral nasal wall. (B) The angle of the septal deviation was measured between the y-axis and the most deviated point of the nasal septum. (C) The nasal width distance was measured between left and right the most lateral point of the nasal cavity. (D) The nasal height was measured between x-axis and the lowest point of the nasal base. (E) The nasal base angle was measured between the x-axis and the line connecting the x-axis to the lowest point of nasal floor

PP-HR (Degree) and nasal cavity width (mm) which indicates a positive correlation between nasal cavity width and amount of maxillary impaction ($P < 0.05$).

There was also no significant correlation between septal deviation angle and extent of maxillary movement ($P > 0.05$).

The results of correlation analysis are shown Table 3, and there was no significant correlation between the septal deviation angle and the nasal cavity width.

Moreover, no significant relationship was found between nasal cavity height and septum deviation angle ($P > 0.05$).

Discussion

LI osteotomy is one of the most complex surgeries of the maxilla.Postoperative complication rate for LI osteotomies has been reported from 4% to 9.1% in the literature.[16-18] Postoperative complications may include maxillary sinusitis, dental and trigeminal nerve injuries, avascular necrosis, infection, unfavorable fractures, fistulas, hemorrhage, nasal septal deviation, relapse or instability of the maxilla.[16,17,19]

Besides the postoperative complication risks, LI osteotomy is reported to improve breathing as it causes a decrease in the nasal resistance, thus increasing the airflow.[13,20] Moreover, the rhinoscopic and acoustic rhinometric measurements showed that total nasal functions of the patients were enhanced after LI surgery regardless of the direction of the surgery.[1,13]

Our study revealed no significant change for the total nasal cavity width; however, we found a significant decrease for left and right nasal cavity heights was detected after maxillary impaction and advancement. Furthermore, a positive correlation was found between the nasal cavity width and the amount of maxillary impaction.Erbe *et al.*[8] reported no significant nasal airway changes after LI impaction or advancement but they showed an increase for internal width of nose in impaction patients. Spalding *et al.*[21] found no consistent association between amount or direction of maxillary surgery and nasal function parameters. On the other hand, some studies reported that maxillary repositioning extends internal nose dimensions, increase alar base width and increases the cross-sectional diameter at isthmus nasi, thus improves nasal air flow and reduces nasal resistance.[3,20] These conflicting results can be attributed to different types of LI osteotomies and procedures like alar base cinch suture procedure which were used in some of these studies. Alar cinch suture can change external nares from narrow to ovoid form and may improve nasal breathing.[1] Alar cinch suture procedure was applied to all of the patients in our study group.

Impaction of the maxilla with LI osteotomy is commonly used for the treatment of vertical excess and reduction of the anterior facial height. It is difficult to examine the effects of impaction solely, due to accompanying anterior or posterior movements of the maxilla. Maxillary advancement and impaction have similar effects such as widening of alar bases, elevation and widening of the nasal tip. Pourdanesh *et al.*[13] suggested a close relationship between impaction of the maxilla in LI osteotomies and nasal function. In their study, they showed that the total nasal airflow can be improved if the impaction of the maxilla is less than 5.5 mm. They concluded that 5.5 mm of impaction can be used as a reference value for the amount of maxillary impaction. In our study group, the highest amount of impaction of maxilla was 5.2 mm and a positive correlation was found between nasal cavity width and the amount of maxillary impaction.

Deflection of nasal septum was reported to be the one of the commonly occurring complications of LI osteotomies.[8,10,11] The first study which showed nasal septum perforation resulting from a total maxillary osteotomy was performed by Mainous *et al.*[22] Epistaxis and malodor may associate this complication. Erbe *et al.*[8] suggested that the septal perforation may result from the tearing of muco-perichondrium or separation of the maxilla at the junction between nasal crest and septal cartilage.[8] They reported that three of twenty patients had encountered nasal septum perforations after LI surgery but no additional treatments were required for these patients.

The amount of septal deviation seen after the surgery may depend on the direction and the magnitude of the movement of maxilla during LI osteotomy. Accordingly, previous studies revealed that the direction and method of the maxillary movement with LI osteotomies influence the nasal area and nasal septum.[23] Another reason for septal deviation after L1 osteotomies is dislocation by a partially deflated cuff during extubation[24] and Ibrahim *et al.*[10] offered submental orotracheal intubation technique (in which the endotracheal tube is placed directly under the chin) to avoid nasal septal damages. Additionally, this technique provides the surgeon with a clear view of the surgical field, enables easy visualization of occlusal cants, dental midlines, upper lip height and has no effect to any bony structure. It also allows concurrent rhinoplasty and offers an inferior access to the nasal septum.

Moroi *et al.*[24] reported that Le fort I osteotomy has no influence on the nasal septal deviation and also this surgery did not lead to left or right asymmetry in the airway. In this study, there was no significant difference in preoperative and postoperative septal deviation angles and nasal base angles which was in accordance with the findings of Moroi *et al.*[24] study. In our study group, there was just one patient who had a severe nasal septal deviation angle difference (5.7°) and this may be due to asymmetrical impaction or rotation of the maxilla to correct the upper midline for this patient.

Limitations

One of the limitations of this study is the assessment of the nasal septum changes and nasal deviation from two-dimensional (2-D) radiographs. PA cephalometric radiographs help clinicians for the evaluation of maxillofacial structures in transversal plane and cause less radiation exposure for the patient compared to three-dimensional (3-D) computed tomographies. However, 3-D cone-beam computed tomography (CBCT) is more reliable and can give more information than 2-D radiography. On the other hand, 3-D CBCT is not obligatory for all orthognatic surgery patients and higher cost of this process is a disadvantage.

Another limitation is the retrospective nature of this study. Future prospective clinical trials with improves methodology and larger study groups are needed to evaluate the changes in the nasal region after orthognatic surgery.

Conclusions

The surgeon and orthodontist should always include the nasal aesthetics and function in treatment planning of orthognathic patients. Patients should be carefully warned about the nasal changes and the risk of nasal septum deviation before the surgical procedure. Avoiding excessive movements of maxilla is the key to provide undesirable side effects. As a conclusion of this study, although the influence of maxillary impaction with LI osteotomy on nasal septum deviation was not found significant the nasal cavity width remarkably increased.

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Conflicts of interest

There are no conflicts of interest.

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