Evaluation of Sino-Nasal Changes after Le Fort I Osteotomy using CBCT Images

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– Abstract –

Evaluation of Sino-Nasal Change after Le Fort I Osteotomy using CBCT Images

Orthognathic surgery including Le Fort I osteotomy involves changes in the nasal septum and maxillary sinus. This study 1) assess nasal septum changes after Le Fort I osteotomy using cone beam computed tomography (CBCT) images and 2) evaluates mucosal changes in the maxillary sinus after the surgery. This was a retrospective study of 33 patients who underwent orthognathic surgery including Le Fort I osteotomy. To assess the maxillary sinus, changes in the mucosa of the maxillary sinus were analyzed by volume and geometry. The air cavity *per se* and mucosal thickening of the maxillary sinus using SIMPLANT (Materialise, Belgium) software was measured. And the geometry of the distribution of the mucosa was analyzed using CBCT images. The septal angle was decreased after Le Fort I osteotomy, but not significantly ($P>0.05$). The volume reduction of the air cavity *per se* and increasing of the volume of the mucosal thickening after Le Fort I osteotomy were statistically significant ($P<0.05$). Mucosal thickening was observed in the posterior-inferior direction. In this study, nasal septum deviation was not statistically significant after Le Fort I osteotomy. The changes of the maxillary sinus after the Le Fort I osteotomy is inevitable. But the studies that take into consideration of the importance of the evaluation of nasal septum and maxillary sinus were insufficient. Using CBCT images we evaluated pre and post-operative changes of the nasal septum and maxillary sinus. Decrease of the air cavity *per se*, decrease of the total volume of the maxillary sinus, and increase of mucosal thickening were prominent. Furthermore, the mucosal thickening that occurs after surgery

appears to be mainly in the posterior lower part of the maxillary sinus.

Key Words : Osteotomy, Le Fort ; Nasal Septum ; Maxillary Sinus

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I. INTRODUCTION

The maxillary sinus is the largest air sinus in the body. Found in the body of the maxilla, this sinus has three recesses: an alveolar recess pointed inferiorly, bounded by the alveolar process of the maxilla; a zygomatic recess pointed laterally, bounded by the zygomatic bone; and an infraorbital recess pointed superiorly, bounded by the inferior orbital surface of the maxilla. The sinus is lined with mucoperiosteum, with cilia that beat toward the ostia. This membrane is also referred to as the "Schneiderian Membrane", which is histologically a bilaminar membrane with ciliated columnar epithelial cells on the internal (or cavernous) side and periosteum on the osseous side. The size of the sinuses varies in different skulls, and even on the two sides of the same skull. The fleshy external end of the nasal septum is sometimes also called columella. The nasal septum contains bone and hyaline cartilage. It is consists of the perpendicular plate of ethmoid bone, vomer bone, septal nasal cartilage, crest of the maxillary bone, and crest of the palatine bone. The nasal septum can depart from the centre line of the nose in a condition that is known as a deviated septum caused by trauma. However, it is normal to have a slight deviation to one side.

In the realm of oral maxillofacial surgery, orthognathic surgery including Le Fort I osteotomy has been performed to resolve dentofacial deformities and to recover occlusal function. The LeFort 1 osteotomy is a procedure used by maxillofacial surgeons to correct a wide range of dentofacial deformities. Because of its versatility and simplicity, it has gained popularity for a wide range of uses. The osteotomy can be performed quickly and efficiently if appropriate preoperative and intraoperative preparations are followed. The complication profile of this procedure is well established and should be understood prior to execution. The movement of the maxilla affects nasal structures, and various complications have been

reported. (Kramer et al., 2004; Kim and Park, 2007) Le Fort I osteotomy was first introduced in 1867 and was standardized by Bell in 1975. It is widely used in oral and maxillofacial surgeries, such as orthognathic surgery. (Drommer, 1986) Owing to the nature of the surgery, the maxillary sinus area is included in the osteotomy line, and the surgery may also affect the nasal septum above the maxilla.

The nasal septum is made up of various components, especially septal cartilage, the perpendicular plate of the ethmoid bone, and the vomer, with different developmental origins. (Akbay et al., 2013[4])Structural problems in the nasal septum are one of the most common conditions encountered in otolaryngology. Therefore, many studies have been done on patients with nasal obstructions; studies on the relationship between septal deviation and the inferior turbinate are typical. (Akoglu et al., 2007) There have been few studies on nasal septum deviation associated with Le Fort I osteotomy. Instead, examinations have focused on insufficient resection of the septal cartilage during Le Fort I osteotomy, nasotracheal intubation, and dislocation of the septal cartilage by an incompletely deflated cuff during extubation. (Posnick et al., 2007; Shin et al., 2016)

In Le Fort I osteotomy, the maxillary bone is completely separated from the midface. The maxillary sinus is necessarily included in the osteotomy line. Therefore, the physiology of the maxillary sinus may be changed by the surgery. Sinusitis is a very common disease in the United States; it usually refers to maxillary sinusitis, which affects 16% of the population annually.(Kretzschmar and Kretzschmar, 2003) There have been many reports that maxillary sinusitis can occur after surgery. (Bell et al., 1986; Menendez et al., 1996) Pereira-Filho et al reported the incidence of maxillary sinusitis after Le Fort I osteotomy as 4.76%.(Pereira-Filho et al., 2011) Nevertheless, evaluation of the maxillary sinus before and after surgery

has not generally done. The published studies on the maxillary sinus mainly report on, in this order of frequency, postoperative complications, treatment, and the causal relationship between surgery and complications. (Moses et al., 2000; Kramer et al., 2004; Pereira-Filho et al., 2011; Valstar et al., 2013)

So far, studies on the changes of nasal septum and maxillary sinus have been made through clinical and radiological evaluation. There are few studies on nasal septum before and after surgery, and there is a lack of reproducibility in the evaluation method using CT image. The changes of the maxillary sinus were evaluated by clinical methods such as endoscope and radiological evaluation of CT. However, the quantitative analysis of the change was insufficient

The purpose of this study is 1) to predict postoperative complications related to the nasal septum and 2) to observe changes in the maxillary sinus in order to identify potential problems during the follow-up period. This study may provide insight into changes in the nasal septum and maxillary sinus that are associated with Le Fort I osteotomy. In addition, anticipation of the side effects of the surgery will help to establish a proper surgical plan to prevent the complications.

II. PATIENTS AND METHODS

A. PATIENTS

The subjects of this study consisted of patients who visited the Department of Oral and Maxillofacial Surgery at Ajou University Hospital (South Korea) between September 2009 and June 2016 and had orthognathic surgery including Le Fort I Osteotomy. This study was approved by the AJOU University Hospital IRB.(AJIRB-MED-MDB-16-433) The type of surgical procedure to be used in Le Fort I osteotomy was determined according to the treatment plan. Le Fort I osteotomy was performed as usual. To prevent nasal septum deviation after surgery, the nasal septal cartilage, vomer, and lateral wall of the nasal cavity were carefully separated from the maxilla with fine osteotomes. By down-fracturing the maxilla, the septum and the floor of the nose were exposed and then the septal cartilage was resected with heavy scissors. Osteotomized maxillary bone was fixed by L-shaped titanium plates and screws. Intermaxillary fixation by wire was maintained for at least 2 weeks. Patients with both preoperative and postoperative cone beam computed tomography (CBCT) images available were included in this study. Demographic data on the patients are shown in Table 1.

Table 1. Demographic data of the study subjects.

Patient characteristics	**n**
Gender	
Male	17
Female	16
Mean age (Yr)	24.1
Meant follow-Up CT interval (Mo)	5.1

B. METHODS

(A) PATIENTS GROUPING

For statistical analysis, the patients were divided according to the extent and characteristics of maxillary movement after Le Fort I osteotomy. Movement of the maxilla was determined through preoperative model surgery, and the amount of movement of the maxillary bone established before surgery was confirmed by the operation record. First, patients were divided into impaction groups: impaction greater than 5 mm or less than 4 mm based on the maxillary first molar. Second, patients were divided into a horizontal movement group and a no horizontal movement group. Patients in whom the maxilla were transversally moved, such as anterior-posteriorly or laterally for midline correction, were classified into the horizontal movement group. Third, patients were divided into a symmetrical movement group and a no symmetrical movement group. Patients were classified into the symmetrical movement group when the movement of the maxilla was the same on the left and right sides. Fourth, patients were divided into a total impaction group and a no total impaction group. Patient grouping and the characteristics of maxillary movement are shown in Tables 2 and 3.

Table 2. Summary of maxillary movement in each patient.

Patient Number	Characteristics of Maxillary Movement
#1	Advance 5 mm, Right 5 mm up and Left 4 mm up
#2	Right 3 mm up and Left 3 mm up
#3	Total Impaction 5 mm
#4	Left 3 mm up
#5	Advance 6 mm
#6	Advance 5 mm

#7	Advance 5 mm
#8	Advance 4 mm
#9	Right 7 mm up and Left 4 mm up
#10	Right 4 mm up and Left 4 mm up
#11	ANS 2 mm up, Right 7 mm up and Left 5 mm up
#12	Right 6 mm up and Left 4 mm up
#13	Right 5 mm up, Total Setback 2 mm
#14	ANS 3 mm up, Right 6 mm up and Left 6 mm up
#15	Right 5 mm up and Left 2 mm up
#16	Right 5 mm up and Left 2 mm up
#17	Left 3 mm up
#18	Total Impaction 3 mm and 5 mm side shift to the Left
#19	Advance 5 mm, Right 5 mm up and Left 5 mm up
#20	Advance 5 mm, Right 3 mm up and Left 3 mm up
#21	Right 6 mm up, Left 6 mm up, Total Setback 4 mm
#22	Right 5 mm up and Left 5 mm up
#23	Right 5 mm up and Left 2 mm up
#24	Right 5 mm up and Left 2 mm up
#25	Right 6 mm up and Left 6 mm up
#26	Right 3 mm up and Left 5 mm up
#27	Right 5 mm up
#28	Right 5 mm up and Left 5 mm up
#29	Advance 5 mm, Right 5 mm up and Left 5 mm up

#30	Right 6 mm up and Left 4 mm up
#31	Right 6 mm up and Left 6 mm up
#32	Right 5 mm up and Left 4 mm up
#33	Right 5 mm up and Left 5 mm up

Table 3. Patients groups according to the extent and characteristics of maxillary movement after Le Fort I osteotomy.

The amount of the impaction	≥ 5mm	#1, #3, #9, #11, #12, #13, #14, #15, #16, #19, #21, #22, #23, #24, #25, #26, #27, #28, #29, #30, #31, #32, #33
	≤ 4mm	#2, #4, #5, #6, #7, #8, #10, #17, #18, #20
Horizontal movement group	Yes	#1, #5, #6, #7, #8, #13, #18, #19, #20, #21, #29, #32, #33
	No	#2, #3, #4, #9, #10, #11, #12, #14, #15, #16, #17, #22, #23, #24, #25, #26, #27, #28, #30, #31
Asymmetry movement group	Yes	#1, #9, #11, #12, #13, #15, #16, #17, #23, #24, #26, #27, #30, #32
	No	#2, #3, #4, #5, #6, #7, #8, #10, #14, #18, #19, #20, #21, #22, #25, #28, #29, #31, #33
Total impaction group	Yes	#3, #11, #14, #18
	No	#1, #2, #4, #5, #6, #7, #8, #9, #10, #12, #13, #15, #16, #17, #19, #20, #21, #22, #23, #24, #25, #26, #27, #28, #29, #30, #31, #32

(B) SEPTAL ANGLE MEASUREMENT

Preoperative and follow-up CBCT images in the coronal view were used to measure changes in septal angle before and after Le Fort I Osteotomy. The septal angle was calculated in coronal computed tomography images at the same ostiomeatal unit level. The base of the crista galli was used as the vertex. The other two points measured were the most protruded septal mucosa and the palatal suture (Fig. 1). This method was highly reproducible. Two different examiners took measurements using the same points and the average value was defined as the septal angle.

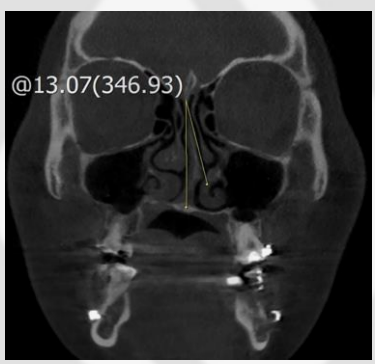

Fig. 1. Septal angle measurement.

The vertex is the base of the crista galli. The other two points are the most protruded point of the septal mucosa and the palatal suture.

(C) MEASUREMENT of the MAXILLARY SINUS VOLUME

Changes in the maxillary sinus before and after Le Fort I osteotomy were analyzed by volume and geometry.

For volumetric analysis, the data were analyzed using the Simplant (Materialise, Belgium) software program. In a user-defined area, the tool for selecting only the pixels (Fig. 2) within a preset range of Hounsfield units (HU) (minimum, -1024; maximum, 1024) was used to

select the pixels regarded as the maxillary sinus on all coronal and axial images, the selected pixels were remodeled into three-dimensional images, and, finally, the volume was calculated. We measured the air cavity *per se* and mucosal thickening of the maxillary sinus. Different HU were used for the two measurements. The air cavity was selected as -1024 HU to -250 HU.

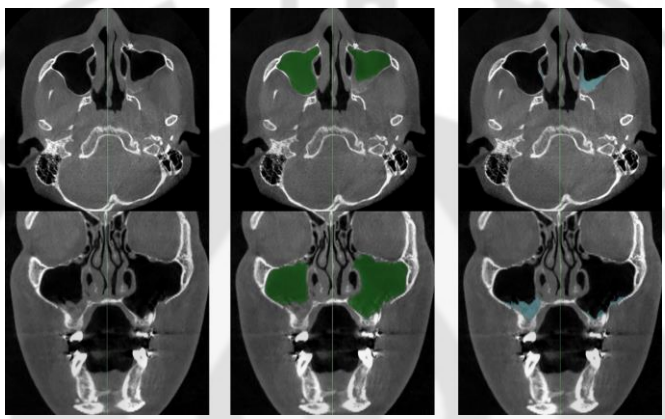

Fig. 2. Select the desired regions on the CBCT coronal images.

The air cavity was selected with -1024 HU to -250 HU. The mucsoa was selected with -250 HU to 300 HU. Selected green surfaces means air cavity per se, and blue surfaces means mucosal thickening

The mucosa was selected as -250 HU to 300 HU. A 3-dimensional image was reconstructed and the volume was calculated (Fig. 3). Two different examiners calculated the volume and mean values were used to reduce error.

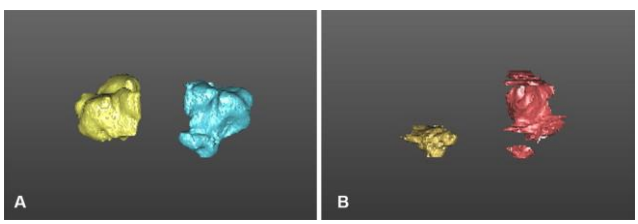

Fig. 3. 3-D reconstructed images.

(A) Recnstruced 3D image of the air cavity per se. (B) Reconstruced 3D image of mucosal thickening.

For plane geometric analysis of mucosal thickening in the maxillary sinus, the distribution of mucosal thickening in the maxillary sinus was divided into vertical, posterior-anterior (P-A), and lateral-mesial (L-M). Vertical indicates the top-to-bottom direction, and the length was divided into three equal parts (Fig. 4A). For example, in case of the mucosal thickening was located only in the lower third of the sinus, 1 point was assigned to the ⅓ area, and if the mucous was distributed from the lower third to the upper third, 3 points were given to each ⅓ (1 point per site). The P-A aspect of the sagittal CBCT image indicates the directions of the posterior nasal spine and the anterior nasal spine, respectively. Again, the length was divided into three equal parts (Fig. 4A). For example, in case of the mucosal thickening was located only in the third of the sinus closest to the posterior nasal spine, 1 point was assigned to that ⅓. And, in case of the mucous was spread all the way from the posterior nasal spine to the anterior nasal spine, 3 points were given, 1 to each ⅓ of the sinus. L-M refers to the direction of the lateral and medial wall of the maxillary sinus (Fig. 4B). For example, in case of the mucosal thickening was distributed only in the ⅓ containing the lateral wall of the maxillary sinus or in the ⅓ containing the medial wall of the maxillary sinus, 1 point was given to the appropriate ⅓ of the sinus. And, in case of the mucosal change was located from the lateral wall to the medial wall of the maxillary sinus, 3 points were given, 1 to each ⅓ of the sinus. The scores were summed and displayed in a plane. This method was used to analyze the location of the mucosal thickening or mucous retention in the maxillary sinus after Le Fort I osteotomy.

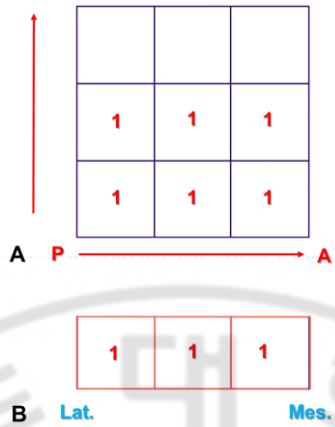

Fig. 4. Plane geometric analysis of mucosal thickening of the maxillary sinus.

(A) Vertical and posterior-anterior distribution of mucosal thickening.

(B) Lateral-mesial distribution of mucosal thickening. Vertical, the top-to-bottom direction of the maxillary sinus; Posterior-anterior, the posterior nasal spine direction and the anterior nasal spine direction, respectively; Lat., the direction of the lateral wall of the maxillary sinus; Mes., the direction of the medial wall of the maxillary sinus.

III. RESULTS

(A) SEPTAL ANGLE MEASUREMENT

With the septal angle measurement method used in this study, a decrease in septal angle after surgery indicates a decrease in septal deviation and an increase in septal angle indicates an increase in septal deviation after surgery (Fig. 5).

Fig. 5. Pre- and post-operative septal angle measurement.

The example of the comparison of the pre-operative and the post-operative septal angle.

Septal angle was increased in 10 patients after surgery, and the mean value was 1.42. There were 23 patients with decreased septal angle after surgery, with an average value of 1.47. The mean preoperative septal angle was 10.65 and the mean postoperative septal angle was 10.13. The mean septal angle decreased after surgery, but the decrease was not statistically significant (Table 4).

Table 4. Changes in septal angle after the surgery.

	n	**Max.** (°)	**Min.** (°)	**Mean** (°)	
Increased septal angle	10	4.19	0.12	1.42	*P*=0.135
Decreased septal angle	23	4.38	0.16	1.47	

Also, there was no statistically significant difference in the postoperative changes in septal

angle according to the extent of maxillary movement or the characteristics of that movement (Table 5).

Table 5. Change in septal angle according to groups.

Group	**N**	**Pre Op**	**Post Op**	**Mean Decrease**	***P***
Impaction group					0.315
≥5 mm	23	10.7°	10.0°	0.7°	
≤4 mm	10	10.7°	10.4°	0.3°	
Horizontal movement group					0.397
Yes	13	10.2°	9.9°	0.3°	
No	20	10.9°	10.3°	0.6°	
Total impaction group					0.424
Yes	4	7.9°	7.7°	0.2°	
No	29	11.0°	10.5°	0.5°	
Symmetry movement group					0.771
Yes	14	10.4°	9.8°	0.6°	
No	19	11.0°	10.6°	0.4°	

(B) MEASUREMENT of the MAXILLARY SINUS VOLUME

With respect to the changes of the maxillary sinus, the volume reduction of the air cavity *per se* and the volume increase of the mucosal thickening were statistically different before and after the surgery (Table 6).

Table 6. Volumetric measurements of the maxillary sinus.

	Volume (mm^3)	Ratio (%)	
Air cavity *per se* (mean)			
Pre Op	19851	96.7	*P*=0.002*
Post Op	15206	85.6	
Mucosal thickening (mean)			
Pre Op	661	3.3	*P*=0.003*
Post Op	2354	14.4	
	P=0.003*		

In addition, the total volume of the maxillary sinus was statistically significantly reduced after the surgery (Table 7).

Table 7. Volumetric measurements of the maxillary sinus.

Maxillary Sinus (Mean)	Volume (mm^3)	
Pre Op	20512	*P*=0.001*
Post Op	17560	

The volume changes of the air cavity *per se* and the mucosal thickening are shown in Figure 6.

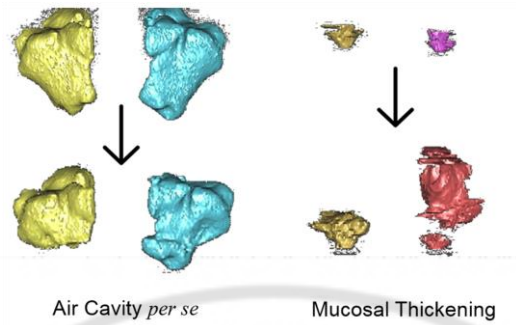

Fig. 6. 3D reconstructed images of the air cavity per se and the mucosal thickening.

The decrease of the volume of the air cavity per se and the increase of the volume of mucosal thickening were significant.

Mucosal thickening in the maxillary sinus is present around about 82% of the screws used for plate fixation, and mucosal thickening around the wall of the maxillary sinus is present in about 85% of all maxillary sinuses after surgery (Table 8).

Table 8. Distribution of mucosal thickening.

	Yes	**No**
Mucosal intervention through screws, n (%)	54 (82%)	12 (18%)
Mucosal thickening around maxillary sinus		
Pre Op, n (%)	16 (24%)	50 (76%)
Post Op, n (%)	56 (85%)	10 (15%)

The difference between groups was not significant when the increase in mucosal thickening was compared according to the time of the follow-up CBCT taken after surgery (Table 9).

Table 9. Volumetric measurements of mucosal thickening according to follow-Up period.

Mucosal Thickening (Mean)	FU 2 MC	FU 3–6 MC	FU 7–15 MC
Sinus (n)	34	28	14
		P=0.548	

FU, Follow-up; MC, Monthly check

By analyzing plane geometry (Fig. 7), we found that mucosal thickening was observed in the posterior-inferior direction in the vertical and P-A analyses and there was an even distribution in the L-M analysis (Table 10).

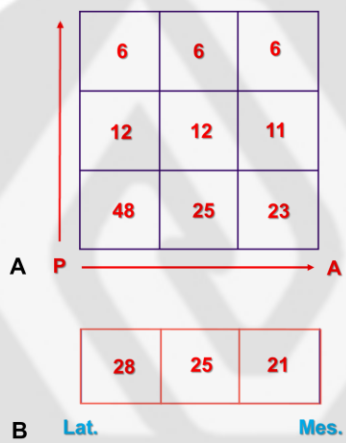

Fig. 7. Plane geometrical distribution of the mucosal thickening.

(A) In the vertical and posterior-anterior directions. (B) In the lateral-mesial direction.

Table 10. Location of mucosal thickening.

Post Op Mucosal Thickening	Distribution points (%)
Vertical	
⅓	36 (54.5%)
⅓–⅔	6 (9.0%)
⅓–1	6 (9.0%)
Posterior-Anterior	
⅓	23 (34.8%)
⅓–⅔	2 (3.0%)
⅓–1	23 (34.8%)
Lateral-Mesial	
⅓	3 (4.5%)
1	2 (4.3%)
⅓–⅔	7 (10.5%)
⅓–1	34 (52.1%)

The mucosal thickening was observed mainly in the floor and the posterior lower part of the maxillary sinus once the mucosal thickening was established (Fig. 8).

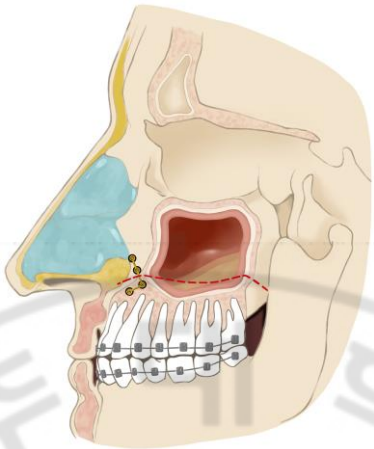

Fig. 8 Illustration of mucosal thickening after Le Fort I osteotomy.

Mucosal thickening was observed mainly in the floor and the posterior lower part of the maxillary sinus. The red dot line means the osteotomy line and the dark-yellow part in the maxillary sinus means postoperative mucosal thickening located posterior lower part of the maxillary sinus.

IV.DISCUSSION

This study quantitatively analyzed the changes of nasal septum and maxillary sinus after Le Fort I osteotomy. Nasal septum deviation was not statistically significant after Le Fort I osteotomy. And the decrease of the air cavity per se, decrease of the total volume of the maxillary sinus, and increase of mucosal thickening were prominent.

The possible deformations of the nasal septum after Le Fort I osteotomy are well documented in some literature. However, as far as author knows, few studies have evaluated whether Le Fort I osteotomy affects nasal septum. Kramer et al published a study on complications after Le Fort I osteotomy. Of 1000 cases, 2.6% were associated with anatomical changes, and the nasal septum accounted for the highest percentage of those changes. (Kramer et al., 2004) Shin et al published a case series discussing successful correction of nasal septum deviation due to complications after Le Fort I osteotomy. (Shin et al., 2016) Moroi et al evaluated changes in the nasal septum after Le Fort I osteotomy. (Moroi et al., 2016) Similar results as the ones in this study were presented, but there was a limitation regarding the lack of reproducibility of the measurements. The septal angle used in this study was crista gaili and the most protruded septal mucosa. This method improves the reliability of research by ensuring reproducibility even in repeated measurements. In addition, the cut on the evaluated computed tomography does not necessarily include the ostiomeatal unit, so an absence of the physiological characteristics of the maxillary sinus is observed.

The normal maxillary sinus has mucociliary action. Therefore, secretions are released into the osteum. Moses et al suggested a “fall back phenomenon” in the maxillary sinus after Le Fort I osteotomy. (Moses et al., 2000) This is caused by the formation of a shelf, or plica, in the maxillary sinus after surgery, which limits the movement of the natural discharge.

The present study and the previously published studies examined changes in the clinical symptoms of the maxillary sinus after surgery, and various methods for evaluating clinical symptoms have already been introduced. (Pereira-Filho et al., 2011; Valstar et al., 2013; Nocini et al., 2016) Methods for evaluating these clinical symptoms include the rhinosinusitis outcome measure-31 questionnaire, visual analogue scale, and sino-nasal outcome-20 questionnaire. The results of the changes in clinical symptoms as determined using the abovementioned methods were different. Pereira-Filho et al reported only 1 case of acute sinusitis in a 6-month follow-up, representing a 4.76% incidence of sinusitis, as evidenced by endoscopic evaluation. There was no significant difference between preoperative and postoperative clinical symptoms. (Pereira-Filho et al., 2011) Also, a study published by Valstar et al showed no statistically significant differences in peak nasal inspiratory flow before and after Le Fort I osteotomy. (Valstar et al., 2013) But Nocini et al reported that an observed increase in sino-nasal outcome scores after a mean follow-up of 32.4 months was statistically significant. The authors of the abovementioned study explained that the reason for the lack of clinical symptoms was that they did not have a longer follow-up period (more than one year). (Nocini et al., 2016) In fact, Pereira-Filho's follow-up period was 6 to 8 months, and Valstar's follow-up period was 2 months. It seems that the longer the duration of the follow up period, the more patients will report symptoms related to maxillary sinusitis.

Otherwise, the results of studies on changes to the maxillary sinus as assessed by radiographs were similar. The present study and others have shown that postoperative mucosal change or mucosal thickening is always present regardless of the duration of the follow-up period. (Valstar et al., 2013)

Toskala and Rautiainen evaluated maxillary sinus mucosa by Scaning Electron Microscopy

and Transmission Electron Microscopy TEM after sinus surgery. (Toskala and Rautiainen, 2003) That study showed that pathologic conditions remained up to 6 months postoperatively, suggesting that the recovery of the maxillary sinus after surgery may be slow and the changes are sometimes irreversible. Our study showed that there was no significant difference in the increase of mucosa according to the length of the follow-up period. Taken together, this study and previously published studies suggest that changes in maxillary sinus after Le Fort I osteotomy are inevitable. Clinical symptoms vary according to the length of the follow-up period. Although maxillary sinusitis, which is characterized by blockage of the osteum or purulent discharge, does not necessarily occur after Le Fort I osteotomy, mucosal changes are always present on radiological examinations

V. CONCLUSION

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Orthognathic surgery not only treats a patient's occlusion, but is also an aesthetic procedure accompanied by changes in the patient's facial appearance, including nasal changes. Oral and maxillofacial surgeons should be aware of the complications associated with facial changes that may occur postoperatively and learn surgical techniques to prevent them.

In this study, nasal septum deviation after Le Fort I osteotomy was not significantly altered, but it should be avoided through concurrent cartilage resection, septoplasty, and turbinectomy.

Most changes in the maxillary sinus that can occur after orthognathic surgery are asymptomatic. Orthognathic surgery usually involves structural and functional changes to the upper airway, but evaluation of the maxillary sinus before and after surgery is not routinely performed. The present study and others show that mucosal changes of the maxillary sinus are present in radiological evaluations but are clinically asymptomatic.

Therefore, long-term follow up of at least 6 months is needed. Also, oral and maxillofacial surgeons should be aware of the clinical symptoms of maxillary sinusitis and cope with postoperative complications appropriately.

REFERENCES

1. Akbay E, Cokkeser Y, Yilmaz O, Cevik C: The relationship between posterior septum deviation and depth of maxillopalatal arch. *Auris Nasus Larynx* 40: 286-290, 2013
2. Akoglu E, Karazincir S, Balci A, Okuyucu S, Sumbas H, Dagli AS: Evaluation of the turbinate hypertrophy by computed tomography in patients with deviated nasal septum. *Otolaryngol Head Neck Surg* 136: 380-384, 2007
3. Bell CS, Thrash WJ, Zysset MK: Incidence of maxillary sinusitis following Le Fort I maxillary osteotomy. *J Oral Maxillofac Surg* 44: 100-103, 1986
4. Drommer RB: The history of the "Le Fort I osteotomy". *J Maxillofac Surg* 14: 119-122, 1986
5. Kim SG, Park SS: Incidence of complications and problems related to orthognathic surgery. *J Oral Maxillofac Surg* 65: 2438-2444, 2007
6. Kramer FJ, Baethge C, Swennen G, Teltzrow T, Schulze A, Berten J, Brachvogel P: Intra- and perioperative complications of the LeFort I osteotomy: a prospective evaluation of 1000 patients. *J Craniofac Surg* 15: 971-977; discussion 978-979, 2004
7. Kretzschmar DP, Kretzschmar JL: Rhinosinusitis: review from a dental perspective. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 96: 128-135, 2003
8. Menendez LF, Biedlingmaier JF, Tilghman D: Osteomeatal complex obstruction and sinusitis following Le Fort I osteotomy. *J Oral Maxillofac Surg* 54: 103-104, 1996
9. Moroi A, Yoshizawa K, Tsutsui T, Saida Y, Hotta A, Fukaya K, Hiraide R, Takayama A, Tunoda T, Saito Y, Ueki K: Assessment of nasal septum after Le Fort I osteotomy with computer tomography. *J Craniomaxillofac Surg* 44: 1187-1193, 2016
10. Moses JJ, Lange CR, Arredondo A: Endoscopic treatment of sinonasal disease in

patients who have had orthognathic surgery. *Br J Oral Maxillofac Surg* 38: 177-184, 2000

11. Nocini PF, D'Agostino A, Trevisiol L, Favero V, Pessina M, Procacci P: Is Le Fort I osteotomy associated with maxillary sinusitis? *J Oral Maxillofac Surg* 74: 400.e401-400.e412, 2016
12. Pereira-Filho VA, Gabrielli MF, Gabrielli MA, Pinto FA, Rodrigues-Junior AL, Kluppel LE, Passeri LA: Incidence of maxillary sinusitis following Le Fort I osteotomy: clinical, radiographic, and endoscopic study. *J Oral Maxillofac Surg* 69: 346-351, 2011
13. Posnick JC, Fantuzzo JJ, Troost T: Simultaneous intranasal procedures to improve chronic obstructive nasal breathing in patients undergoing maxillary (le fort I) osteotomy. *J Oral Maxillofac Surg* 65: 2273-2281, 2007
14. Shin YM, Lee ST, Kwon TG: Surgical correction of septal deviation after Le Fort I osteotomy. *Maxillofac Plast Reconstr Surg* 38: 21, 2016
15. Toskala E, Rautiainen M: Electron microscopy assessment of the recovery of sinus mucosa after sinus surgery. *Acta Otolaryngol* 123: 954-959, 2003
16. Valstar MH, Baas EM, Te Rijdt JP, De Bondt BJ, Laurens E, De Lange J: Maxillary sinus recovery and nasal ventilation after Le Fort I osteotomy: a prospective clinical, endoscopic, functional and radiographic evaluation. *Int J Oral Maxillofac Surg* 42: 1431-1436, 2013

– 국문요약 –

콘빔씨티를 이용한 르포트 1 골절단술 후 상악동 및 코의 변화에 대한 평가

르포트1 골절단술을 포함하는 악교정수술은 코중격 및 상악동의 변화를 수반한다. 본 연구는 콘빔씨티 이미지를 이용하여 르포트1 골절단술 후의 코중격의 변화를 평가하고, 상악동 점막의 변화를 관찰하고자 한다. 본 연구는 르포트1 골절단술을 포함하는 악교정수술을 받은 33명의 환자를 대상으로 하는 후향적인 연구이다. 상악동의 변화를 평가하기 위해, 수술 전 후 상악동의 부피와 지정학적인 분석이 시도 되었다. 우리는 SIMPLANT(Materialise, Belgium) 프로그램을 이용하여 상악동에서 공기가 차지하는 부분과, 점막비후 부분의 부피를 각각 측정하였다. 그리고 상악동 점막의 지정학적인 분석은 씨티 이미지를 이용하여 평가하였다. 코중격의 각도는 수술 후에 감소하였으나, 통계학적으로 유의하지는 않았다($P>0.05$). 상악동에서 공기가 차지하는 부분의 부피 감소 및 상악동 점막 비후의 증가는 통계학적으로 유의하였다($P<0.05$). 수술 후 생긴 점막 비후는 주로 상악동의 후-하방에서 관찰 되었다. 본 연구를 통해 르포트1 골절단 술 후 상악동 중격의 변위는 통계학적으로 유의하지 않았으며, 상악동에서 공기가 차지하는 부피의 감소, 상악동 전체 부피의 감소, 그리고 점막의 비후는 통계학적으로 유의 하였다. 또한 르포트 1 골절단술 후 상악동에 나타나는 점막의 비후는 주로 상악동의 후-하방에서 관찰됨을 알 수 있었다.

핵심어: 르포트 골절단술, 비중격, 상악동