Original Article

Nasal Changes after Surgical Correction of Skeletal Class III Malocclusion in Koreans

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ABSTRACT

Objective: To quantify the changes in the nose after bimaxillary surgery to correct skeletal Class III malocclusion and to test the hypothesis that there is no change in the nasal width following bimaxillary surgical correction of skeletal Class III when a nasal cinch is properly used.

Materials and Methods: Sixty-five adult Korean skeletal Class III patients who had received maxillary advancement/impaction and mandibular set-back surgery in conjunction with an alar base cinch suture were evaluated. The anthropometric variables of the nasal region were measured directly on the soft-tissue surface before and 6 months after surgery.

Results: After surgery, the alar width and alar base width had increased significantly ($P < .001$), while the nasal tip projection decreased ($P < .001$). The nostril morphology also showed widening ($P < .001$). There was a trend for females with a narrow alar width presurgically to have a larger amount of nasal widening compared with those with a broader alar width ($P < .05$).

Conclusion: There is a high probability of nasal and nostril widening after bimaxillary surgery for skeletal Class III malocclusion in Koreans despite the careful performance of alar cinch suture. Nevertheless, the authors believe that alar cinch suture was positive in limiting the nasal widening to the minimum and would consider routine application during bimaxillary surgery for skeletal Class III especially for female patients with a narrow nose who are susceptible to these changes.

KEY WORDS: Nose; Nostril; Bimaxillary surgery; Skeletal Class III; Anthropometry

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INTRODUCTION

The treatment of severe skeletal Class III malocclusion often requires surgical repositioning of the maxilla and the mandible. Although orthodontic treatment and the associated surgical procedures are well planned to achieve an ideal occlusion as well as a balance between the facial profile and function, unwanted changes in the soft tissue, other than the manipulated structures such as the nose, are sometimes encountered.[1–3]

Many studies have reported secondary morphological changes in the nose, including alar flaring after a Le Fort 1 osteotomy.[1–6] The changes might be advantageous for patients with a narrow nose, but they can have a negative effect on the overall esthetics of the face in those with a wide nasal width. This is extremely important particularly for the Asian population because their noses have a wider width and flatter appearance than European Americans,[7–9] while the overall prevalence of severe skeletal Class III requiring orthognathic surgery is apparently high.[10] Thus, a concomitant alar base cinch suture and anterior nasal spine ostectomy are commonly used to prevent the widening of the nose during surgery.[3,11]

However, there is limited information about the morphological changes in the nasal region after bimaxillary surgery in Asians with or without cinch sutures. Therefore, the aim of this study was to evaluate the secondary changes in the nasal region following the bimaxillary surgery of skeletal Class III malocclusion in Koreans and to evaluate whether additional cinch sutures were efficient in preventing these changes. We hypothesized that the alar widening would be minimal if proper cinch sutures were used.

To detect the presurgical and postsurgical changes in the nose, direct anthropometric measurements[7,8,12] were used to detect the postsurgical changes in the nasal morphology.

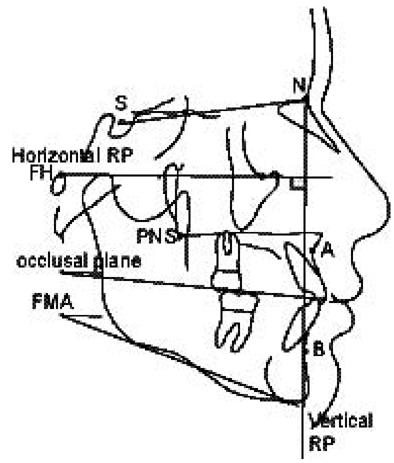

Figure 1. Cephalometric landmarks and reference planes to evaluate the changes of the hard tissue. Frankfort horizontal (FH) plane was used as the horizontal reference plane (RP), while a line perpendicular to the FH passing nasion (N) was used as the vertical reference plane (RP).

MATERIALS AND METHODS

Subjects

The subjects consisted of 65 adult Korean patients (36 females and 29 males, mean age 21.86 $\pm$ 2.59 and 21.86 $\pm$ 3.23, respectively) who underwent orthodontic treatment and bimaxillary surgery due to severe skeletal Class III malocclusion at Yongdong Severance Dental Hospital, Yonsei University, Seoul, Korea.

All patients underwent maxillary advancement with impaction through a conventional one-piece Le Fort 1 osteotomy with a mandibular set-back surgery using intraoral vertical ramus osteotomy or sagittal split ramus osteotomy. A modified cinch suture was placed directly beneath the alar base area passing through the fibro-adipose tissue of the alar base and sutured as a double loop using slowly absorbable 2-0 vicryl. The surgery including the modified cinch suture was performed by the same surgeon. This was followed by reapproximation of the mucoperiosteal flaps with simple vestibular closure. Patients who had a congenital anomaly, history of trauma, or prior experience of rhinoplasty were excluded. All materials were obtained under informed consent according to the World Medical Association's Declaration of Helsinki.

Evaluation of the Hard Tissue and Soft-Tissue Changes

Lateral cephalograms before (T1) and after surgery (T2) were traced and superimposed onto the cranial base to precisely determine the skeletal changes using horizontal and vertical reference planes, as shown in Figure 1. The Frankfort horizontal (FH) plane was used as the horizontal reference, while a line perpendicular to the FH passing the nasion (N) was used as the vertical reference plane. The subspinale (A point) and tip of the posterior nasal spine (PNS) were used to represent the position of the maxilla, while the supramentale (B point) was used to represent the mandible. The anterior nasal spine (ANS) was not used as a reference point because ANS contouring had been performed in some patients. The net movement (mm) of each representative point was given a positive value for the anterior or superior displacement or a negative value for posterior or inferior displacements. All cephalometric tracing and superimpositions were carried out twice by the same examiner following a 2-week interval.

Anthropometric Evaluation of the Nasal Morphology

The presurgical and postsurgical nasal morphology was measured using the anthropometric landmarks and variables[7–9,12,13] (Figure 2).

The anthropometric variables were measured directly on the patient using a digital sliding caliper (Mitutoyo, Tokyo, Japan)[12] after a slight indentation process of the soft-tissue reference points using the tip of the caliper. All the measurements were made in the supine position. Each subject was seated in the dental unit chair, and a face bow was placed to detect the FH plane. The measurements were taken from 1 day to 1 week before surgery (T1) and postsurgery (T2, average of 10.5 months) along with the matching lateral cephalograms. The T2 measurements were delayed a minimum of 6 months to allow for the complete reduction of edema and the establishment of soft-tissue stability.[1] All the measurements at both stages

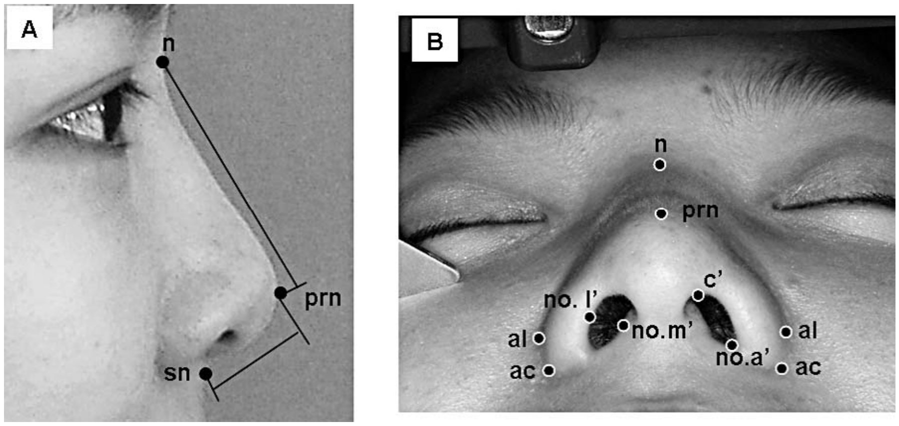

Figure 2. Anthropometric landmarks and measurements of the nose. Landmarks include alare (al), the most lateral point on each alar contour; alar curvature (ac), the most lateral point in the curved base line of each ala indicating the facial insertion of the nasal wing base; pronasale (prn), the most prominent point on the nasal tip; subnasale (sn), the midpoint of the angle at the columella base; soft-tissue nasion (n), the point in the midline of both the nasal root and the nasofrontal suture; columella apex (c′), the highest spot of each nostril; nostril apex (no.a′), the lowest spot of each nostril; nostril lateral′ (no.l′), marking the level at the midportion of the outer nostril wall; and nostril median′ (no.m′), marking the level at the midpoint of the inner nostril wall. The measurements (mm) included the nose/alar width, al-al; alar base width, ac-ac; nostril apex width, no.a′-no.a′; nasal tip protrusion, sn-prn; nasal bridge length, n-prn; length of the long nostril axis, c′-no.a′; and length of the short nostril axis, no.l′- no.m′.

were performed twice by the same examiner in 2- to 7-day intervals.

Examination of Susceptibility to Nasal Widening After Surgery

It has been reported that patients with a narrow nose presurgically show more widening than those with a broad nose after a Le Fort 1 osteotomy.[6] To confirm whether a narrow nose was more susceptible to changes after surgery, the subjects were further divided into two groups. Group 1, the narrow-nose group (n = 5 for each gender), was composed of those with a significantly narrower presurgical alar width than the mean value within our subjects. Group 2, the wide-nose group (n = 5 for each gender), had a significantly wider alar base than the mean value.

Statistical Analysis

The statistical evaluation of the differences between the presurgical and postsurgical measurements of the nose and the hard tissue were examined with a paired *t*-test using SPSS statistical software (Chicago, Ill). A Student's *t*-test was used to examine the gender differences, and a Mann-Whitney *U*-test was used to examine the susceptibility to nasal widening after surgery. All the results are reported as mean ± standard deviation. A P value <.05 was considered significant.

The measurement reliability was assessed by calculating the intraclass correlation coefficient for each measured variable. The intraclass correlation ranged from $r = .91$ to .97 ($P < .001$), indicating that the measurements and recordings were reliable.

RESULTS

Mean Changes of the Hard Tissue After Bimaxillary Surgery

The presurgical cephalometric measurements indicated a skeletal Class III malocclusion due to a retrusive maxilla combined with a protrusive mandible. Maxillary advancement and mandibular set-back surgery balanced the maxillomandibular relationship into a skeletal Class I within the normal range (Table 1).

Vertical and horizontal changes in the maxilla (A point and PNS) and the mandible (B point) indicate posterior impaction of the maxilla along with advancement and mandibular set back in both males and females (Table 2).

Changes in Nasal Morphology After Bimaxillary Surgery

The nose/alar width was increased by a mean of 2.2 ± 0.93 mm (for both males and females) and the alar base width by 1.24 ± 0.93 mm (for both males and females) after bimaxillary surgery ($P < .001$). The nostril apex width and length of the long nostril axis were significantly larger, while the length of the short nostril axis and nasal tip protrusion were significantly lower ($P < .001$) after surgery. There were no significant changes in the nasal bridge length. The changes were similar in both genders (Table 3).

Female patients with a narrow nose tended to be more susceptible to nasal changes. For males, the nose/alar width increased similarly in the narrow-nose (n = 5) and broad-nose groups (n = 5). However, for the females, the widening of the alar width in the nar-

Table 1. Cephalometric Variables Before and After Bimaxillary Surgery

	Male					Female				
	Presurgery (T1)		Postsurgery (T2)			Presurgery (T1)		Postsurgery (T2)		
Variable	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
SNA, °	81.6	3.7	83.7	3.4	***	79.4	4.0	82.4	4.9	**
SNB, °	82.9	4.9	81.1	3.7	***	81.7	5.9	78.3	4.7	**
ANB, °	−1.2	5.2	2.6	2.9	***	−2.4	3.8	4.1	2.2	***
WITS	−9.2	8.3	−5.5	3.4	***	−10.1	4.6	−3.6	3.2	*
FMA, °	26.8	5.4	28.5	5.1	*	29.5	7.6	33.3	7.9	*
Post./Ant. Facial height	66.4	4.4	64.9	4.0	*	62.8	5.7	60.0	5.1	*
Upper lip to E-LINE (mm)	−1.9	4.0	−0.6	2.8	***	−3.0	3.2	−0.1	2.4	*
Lower lip to E-LINE (mm)	2.2	3.6	0.0	2.8		1.4	3.1	1.4	2.1	***

* $P < .05$; ** $P < .01$; *** $P < .001$.

Table 2. Horizontal and Vertical Changes (mm) of the Hard Tissue After Surgery[a]

	Male (n = 29)		Female (n = 36)	
	Mean	SD	Mean	SD
Vertical changes (T2-T1), mm				
PNS	4.2	1.36	4.1	2.2
Point A	0.9	1.7	0.3	0.76
Horizontal changes (T2-T1), mm				
Point A	3.0	1.58	3.8	1.5
Point B	−6.0	5.63	−4.2	3.9

[a] A positive value indicates superior (impaction) and anterior (advancement) changes, while a negative value indicates inferior and posterior (set-back) movement.

row-nose group was significantly higher than that of the broad-nose group ($P < .05$). The widening of the alar base width was similar between the narrow-nose and broad-nose groups regardless of gender (Table 4).

DISCUSSION

In general, Asians, especially Koreans, have a broad and flat nose compared with European Americans.[7,14,15] Therefore, additional alar widening or flaring is considered esthetically displeasing for most Koreans, and in many cases, nasal cinch sutures are routinely performed during bimaxillary surgery. However, based on our results, it is suggested that there is an increase in the nasal and nostril width after bimaxillary surgery in the Korean population, even though procedures such as modified cinch sutures had been carefully performed.

The morphologic changes in the external nose are mainly accompanied by positional changes in the maxilla through Le Fort 1 osteotomy.[2,4,6,16] In this study, the direction of maxillary movement after the Le Fort 1 osteotomy was mainly advancement and posterior impaction, resulting in a steeper occlusal plane. Although the skeletal Class III malocclusion of Koreans is primarily due to mandibular prognathism (48%) rather than a retrognathic maxilla,[17] the prevalence of bimaxillary surgery in the Korean orthodontic population is much higher than the mandibular set back alone.[15] Korean skeletal Class III patients show a hyperdivergent profile with increased facial height and gonial angle,[15,18] and thus, bimaxillary surgery accompanied by a maxillary posterior impaction is highly preferred for the achievement of balanced facial esthetics and to increase surgical stability.[15,19,20] However, the skeletal rotation of the maxilla coupled with maxillary advance-

Table 3. Changes in Nasal Morphology Before and After Surgery

	Male (n = 29)					Female (n = 36)				
	Presurgery (T1)		Postsurgery (T2)			Presurgery (T1)		Postsurgery (T2)		
Measurement, mm	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Nose/alar width	39.2	2.3	41.4	2.2	***	35.6	2.0	37.7	1.8	***
Alar base width	28.3	3.9	29.6	3.6	***	26.4	3.0	27.6	2.9	***
Nostril apex width	24.1	2.8	25.7	2.6	***	22.2	2.5	23.6	2.4	***
Nasal tip protrusion	18.6	1.6	17.7	1.6	***	18.2	1.9	17.2	1.6	***
Nasal bridge length	46.9	3.9	46.7	4.0		42.2	3.6	42.2	3.7	
Long nostril axis	12.8	1.9	13.0	1.9	***	11.9	1.3	12.0	1.3	***
Short nostril axis	6.7	1.3	6.5	1.3	***	6.5	0.9	6.3	0.9	***

*** $P < .001$.

Table 4. Postoperative Changes Between the Narrow-Nose and Broad-Nose Groups

Changes (T1-T2), mm	Male (n = 10)					Female (n = 10)				
	Narrow Nose (n = 5)		Broad Nose (n = 5)			Narrow Nose (n = 5)		Broad Nose (n = 5)		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
PNS	6.0	1.0	3.5	1.5	*	2.2	2.7	1.3	1.5	
Point A (vertical)	1.6	2.3	1.5	2.1		0.6	0.9	0.3	0.4	
Point A (horizontal)	4.2	1.1	3.1	0.8		1.2	1.8	1.0	1.2	
Point B	−10.7	5.9	−5.8	7.8		−3.4	4.7	−1.6	2.4	
Nose/alar width	2.4	1.1	1.9	0.6		2.4	0.9	1.1	0.7	*
Alar base width	1.7	0.9	0.9	1.0		1.6	1.3	0.8	0.5	

* $P < .05$.

ment can increase the amount of nasal and nostril flaring because the bone structures of the base of the nose would move further forward compared to the dentition. Edema, anterior and superior spatial changes in the supportive bone of the nasal base, and the release of muscle and periodontium adjacent to the nose can also cause widening of the ala.[21,22] To reduce these effects, a modified cinch suture was performed in all subjects, with additional ANS contouring in patients with a larger amount of maxillary impaction and advancement to reduce the anterior movement of the supportive bone at the nasal base area.[3,11,23,24]

Soft-tissue changes after mandibular set-back surgery alone appear to be limited to the mandibular area and mouth corner.[25] The nasal changes in these subjects seem to be mainly influenced by the movement of the maxilla through the Le Fort 1 osteotomy. Although a certain amount of nasal widening was present in our subjects, even with additional cinch sutures, we believe that additional cinch sutures were advantageous and would predict a larger amount of alar widening in case cinch sutures or ANS contouring were not performed. Previous studies have also confirmed that subjects without cinch sutures have more alar base widening than those with a cinch suture.[2,3,23,24]

The frontal morphology of the nose is important for balanced facial esthetics, and its shape is a signature indicating ethnicity, race, age, and gender.[7,9,13] Previous studies have used different methodologies to quantify nasal morphology, such as cephalometrics,[1,5] standardized full-facial photographs,[3,8] stereophotogrammetry,[26] fabrication of nasolabial casts,[6] and three-dimensional imaging.[4,16] Recently, three-dimensional digital imaging has been used to make a reliable quantitative assessment of the nasal changes in both the area and volume; however, the high cost needed for this process can be a disadvantage.[4]

This study assessed the changes in nasal morphology using direct anthropometric measurement.[7–9,13] Because soft-tissue morphology can vary according to the measurement position and direction, the standardized head position was set at the supine position. The supine position is best for measurements beneath the nasal tip, particularly the base of the nose, with high reproducibility. According to our experience, the advantage of the direct anthropometric measurement lies in its simplicity. It is an economical, rapid, and noninvasive technique without any adverse effects or additional cost to the patient. It allows assessments in multiple directions including the frontal plane. However, precise measurements and confirmation of the measurement error and reproducibility are always advisable.

Similar to other reports, a tendency toward an upward and forward movement of the nasal tip was observed in many of our subjects.[2,4–6,23] The nasal length measured from the soft-tissue nasion to the nasal tip showed a tendency to decrease after surgery, which is possibly due to changes in the direction of the nasal tip.[4]

Nostril changes after orthognathic surgery are not fully understood. According to these results, the nostril apex width and the length of the long axis increased significantly, while the length of the short nostril axis decreased significantly, suggesting lateral widening/flaring of the nostril similar to the alar/alar base widening. Since the nostrils function to allow air intake, the relationship between the nasal airflow or the external nasal valve area and the changes in the nostril morphology would be an interesting topic for future studies.

Based on our results, individual nasal characteristics and morphology should be taken into account during the planning for surgical treatment. For patients with normal maxilla, a mandibular set back rather than bimaxillary surgery may be a more desirable alternative because of the negative esthetic changes in nasal morphology.[15] For the patient in need of bimaxillary surgery, a nasal cinch suture is advised, especially in Koreans and other Asian populations who normally indicate an initial broad nasal width. In addition, the high susceptibility of nasal widening and the possible need for secondary rhinoplasty for esthetic improvement should be part of the informed consent for the patients.

CONCLUSIONS

- Widening of the alar and nostril was observed after bimaxillary surgery of Korean skeletal Class III malocclusion patients, even though cinch sutures had been carefully performed.
- Female patients with a narrow nose presurgically were more susceptible to alar widening than those with a broad nose.

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