Long-Term Effect of Maxillary Distraction Osteogenesis (DO) on Nasal Index in Adult Patients with Cleft Lip and Palate Deformities

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Abstract

Purpose To test the hypothesis that there is no immediate and long-term effects of maxillary distraction osteogenesis (DO) on nasal index among adult subjects with cleft lip and palate deformities.

Materials and Methods Twelve adult subjects in the age range of 17–20 years with complete unilateral cleft lip and palate underwent advancement of maxilla by DO. The immediate and long-term effects of maxillary DO on nasal index were evaluated from extra-oral full face frontal photographs recorded prior to DO (T_0), at the end of active DO (T_1) and at least 2-years after the DO (T_2). The ANOVA, Post Hoc test (Bonferroni) and Pearson correlation coefficients were used. The probability value (P value) 0.05 was considered as statistically significant.

Results SNM angle and Ptm-M distance increased significantly by DO ($P < 0.001$). The nasal index increased significantly ($P < 0.01$) by 13.85 % from T_0 value of 85.15 ± 4.49 to 99.02 ± 11.16 % at the end of active distraction (T_1) and by 12.69 to 97.84 ± 9.14 % at the end of long-term follow-up (T_2). The correlation between sagittal maxillary advancement and nasal index was statistically significant ($P < 0.001$). For each millimeter of

maxillary advancement, the nasal index increased by 1.38 % and 1.8 % at the end of active distraction and long-term follow-up respectively.

Conclusion The advancement of maxilla by distraction osteogenesis among subjects with cleft lip and palate deformities increased nasal index significantly.

Keywords Maxillary advancement · Distraction osteogenesis · Nasal index · Cleft lip and palate

Introduction

The changes in the external nasal morphology are very common following maxillary surgery. The favorable and unfavorable changes in the nasal morphology following maxillary surgery is related to both direction and magnitude of maxillary repositioning [1]. The maximum unaesthetic change in nasal morphology occurs following superior and/or anterior repositioning of maxilla [1]. The persons with normal frontal-nasal aesthetics and those with wide alar bases undergo maximum worsening of nasal aesthetic with maxillary advancement [1]. Distraction osteogenesis (DO) is commonly used over conventional orthognathic surgery for major advancement of maxilla in patients with severe maxillary deficiency [2]. This procedure is being increasingly used for the correction of severe maxillary hypoplasia particularly in patients with cleft lip and palate and syndromic craniosynostosis patients [3–5]. Distraction osteogenesis is more stable and generates more consistent hard to soft tissue ratios as compared to conventional orthognathic surgery [2, 3, 6]. The Le Fort-I osteotomy which is the mainstay of procedures used to correct defects of the maxilla, is well known to cause adverse changes in the nose including widening of the alar

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base and upturning of the nasal tip [7–11]. Although there are many reports in the literature describing the changes in the nose following advancement of maxilla by conventional orthognathic surgery [7–11], but to our knowledge there is no study in literature mentioning changes in the nasal index following maxillary DO at Le Fort-I level. Thus the present study was designed to evaluate the immediate and long-term changes in the nasal index following maxillary DO among subjects with cleft lip and palate deformities.

Materials and Methods

The study was approved by the Institute Review Board and conducted as per the guidelines of Helsinki Declaration. Subjects in the age range of 17–20 years who had complete unilateral cleft lip and palate deformity with severe anteroposterior maxillary hypoplasia, Class-III malocclusion, reverse overjet of 8–10 mm, and in whom distraction osteogenesis was carried out for maxillary advancement were included in the study. Subjects with cleft lip and palate deformities in whom rhinoplasty and lip revisions were performed following maxillary distraction were excluded from the study. Of the 29 subjects screened, 12 (M = 7, F = 5) subjects fulfilled the selection criteria and were included in the study. The mean age of subjects at the beginning of distraction was 18.91 ± 1.04 years.

In all subjects maxillary arch was prepared by multi-bonded fixed orthodontic appliance prior to DO. A customized tooth born acrylic splint was fabricated prior to surgery. Le Fort-I osteotomy with septal and pterygomaxillary disjunction was carried out under general

anaesthesia. Superior extent of the osteotomy was just below the infraorbital neurovascular bundle and gently curving anteriorly and posteriorly. Customized rigid external distractor was used for distraction. The customized distractor device consisted of a halo frame like cranial fixation component and pins, a distractor, and a vertical rod connecting the halo frame and distractor (Fig. 1). The acrylic splint was cemented to maxillary teeth with glass ionomer cement. The distraction vector was kept parallel to occlusal plane.

After a latency period of 4–6 days, distraction was started at the rate of 1 mm/day in three rhythms. All the subjects were followed up weekly and active distraction was continued until 5–8 mm of positive overjet was achieved. After a consolidation period of 6–8 weeks, the distractor and occlusal splint were removed. The fixed orthodontic therapy was continued and the maxilla in new position was retained by Class III elastic traction ($\frac{1}{4}$, 6oz force). The same oral surgeon (VR) carried out the procedures in all patients.

The amount of sagittal maxillary advancement was evaluated from the lateral cephalograms and the effect of maxillary DO on nasal index was evaluated from extraoral full face frontal photographs recorded prior to DO (T_0), at the time of removal of distractor (T_1) and at least 2-years after the DO (T_2). The mean time interval between T_0 and T_1 was 81.33 ± 13.80 days and between T_1 and T_2 was 917.08 ± 210.35 days. All the cephalograms and photographs were analyzed by same investigator (AKJ).

The amount of sagittal maxillary advancement by the distraction was evaluated from lateral cephalograms. The cephalograms were traced manually for the evaluation of linear and angular parameters. Various cephalometric

Fig. 1 Front (A) and lateral profile (B) views of a patient with maxillary distractor showing various components of the customized maxillary distractor

landmarks, linear and angular measurements for the evaluation of sagittal maxillary advancement at various stages of maxillary distraction are described in Fig. 2.

Extraoral full face photographs were recorded under standardized condition fulfilling all recommended criteria [12, 13]. The lighting was strictly controlled and the patients were seated and asked to close lightly on their back teeth with lip relaxed. The photographic frame was encompassed on the top of the patient's head to an inch or two below the chin. The inter-pupillary line was kept parallel to the floor. The distance from the outer canthus of the eye to the hairline was kept equal on each side. The line from the outer canthus of the eye to the superior attachment of the ear which is parallel to the FH plane is considered as constant, practical and clinical anatomic reference was kept parallel to the floor. This line was used to establish consistent parallelism between the eyes and the horizontal plane and to prevent tilting of the head in frontal and lateral views. The point of focus was at the eye lashes. The nasal

index was calculated using the formula: Nasal index = [Nasal width/Nasal height] $\times$ 100. The photographic method for the measurement of nasal height and nasal width are described in Fig. 3. For each patient, the measurements were measured twice and their mean was considered for statistical analysis.

Statistical Methods

All the statistical analyses were performed by using Statistical package for Social Sciences software (SPSS Inc., Chicago, IL, version 15.0 for Windows). The data were subjected to descriptive analysis. The ANOVA and Post Hoc test (Bonferroni) for multiple comparisons were used. The Pearson correlation coefficient test was used to detect any direct relationship between the amount of maxillary advancement and nasal index. The probability value (P value) 0.05 was considered as statistically significant.

Fig. 2 Cephalometric landmarks and linear and angular parameters for the evaluation of skeletal changes at various time intervals of maxillary distraction. Landmarks *S* sella, *N* nasion, *Po* porion, *Or* Orbitale, *M* center of the pre-maxilla, *Ptm* pterygomaxillary fissure. Reference planes *SN plane* line joining 'S' and 'N', *FH plane* line joining 'Po' and 'Or'. Linear and angular parameters. 1 SNM: The angle between 'S', 'N' and 'M' points. 2 Ptm-M: Linear distance between the perpendiculars drawn from 'Ptm' and 'M' points on FH plane

Fig. 3 Measurement of nasal index. Nasal index = Nasal width (**A**)/Nasal height (**B**) $\times$ 100. Inter-pupillary line (*IP-line*) was drawn between the pupil of *right* and *left* eyes. The nasal width (**A**) was measured as the distance between the perpendiculars drawn from *right side ala* (alar) and *left side ala* (alar) of the nose on the inter-pupillary line and the height of the nose (**B**) was measured as the perpendicular distance from the subnasale (*sn*) the junction between the lower end of the nasal septum and the upper lip to the inter-pupillary line

Results

The amount of sagittal maxillary advancement and the changes in nasal index at various stages following maxillary distraction is described in Table 1. The SNM angle increased significantly from $66.29^\circ \pm 7.77^\circ$ at pre-distraction (T_0) to $76.42^\circ \pm 5.29^\circ$ at the end of active distraction ($P < 0.001$) and to $73.92^\circ \pm 4.42^\circ$ at the end of long-term follow-up (T_2) ($P < 0.01$). The Ptm-M distance also increased significantly at the end of active distraction and long-term follow-up ($P < 0.001$). The nasal index increased significantly ($P < 0.01$) by 13.85 % from the T_0 value of 85.15 ± 4.49 % to 99.02 ± 11.16 % at the end of active distraction (T_1) and by 12.69 % to 97.84 ± 9.14 % at the end of long-term follow-up (T_2). The correlation between the nasal index and sagittal maxillary advancement was statistically highly significant ($P < 0.001$) (Table 2). For each degree of maxillary advancement (SNM angle), the nasal index increased by 1.37 % at the end of active distraction and by 1.66 % at the end of long-term follow-up. For each mm of maxillary advancement (Ptm-M distance), the nasal index increased by 1.38 % at the end of active distraction and by 1.8 % at the end of long-term follow-up.

Discussion

Distraction osteogenesis offers a solution for the correction of severe maxillary hypoplasia in subjects with cleft lip and palate deformities, and it is widely accepted, predictable and stable technique for maxillary advancement [3, 14–16]. The improvement of soft tissue profile of the midface is better following maxillary distraction than the conventional maxillary osteotomies [17]. Recently it was also described that maxillary distraction osteogenesis at Le Fort-I level could induce bone apposition at infraorbital rim and improve the overall esthetic of midface [18]. There are many reports in the literature describing the changes in the nose following advancement of maxilla by conventional orthognathic surgery [7–11]. However, there is no mention about the effect maxillary distraction on nasal index. So we

Table 2 Correlation between nasal index and sagittal maxillary advancement

	SNM	Ptm-M	Nasal index
Nasal index	0.758***	0.640***	1

*** $P < 0.001$

evaluated the immediate and long-term changes in nasal index following maxillary distraction osteogenesis.

The craniofacial anthropometry is very important in planning and evaluation of treatment particularly in dentistry [19–22]. The traditional use of 2-dimensional clinical photographs for the objective assessment of treatment quality and natural changes through growth is well established and valid [14, 22]. The use of two-dimensional photographs for quantitative assessment of facial structures among subjects with cleft lip and palate is very common and reliable [23, 24]. So we used clinical photographs for the assessment of nasal index. However, various 3D imaging such as laser scanning, digital stereophotogrammetry, morphoanalysis and moiré topography etc. have wide application in facial plastic and reconstructive surgery and should be used to overcome the shortcomings of conventional 2-dimensional imaging.

The nose is not only accepted to be part of the facial features used in assessing beauty [25] but its index may suggest ethnicity, race or sex [26, 27]. The nose is classified into three types, the typical long and narrow Caucasian nose (leptorhine) has nasal index < 70 %; the medium nose of Orientals (mesorhine) has nasal index of 70–84.90 % and the short and broader Negroid nose (platyrhine) has nasal index of 85 % and above [28]. A wide and asymmetrical nose with flattening at the dome of nasal crura and appreciable flattening of the furrow of philtrum are common among subjects with cleft lip and palate deformities as compared to normal subjects [29, 30]. In the present study we also observed increased nasal index among subjects with cleft lip and palate deformities prior to distraction osteogenesis. Similar to our observation, Othman et al. [30] also reported that the nasal index in adult subjects with unilateral cleft lip and palate deformities was significantly more as compared to subjects without cleft deformity.

Table 1 Sagittal maxillary advancement and nasal index changes at various stages of maxillary advancement

Parameters	Pre-distraction (T_0)	Post-distraction (T_1)	Long-term post-distraction (T_2)	P value	Comparison		
					T_0-T_1	T_0-T_2	T_1-T_2
SNM ($^\circ$)	66.29 ± 7.77	76.42 ± 5.29	73.92 ± 4.42	0.000	***	**	NS
Ptm-M (mm)	38.37 ± 3.12	48.39 ± 3.29	45.42 ± 3.10	0.000	***	***	NS
Nasal index (%)	85.15 ± 4.49	99.02 ± 11.16	97.84 ± 9.14	0.001	**	**	NS

NS non-significant; ** $P < 0.01$; *** $P < 0.001$

The effects of Le Fort-I osteotomy on nasal aesthetics has been reported widely in the literature [7–11]. Typically, there is widening of the base of the nose and associated flattening and thinning of the upper lip. When the maxilla is advanced, the most profound influence on nasal morphology is observed in the tip region and the change following advancement occurs immediately and without muscle action because of tissue pressure alone. With maxillary advancement, the columella become lowered and results in a more pronounced supra tip depression due to nasal tip rise. The response of facial soft-tissue is related in part to the amount and direction of maxillary movement, quality and quantity of soft tissues, treatment of nasal crest of the maxilla, and management of soft tissue during the wound closure. However, the widening of nasal base is only partially dependent on amount of skeletal movement and the most important is amount of subperiosteal dissection and elevation accomplished. We observed that the nasal index was increased by 13.85 % at the end of active distraction osteogenesis and remained increased by 12.69 % at the end of long-term follow-up. For 1 mm of maxillary advancement, the nasal index was increased by 1.8 % at the end of long-term follow-up. The increase in the nasal index after maxillary advancement is mainly due to widening of the nasal base [31, 32] and partly due to decrease of nasal height [33]. Betts et al. [31] observed 65 % increase in the nasal width and 59 % decrease in the nasal tip height following Le Fort-I maxillary advancement. When the maxilla is advanced by distraction at Le Fort-I level, the advancement of nose at its base is more as compared to its tip [6] and results in flattening of the nose and increase in the nasal index. As the facial muscles are detached from the nasolabial area and anterior nasal spine, it makes the outcome frequently asymmetric and unpredictable [34]. Therefore, secondary rhinoplasty often becomes necessary after a period of 6–12-months following maxillary surgery. Nevertheless, the secondary effect on nasal aesthetics induced by Le Fort-I osteotomy needs to be minimized whenever possible during the first operation i.e. controlling the widening of alar base is one of the major aspects. The use of alar base cinch is very common for the prevention of alar base widening. The alar cinch is recommended in persons who have normal or excessively wide alar bases preoperatively and patients who undergo major superior and/or anterior repositioning of the maxilla [35, 36]. However the benefit of alar cinch is questionable due to difficulty in forecasting the exact anatomic location of nasal tip. Recently it was also reported that alar cinch was not useful in preventing the nasal base widening [10]. Moreover, the use of alar cinch suture in cases of maxillary advancement with distraction is not indicated. Most of the cleft lip and palate patients after distraction of maxilla need rhinoplasty and revision lip surgery. The problem of

increased nasal width can be reduced at revision surgery. Therefore, patients should be forewarned regarding this problem and the possible need for corrective revision surgery.

Thus the soft tissue changes of midface invariably occur on manipulation of maxilla. However the ability of a surgeon to accurately plan postoperative changes relies on being able to correlate the soft tissue response of nose to underlying osseous movement. Although we found a significant increase in nasal index following maxillary distraction among subjects with cleft lip and palate deformities, but due to small sample size the results should be viewed with caution.

Conclusion

The null hypothesis was rejected and following conclusions were drawn from the present study.

1. The advancement of maxilla by distraction osteogenesis at Le Fort-I level among subjects with cleft lip and palate deformities increased nasal index significantly.
2. For each mm of maxillary advancement the nasal index increased by 1.38 % at the end of active distraction and by 1.8 % at the end of long-term follow-up.

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