J. Maxillofac. Oral Surg. (Apr–June 2016) 15(2):199–206
DOI 10.1007/s12663-015-0831-0

ERRATUM

Erratum to: Nasal Profile Changes Following Anterior Maxillary Segmental Osteotomy: A Lateral Cephalometric Study

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Published online: 4 November 2015

Abstract
Purpose Orthognathic surgery in reference to the maxilla attempts to correct underlying skeletal deformities and improve function. Consequently, it has the potential to significantly alter the central esthetic unit of the face, the nasolabial region. In order to evaluate the nasal morphological changes which would result following anterior maxillary segmental osteotomy (superior and posterior repositioning), four angles, namely nasolabial, nasal tip projection, columellar labial and supra tip break angle, were evaluated.
Method and Materials In ten selected subjects who have undergone anterior maxillary segmental osteotomy with superior and posterior repositioning, preoperative (T1) and postoperative (T2) lateral cephalometric parameters pertaining to the four angles were analyzed using Wilcoxon's signed-rank test.
Results A significant increase in nasolabial angle and mild changes in nasal tip projection, columellar labial angle and supratip break angle were observed.
Conclusion The results of this study emphasize the need for the presurgical evaluation of nasal morphology in every individual planned for anterior maxillary segmental osteotomy.

Keywords Anterior maxillary segmental osteotomy · Nasal profile · Superior and posterior repositioning · Lateral cephalometrics

Introduction

Orthognathic surgery in reference to the maxilla attempts to correct underlying skeletal deformities and improve function. Consequently, it has the potential to significantly alter the central esthetic unit of the face, the nasolabial region. The nose is a keystone of facial esthetics and thus is of central importance in planning and execution of orthognathic surgery [1, 2]. A key to achieving a good functional as well as esthetic result involves both comprehensive surgical planning and an understanding of the effects that orthognathic surgery of the maxilla will have on the soft tissues within the nasolabial region. This is why the standard or classic lateral cephalometric skeletal analyses need to be augmented by the addition of soft tissue evaluations. Although a number of studies pertaining to

The online version of the original article can be found under doi:10.1007/s12663-015-0797-y.

Unfortunately, the latest version of the manuscript has not been used in the original publication which has been rectified through this erratum.

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soft tissue changes in the face with the maxillary procedure can be found in the orthodontic and oral surgery literature, information is limited when detailed evaluation of changes specific to nasal morphology is desired [3–5]. This incited need for the study.

Materials and Methods

Ethical Approval

Ten subjects, six females and four males between 18 and 25 years of age diagnosed with skeletal class II malocclusion or bimaxillary protrusion requiring to undergo anterior maxillary segmental osteotomy (superior and posterior vector movement of maxilla), were selected for the study. None of these patients had any adjunctive nasal surgery such as septoplasty or rhinoplasty being performed in conjunction with the anterior segmental osteotomy. Subjects with associated syndromes, cleft lip and palate deformity or facial asymmetry were excluded. After obtaining written informed consent from each individual, lateral cephalogram and other diagnostic records were made. All the ten individuals selected for the study underwent presurgical and postsurgical orthodontic treatment.

Out of the ten subjects, six of them underwent anterior segmental osteotomy in maxilla for superior and posterior repositioning and advancement genioplasty in mandible. Two patients underwent anterior segmental osteotomy in the maxilla and anterior subapical osteotomy in the mandible. Remaining two patients were treated only with anterior segmental osteotomy in maxilla as a single procedure.

Methodology

The nasal profile was evaluated by lateral cephalogram analysis in two stages as follows:

T1: Presurgical (2–3 weeks before surgery)
T2: Postsurgical (6 months after surgery)

Lateral cephalograms were obtained as per standard criteria, in centric occlusion with lips in repose using the PlanMeca 2002 Proline Cephalometric unit (Helsinki, Finland) at the same target-to-film and subject-to-film distances. All the lateral cephalograms were hand traced by single operator using 0.003″ acetate tracing sheet and 0.5-mm lead pencil.

Two cephalometric landmarks, sella and nasion, were identified and utilized to construct the two reference lines as follows:

- Nasion horizontal (NH): A horizontal reference line constructed at 7° above sella–nasion plane.
- Nasion vertical (NV): A vertical reference line constructed at 90° to NH.

Following soft tissue points were identified for evaluation of nasal profile:

- Supra nasal tip (SNt): The most anterosuperior point on the outline of the soft tissue nose, located with a tangent from nasion.
- Anterior nasal tip (Ant): The most anterior point on the outline of the soft tissue nose, located as the most anterior perpendicular to nasal vertical.
- Columella point (Cm): The most anterior point on the columella of the nose.
- Labrale superius (Ls): The most anterior point on the upper lip.
- Subnasale (Sn): The point at which the nasal septum merges with the upper cutaneous lip in the mid sagittal plane.

Following four angles were measured up to accuracy of 0.5° and evaluated:

- Nasal tip projection angle (NTPA): Measured from the horizontal line (NH) to the most anterior superior point on the nose (Fig. 1).
- Nasolabial angle (NLA): Measured as the angle formed by the nasal columella and labial philtrum (Cm–Sn–Ls) (Fig. 1).

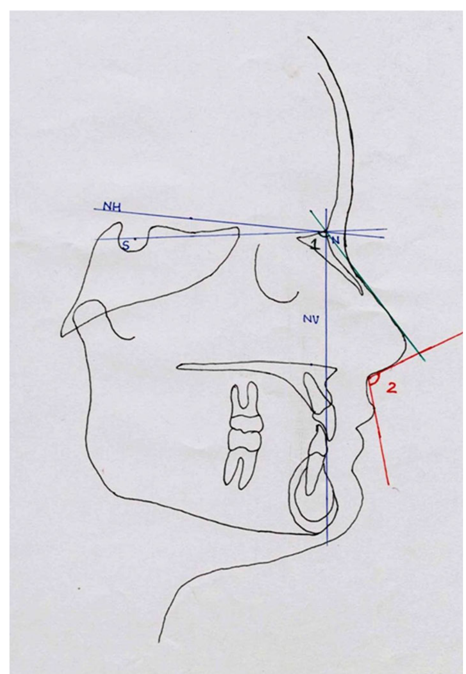

Fig. 1 Nasal tip projection angle (*1*), nasolabial angle (*2*). *N* nasion, *S* sella, *NH* nasion horizontal, *NV* nasion vertical

- Columellar labial angle (CA): Measured from the vertical reference line to columellar tangent (Fig. 2).
- Supratip break angle (STBA): Measured from the nasal dorsum tangent to the supra tip tangent (Fig. 2).

The postsurgical (T2) tracing was superimposed on presurgical (T1) tracing using anterior cranial base structures and two reference lines (Fig. 3).

Surgical Technique

An incision was placed in labial vestibule, 5 mm above the attached mucosa. Maxillary first premolars were extracted intraoperatively. Along with subperiosteal reflection of the labial mucosa, palatal tunneling and meticulous reflection of nasal mucosa was performed. The horizontal osteotomy cuts were placed from the pyriform rim extending laterally to join the vertical osteotomy cuts through the extraction sockets bilaterally, and transpalatal osteotomy was completed. Nasal septum was trimmed by 2–3 mm to suit the clinical requirement and prevent its buckling. Although anterior nasal spine was left intact, any sharp anterior nasal spine was trimmed. The osteotomized segments were stabilized with either two-mm-thickness L plates or four-hole mini-plates.

In all the ten subjects, superior repositioning achieved was with a mean value of four mm and posterior repositioning was four and a half mm.

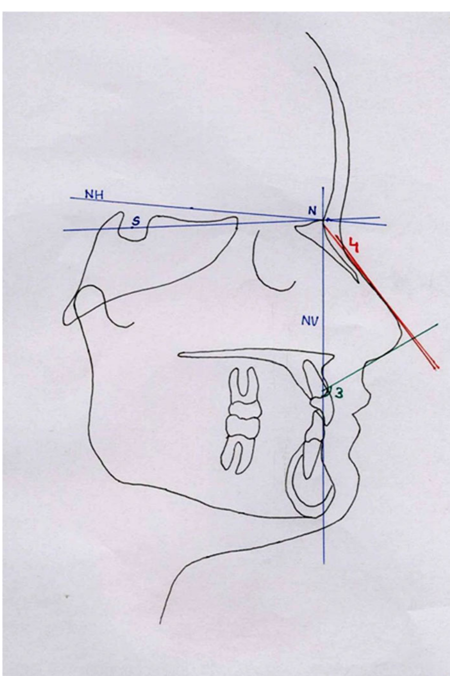

Fig. 2 Columellar labial angle (*3*), supratip break angle (*4*). *N* nasion, *S* sella, *NH* nasion horizontal, *NV* nasion vertical

Fig. 3 Pre- and postsurgical superimposition tracing. *Blue* preoperative soft tissue outline (T1). *Red* postoperative soft tissue outline (T2)

Wound site was closed with 3–0 Vicryl (Polyglactin 910) in V–Y pattern to achieve increase in lip length; however, alar cinch sutures were not placed.

A significant improvement in nasal and facial profile was achieved in all ten patients (Figs. 4, 5, 6, 7).

Statistical Analysis

The data collected were subjected to Wilcoxon's signed-rank test to test the difference between pre- and postsurgical measurements of the various parameters. Box plots were also illustrated to depict the minimum, maximum, median and interquartile range of all the four parameters analyzed in the study (Figs. 8, 9, 10, 11). A p value of less than 0.05 was considered to be significant, and any value more than 0.05 was considered not significant.

Results

The four angles NLA, NTPA, CA and STBA were evaluated, and a comparison was made between the presurgical (T1) and postsurgical (T2) values in a group of ten patients. The statistical analysis demonstrated highly significant postoperative changes in NLA with a p value of 0.007. The changes in other three angles did not show significant changes postsurgically (Tables 1, 2, 3, 4).

Fig. 4 Presurgical lateral profile photograph

Fig. 5 Presurgical lateral cephalogram (T1)

Fig. 6 Postsurgical lateral profile photograph

Fig. 7 Postsurgical lateral cephalogram (T2)

Discussion

Maxillary surgical procedures have shown significant alterations in the nasolabial region, which is considered to be the central esthetic unit of the face. These changes could be widening of the base of the nose and associated flattening and thinning of the upper lip, especially noticeable as loss of the visible vermilion border. Many factors such as the direction of the skeletal movement, the handling of the soft tissues, the skin thickness and the preexisting nasal

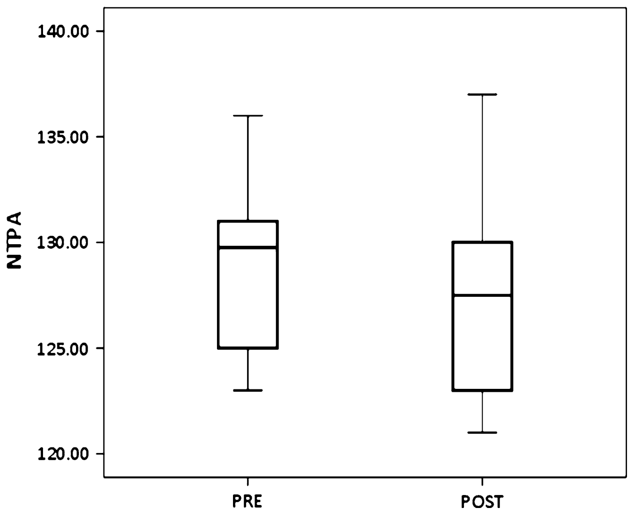

Fig. 8 Pre- and postsurgical NTPA (*box plots* showing minimum, maximum, median and interquartile range)

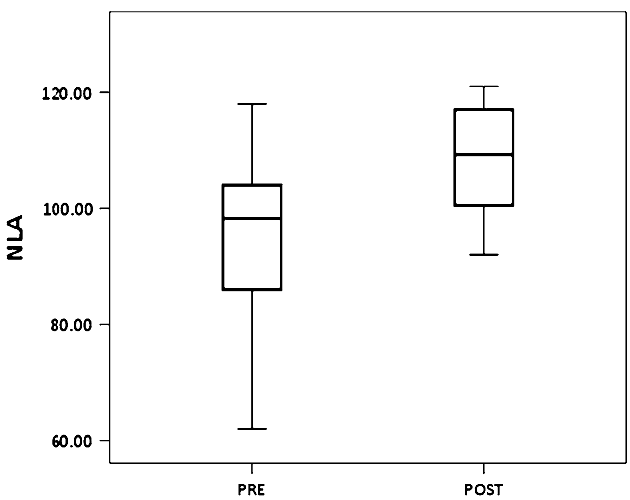

Fig. 9 Pre- and postsurgical NLA (*box plots* showing minimum, maximum, median and interquartile range)

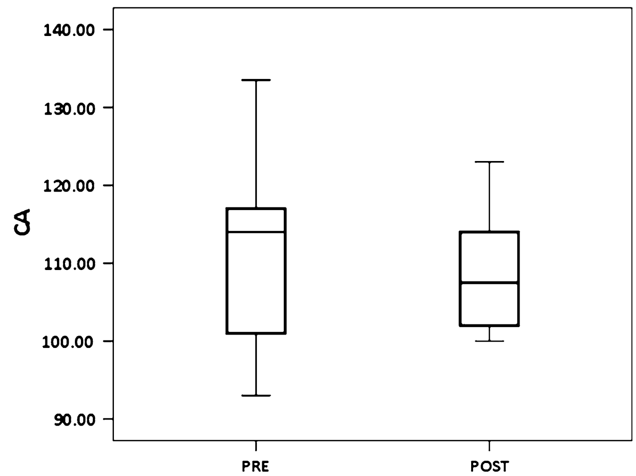

Fig. 10 Pre- and postsurgical CA (*box plots* showing minimum, maximum, median and interquartile range)

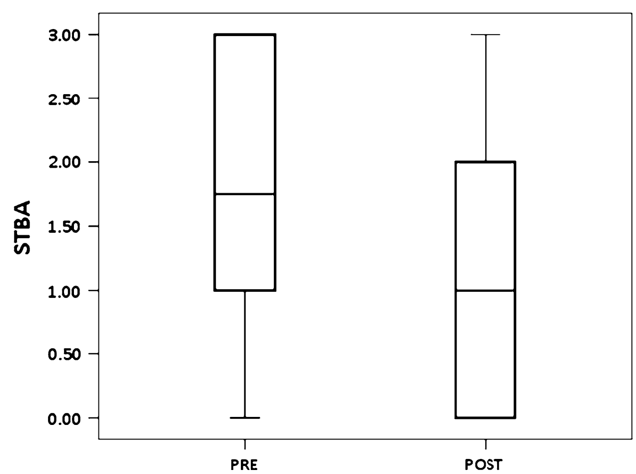

Fig. 11 Pre- and postsurgical STBA (*box plots* showing minimum, maximum, median and interquartile range)

structure demonstrate considerable effect over changes in nasal tip structure and dorsum. Nasal morphological changes are secondary to alterations in the regional anatomy associated with surgical repositioning. The consequential effect of the surgery is seen in the overlying skin and subcutaneous tissue as changes in the previously identified external landmarks [6].

Various studies in the literature have been conducted for the assessment of soft tissue changes in response to anterior segmental maxillary osteotomy using lateral cephalograms. A study by Jayaratne et al. [7] done to evaluate the facial soft tissue response to anterior maxillary osteotomies was carried out based on the electronic databases including 11 studies. The review of these 11 studies indicated a reduction in the labial prominence with an increase in the nasolabial angle ranging from 8.9° to 18° being noted. The magnitude of the reported soft tissue changes and their ratios corresponding to the osseous movements varied among studies.

Park and Hwang [8] in their study on a group of 30 patients have stated an increase in the nasolabial angle ranging from 94.96° ± 9.67° to 109.03° ± 9.08°.

A pilot study conducted on 20 adult patients to investigate and predict soft tissue changes in the forehead, nose, lips and chin in association with anterior maxillary osteotomy has demonstrated backward displacement of the subnasale and the upper and lower lips [9].

In a case report, Natao Suda et al. [10] have stated that the anterior maxillary osteotomy causes an increase in value of nasolabial angle with a mean of +3.5° to 11.0°.

In view of the nasal changes pertaining to maxillary surgical procedures, the present study has been carried out to evaluate nasal profile changes following superior and

Table 1 Summary measures of presurgical (T1) and postsurgical (T2) NTPA

	N	Mean ± SD	I Quartile	Median	III Quartile
NTPA PRE (T1)	10	128.7 ± 4.14	124.88	129.75	131.25
NTPA POST (T2)	10	127.6 ± 5.01	122.88	127.50	130.63

Wilcoxon's signed-rank test

	NTPA POST–NTPA PRE
Z	−.852[a]
p value	0.394 (not significant)

[a] Based on positive ranks

Table 2 Summary measures of pre- and postsurgical NLA

	N	Mean ± SD	I Quartile	Median	III Quartile
NLA PRE (T1)	10	95.5 ± 16.16	84.25	98.25	105.50
NLA POST (T2)	10	107.95 ± 10.11	98.50	109.25	117.00

Wilcoxon's signed-rank test

	NLA POST–NLA PRE
Z	−2.701[a]
p value	0.007 (significant)

[a] Based on negative ranks

Table 3 Summary measures of pre- and postsurgical CA

	N	Mean ± SD	I Quartile	Median	III Quartile
CA PRE (T1)	10	111.3 ± 12.44	100.00	114.00	118.50
CA POST (T2)	10	108.9 ± 8.5	101.75	107.50	116.00

Wilcoxon's signed-rank test

	CAPOST–CAPRE
Z	−.868[a]
Asymp. sig. (two-tailed)	0.386 (not significant)

[a] Based on positive ranks

Table 4 Summary measures of pre- and postsurgical STBA

	N	Mean ± SD	I Quartile	Median	III Quartile
STBA PRE (T1)	10	1.7 ± 1.18	0.75	1.75	3.00
STBA POST (T2)	10	1.05 ± 1.01	0.00	1.00	2.00

Wilcoxon's signed-rank test

	STBA POST–STBA PRE
Z	−.872[a]
Asymp. sig. (two-tailed)	0.383 (not significant)

[a] Based on positive ranks

posterior maxillary impaction osteotomy. Presurgical (T1) and postsurgical (T2) lateral cephalograms of each patient were evaluated. Postsurgical cephalogram was taken after six months of time interval as suggested by many authors [11–13], in order to allow soft tissue stabilization and adaptation.

All the lateral cephalograms were taken using standardized cephalometric technique. Using the same cephalometer with the same source-to-subject and subject to-film distances and patient positioning in natural head position with the teeth in centric occlusion and soft tissue in repose. On the presurgical and postsurgical cephalograms, two landmarks were used, namely sella and nasion, as their reliability was found to be high [14]. Only these two landmarks were required to construct the two reference lines so that high reproducibility and reliability were ensured. All additional soft tissue points were marked on the cephalograms. The postsurgical tracing was then superimposed onto the presurgical tracing (using anterior cranial base structures), and the two reference lines were transferred. The four angles NTPA, NLA, CA and STBA were evaluated in T1 and T2 and then superimposed to evaluate the changes between the values of the above four angles.

Only one angle, NLA, showed significant postsurgical changes with a significant p value of 0.007. A Wilcoxon signed-rank test indicated that postsurgical (T2) NLA (median = 109.25, IQR = 98.5–117.0) was significantly higher than presurgical (T1) NLA (Median = 98.25, IQR = 84.25–105.5) ($Z = 2.7$, $p = 0.007$). This increase in NLA can be attributed to movement of soft tissue points Ls and Sn. The movement of soft tissue point Ls seems to be related to maxillary incisor retraction and also associated with setback or retrusion of the anterior maxillary segment. Movement of the maxilla in a posterior vector implicates changes in upper lip morphology and changes in position of the soft tissue points Ls and Sn in a posterior direction and thus results in a significant opening of NLA (Cm–Sn–Ls). As most of the patients included in this study were females (60 %), this increase in nasolabial angle did enhance the nasal profile postoperatively. The result obtained in regard to NLA was in concordance with various studies [7–10] carried out to evaluate the soft tissue changes after anterior maxillary osteotomy.

Although statistically no significant changes were seen in nasal tip projection and columella labial angle, they demonstrated a range of changes in their value by $-10°$ to $+3°$ and $-11°$ to $+14°$, respectively. These results were in agreement with many other authors [7, 9, 15]. In this study, NTPA has shown a minimal decrease in its value by a mean of $-1.1°$ which is in contrast to a study conducted by Park et al. [8] which states a minimal increase in nasal tip projection following anterior maxillary segmental osteotomy. The change in nasal tip projection and columellar angle could not be appreciated clinically. Supratip break angle exhibited a mean change of $-0.65°$ which was statistically not significant. Further studies may be required to establish the change in supratip break in regard to maxillary orthognathic procedures.

The result of this study does demonstrate nasal changes following anterior maxillary segmental osteotomy with a superior and posterior repositioning. The technique of anterior maxillary osteotomy dictates osteotomy cuts to be at the level of anterior nasal spine, and also, it requires minimal perinasal musculature dissection. It requires minimum retraction of the paranasal soft tissues and an intact anterior nasal spine. Also, the degree of superior impaction that can be achieved by anterior maxillary osteotomy is limited by the level of the osteotomy cuts. Thus, a consequent favorable nasal change is to be expected following anterior maxillary osteotomy.

Thus, it can be concluded that the anterior segmental osteotomy in the maxilla for superior and posterior repositioning has resulted in significant opening of nasolabial angle and mild change in nasal tip projection angle.

Thus, subjects with acute nasolabial angle and poor nasal tip projection will be benefited with enhancement in their nasal profile following anterior maxillary osteotomy. Surgical goals must maximize the soft tissue esthetics. Hence, the importance of presurgical planning with soft tissue analysis specific to nasal morphology in a patient planned for maxillary orthognathic procedures cannot be underestimated. Further long-term studies are required with large number of samples and in different ethnic groups.

Acknowledgments Authors acknowledge the support extended by Prof. (Dr.) S.M. Sharma, Head of the Department of Oral and Maxillofacial Surgery, and Prof. (Dr.) B. Rajendra Prasad, Dean and Principal, A.B. Shetty Memorial Institute of Dental Sciences, Mangalore, India.

Compliance with Ethical Standards

Conflict of interest None.

Ethical Approval Ethical approval was obtained from the Institutional Ethical Clearance Committee.

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