Changes in Maxillary Alveolar Morphology with Nasoalveolar Molding

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Aim: *To evaluate the changes in maxillary alveolar morphology in unilateral cleft lip palate infants treated with nasoalveolar molding(NAM).* ***Setting and Design:*** *Study was carried out in the orthodontic department associated with a operating cleft unit in a rural region of central India. Ten UCLP (unilateral cleft lip palate) infants less than 6 weeks of age were treated with NAM prior to surgical repair.* ***Materials and Methods:*** *Pre NAM and Post NAM study models of the UCLP infants were analyzed. Critical linear dimensions including inter- canine width, inter-tuberosity width, arch length and midline deviation were recorded at the different stages using a digital vernier caliper and compared. Statistical analysis were performed using SPSS 13.00 statistical software.* ***Results:*** *Results from this study showed that the width of the alveolar cleft showed a significant decrease with NAM. The arch length and width of the arch in the anterior region also showed a reduction with NAM. The intertuberosity width showed a statistically significant increase during treatment. The arch perimeter showed a significant increase with NAM.* ***Conclusion:*** *NAM was effective in reducing the severity of the initial cleft deformity mainly at the anterior portion of the maxillary arch.*

Keywords: *Nasoalveolar molding, Presurgical infant orthopedics, Cleft lip palate infant.*
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INTRODUCTION

Cleft lip and palate (CLP) is one of the most common congenital anomalies affecting the orofacial region.[1] A multidisciplinary team approach is involved in providing care for affected individuals with the aim of restoring normal form and function.

McNeil and Burstone were the modern day pioneers of infant maxillary orthopedics.[2] In the 1950s using this approach they successfully approximated the cleft at the level of alveolus and hard palate. The therapeutic possibilities of this approach were however overestimated by the pioneers leading to opposition and an early but temporary demise. Presurgical infant orthopedics (PSIO) is defined as any orthopedic manipulation of the segments of the clefted maxilla in a newborn with complete unilateral or bilateral CLP aiming at establishing a more normal maxillary alveolar arch form or at retracting a protruding premaxilla to facilitate the surgical repair of the lip.[3] The underlying objective of PSIO is to reduce the severity of the cleft deformity at all areas thereby making surgical correction easier and results of repair better.

Several different approaches to PSIO have been put forward after McNeil and Burstone and the different appliances have been previously reviewed.[4] Presurgical Nasoalveolar Molding (NAM) is a type of infant orthopedic procedure that targets an often neglected area of the deformity, that of the nose.[5] NAM has emerged as an adjunctive procedure to aid the surgeon in achieving excellent results. In addition to the nose, NAM also helps mold the alveolar segments. The objective at the alveolar level for NAM is to align the displaced alveolar segments and approximate them.

Primary bone grafting of the maxillary alveolar cleft deformity is advocated by only few centers and the opposition to it is mainly due to restriction of midfacial growth in the future.[6] NAM followed by gingivoperiosteoplasty (GPP) has been put forward as an alternative and cost effective approach to the management of the alveolar cleft deformity.[7]

Most of the studies to evaluate the changes that result from NAM have concentrated on the nasal component of the deformity. These include 2D and 3D assessments of improvements in nasal morphology with NAM.[8,9,10] Studies on predental models of cleft infants have investigated the

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effects of different appliances and treatment protocols on alveolar morphology.[11,12,13,14] However, relatively few studies have investigated the effects of NAM on the maxillary alveolar morphology.[15,16] This study was carried out to evaluate the changes induced in the maxillary alveolar morphology with NAM.

Subjects and Methods

Ten infants (seven males and three females) with non-syndromic CUCLP, who attended the Cleft Lip and Palate and Clinic were included in the study. Parents of all infants consented to the treatment. Subjects older than 6 weeks of age were not included in the study. All the infants underwent a course of NAM prior to surgery. Primary cheiloplasty and semi open rhinoplasty were carried out in all the subjects and in one case GPP post NAM.

NAM procedure

The parents of the infants are advised on the potential benefits and possible complications of NAM and the need for parental cooperation in successful outcome is stressed in the initial visit. This is followed by an intraoral maxillary impression of the infants with elastomeric putty impression material (Provil Novo(R), Heraeus Kulzer,USA) following the procedure previously outlined by the authors.[17] Two sets of models are obtained one of which is used for the study and the other for appliance fabrication. The intraoral plate is fabricated using autopolymerising resin along with an

Figure 1. Infant wearing NAM appliance with retentive button.

acrylic retentive button (Figure 1). Alveolar molding is undertaken by sequential addition of soft acrylic and removal of hard resin from selected areas of the plate. As the alveolar cleft reduces to 5 mm a nasal stent is added to the plate (Figure 2B). The nasal stent provides extra reciprocal force for alveolar molding.

Study models were obtained initially at the beginning of treatment (T1) and at the day of surgery (T2). Figure 3A–C show the study models of progressive changes in maxillary alveolar morphology with NAM. Study models obtained at

Figure 2. A.Lip taping to approximate the lip segments, B: Improvement in nasal morphology with nasal stent addition.

Figure 3. A,B,C. Progressive changes in alveolar morphology with NAM.

Figure 4. Reference points used in the study.

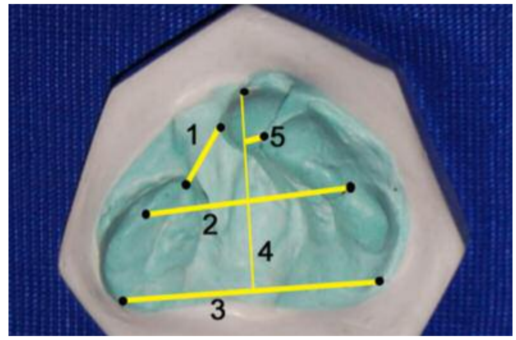

Figure 5. Linear measurements used in the study: 1) Alveolar cleft width; 2) Anterior arch width; 3) Posterior arch width; 4) Arch length; 5) Midline deviation

TI and T2 were evaluated in the study. Table 1 shows the reference points (Figure 4) and linear measurements (Figure 5) of the critical dimensions including inter- canine width, inter-tuberosity width, arch length and midline deviation that were evaluated on the study models. Measurements were recorded using a digital vernier caliper. The reference points were drawn from two previous studies[15,16] and marked on the models using a 0.3 mm lead pencil by one author. All landmarks were erased after the measurements were noted. The landmarks and measurements were repeated by the same author after a one month interval. Duplicate measurements were conducted to establish intraexaminer reliability. Using t tests, no statistically significant differences were noted between the repeated measures in any of parameters at the different time periods.

The changes in the linear measurements for the infants at T1 and T2 were analyzed. All statistical analysis were performed using SPSS 13.00 statistical software. Data were summarized as means ± standard deviation. Changes in the linear distances from T1 to T2 were calculated by using percentage changeover. Significant values were tested at 5% and 1 % level of significance.

RESULTS

The initial visit (T1) was at mean age of 16 days and the end of treatment with NAM at (T2) was at a mean age of 178 days. The mean duration of treatment with NAM for the infants was 162 days.

Evaluation of change in various parameters (Table 2)

Width of the alveolar cleft (A1–A2) - The mean cleft width was 9.72 mm at T1 and 2.96 mm at T2.The width of the alveolar cleft showed a progressive and significant decrease from time period TI to T2 ($p<0.01$).The percentage decrease in the alveolar cleft during this time period was 69.55%.

Table 1. Description of reference points, lines and linear variables used in the study

REFERENCE POINTS	DESCRIPTION
A1	Midpoint of the margin of the alveolar process medial to the cleft
A2	Midpoint of the margin of the alveolar process lateral to the cleft
C1	Point of intersection between the alveolar ridge and groove of the lateral labial frenum on the greater segment
C2	Point of intersection between the alveolar ridge and groove of the lateral labial frenum on the lesser segment
Tb1	Junction of the alveolar ridge with the outline of the tuberosity on the greater segment
Tb2	Junction of the alveolar ridge with the outline of the tuberosity on the lesser segment
Ic	Point of intersection between the alveolar ridge and groove of the median labial frenum
M	Midpoint of Tb1 Tb2 line
AP max	Most anterior point of the greater segment from Tb1 Tb2 line
LINEAR VARIABLES	**DESCRIPTION**
A1 A2	Alveolar cleft width
C1C2	Anterior arch width
Tb1Tb2	Posterior arch width
Arch length (AL)	Distance from the APmax to the M point
Midline Deviation(ML)	Perpendicular distance from Ic point to line from M point to AP max
Arch Perimeter (AP)	Sum of distances Tb1-C1 + C1-Ic + Ic-A1 + A2-C2 + C2-Tb2

Table 2. Mean Standard Deviation and percentage change in the various parameters

Parameter	Mean Values ± S.D		% change	P value
	T1	T2		
A1 A2	9.72±3.23	2.96±2.61	-69.55	0.0013**
C1C2	24.74±2.79	24.31±3.32	-1.73	0.9445
Tb1Tb2	30.93± 1.1	31.51± 1.08	1.87	0.0001**
A1 I	8.58±1.68	9.60±2.02	11.89	0.4272
IC1	8.21±2.14	8.58±1.68	4.51	1.6431
C1Tb1	17.63±2.51	18.19±2.51	3.18	0.3213
A2C2	9.71±1.57	10.30±1.22	6.08	0.1293
C2Tb2	14.99±1.79	16.38±1.72	9.27	0.1143
AL	29.65±3.54	26.52±3.14	-10.56	0.5239
AP	59.12±3.69	63.05±3.80	6.65	0.0124*
ML	8.64±2.76	5.18±2.48	-40.05	0.0136*

**significant at P <0.01
* Significant at P <0.05
P value was calculated using the linear trend method

Width of the arch in the anterior region (C1–C2) - The width of the arch in the anterior region also showed a slight reduction from 24.74mm at T1 to 24.31 mm at T2. The reduction observed was however only 1.73% during this period.

Width of the arch in the posterior region (Tb1–Tb2) - There was an increase seen in the mean intertuberosity width from 30.93 mm to 31.51 mm, a increase of only 1.87%, which was statistically insignificant.

Arch Perimeter - The arch perimeter was calculated as the sum of the linear dimensions A1I, IC1, C1Tb1, A2C2 and C2Tb2.The arch perimeter showed a significant increase (P <0.05) of 6.65 % from 59.12 mm at T1 to 63.05 mm at T2.

Arch length - The arch length which was measured from the midpoint of the intertuberosity distance to the most anterior on the greater segment showed a mean reduction from 29.65 at T1 to 26.52 at T2.

Midline deviation - As treatment progressed there was a reduction in the severity of the midline deviation from T1 to T2 as seen from the data. The initial measurement at T1 was 8.64 mm and at T2 was 5.18 mm.

DISCUSSION

When a post surgical esthetic evaluation of the nasolabial region in UCLP individuals at age 9 years was undertaken, the nasal form gave the poorest esthetic rating.[18] With NAM assisted surgery however many centers have reported on the improved nasolabial esthetics in the short and long term without detrimental effects on midfacial growth.[8, 19, 20]

Relatively few studies have reported on the changes at the level of the alveolus from NAM. This study was done to shed more light on this area. One of the questions we wished to answer was, how the alveolar segments approximate as a result of NAM. It was seen that there was a progressive and significant reduction in the dimensions of the alveolar cleft. At the same time there was an improvement in the midline position of the maxillary arch as well. This is substantiated by a reduction in the perpendicular distance from the incisive papilla point to the perpendicular line constructed from the intertuberosity midline. Additionally the arch length also showed a progressive decrease with treatment. These factors could lead us to deduce that the reduction was primarily due to an inward and medial bending of the greater segment. Another contributing factor is possibly growth occurring at the margins of the lesser and greater segments towards each other due to the constrictive effect of the NAM plate. In the present study this is expressed as increases in the linear distances A1I and A2C2. Similar increases were noted in the linear dimensions at the margins of the cleft with the use of passive presurgical appliances in papers by Mishima *et al*[21] and the Dutch national study by Prahl *et al.*[22]

Significant reductions in cleft width were also reported by the Dutch national study and Kozelj[23] with the use of passive preoperative appliances. The Dutch national study however reported that the effects on maxillary arch dimensions were temporary and did not last beyond soft palate closure.

The balance between the compressive forces of the facial muscle ring and expansile forces of the tongue musculature determines the final alignment of the dental arches. The restraining force from an intact outer lip musculature is absent in CLP infants. In NAM lip taping mimics the action of a continuous orbicularis oris muscle ring and thereby eliminate the laterally displacing pull forces that results from unrestrained musculature. Also the false palate formed by the acrylic plate prevents the push forces that result from the activity of the tongue in the cleft. The interplay between these forces and directed growth are possibly responsible for reducing the cleft width.

Transverse arch changes were assessed in the anterior (C1–C2) and posterior regions (Tb1–Tb2). With regard to the anterior arch width, a non significant reduction in this dimension was seen. A Korean paper too reported a similar but significant reduction in the anterior arch width with NAM.[15] A British study[13] similarly reported anterior arch width reduction of approximately 1mm in the first 3 months of active preoperative orthopedic treatment with a spring based preoperative appliance. The Dutch study reported that the anterior arch width decreased in both the infant group treated with the passive plate and the control group when studied upto 78 weeks. The posterior arch width in this study showed minimal change during the period from T1to T2. Since no modifications were undertaken in the posterior areas of the arch, the minor increase observed can be attributed to growth. Huddart[12] and Ball *et al*[13] too have reported minor increases of approximately similar amounts.

For a successful GPP to be executed without affecting maxillary growth, and increase the likelihood of possible bone formation, the gap between the cleft alveolar segments should ideally be less than 2mm.[24] In the sample it was possible to reduce the cleft width to 2mm or less in 50% of the cases. Though the intraoral objective of NAM is to approximate the alveolar cleft, caution has to be exercised in aggressive attempts to approximate the cleft width at the expense of inter arch relationship. Clefts vary in severity and in addition to displacement and deviation there may also be a deficiency of alveolar tissue. In such instances there may be a tendency for reverse overjet or edge to edge relation of the arches to occur during molding which should be avoided.[25] GPP was possible in only one case at the center as the surgical team experienced technical difficulties in operating in a narrow space.

It was observed that the mean age of surgery for infants was 178 days after birth. This is higher than reported by most other centers. However we wish to clarify that this is not due to the additional time required to achieve preoperative objectives with NAM. This was mainly because most infants do attain adequate weight and nourishment fit for surgery later than infants from other developed parts of the world.[26]

All parents of the infants included in this study were in agreement on the feeding benefits provided by the plate which acted as an artificial palate. In fact, most of the infants experienced difficulty in feeding without the plate. However most parents in the study had to bottle feed the infants as the retentive button and nasal stent were potential impediments to breast feeding.

This study was restricted to assessing only the dimensions of width and length and not the changes in the depth of the palatal shelves. Another shortcoming of this study is the small sample size. The population under investigation is CUCLP infants. The rural center where the unit is situated caters to a large number of underprivileged people and many of them report late for surgery for a variety of reasons ranging from socioeconomic, lack of awareness to poor referral systems. Outcome of NAM is time bound and older individuals do not respond favorably leading to exclusion from NAM of many subjects seen at the center. Additionally evaluation and comparison of individuals after surgery treated with and without NAM is regrettably not possible at the center as the surgical and orthodontic teams are convinced on the potential benefits of NAM. Longer follow up of the study sample up to palatoplasty and beyond is necessary to add to our existing knowledge.

CONCLUSIONS

The present study was done on CUCLP infant models to evaluate changes in maxillary alveolar morphology with NAM. Results from the study showed that NAM was effective in reducing the alveolar cleft width. In five out of the ten cases the alveolar cleft dimension was reduced to less than 2 mm. The intertuberosity width was mildly increased as a result of growth. A reduction in the arch length was seen as the displaced greater segment was brought to a more ideal anatomic position. The anterior arch width however showed a slight reduction. NAM was effective in reducing the severity of the initial cleft deformity mainly at the anterior portion of the maxillary arch.

REFERENCES

1. Owens JR, Jones JW, Harris F. Epidemiology of facial clefting. Arch Dis Child, 60: 521–24, 1985.
2. Burston WR. The early treatment of cleft palate conditions. Dent Pract Dent Rec, 9: 41–52, 1958.
3. Daskalogiannakis J. Glossary of Orthodontic Terms. 1st ed. Berlin, Quintessence Publishing, 222, 2000.
4. Sabarinath VP, Hazarey PV, Ramakrishna Y, Vasanth R, Girish K. Caring for cleft lip and palate infants: Impression procedures and appliances in use. J Indian Prosthodont Soc, 9: 76–80, 2009.
5. Grayson, BH, Santiago PE, Brecht, LE, Cutting, CB, Presurgical nasoalveolar molding in infants with cleft lip and palate. Cleft Palate Craniofac J, 36: 486–98, 1999
6. Bajaj AK, Wongworawat AA, Punjabi A. Management of Alveolar Clefts. J Craniofac Surg, 14: 840–46, 2003.
7. Pfeifer TM, Grayson BH, Cutting CB. Nasoalveolar Molding and Gingivoperiosteoplasty Versus Alveolar Bone Graft: An Outcome Analysis of Costs in the Treatment of Unilateral Cleft Alveolus. Cleft Palate Craniofac J, 39: 26–9, 2002.
8. Liou EJW, Subramanian M, Chen PKT, Huang S. The Progressive Changes of Nasal Symmetry and Growth after Nasoalveolar Molding: A Three-Year Follow-Up Study. Plast Reconstr Surg, 114 :858–64, 2004.
9. Singh GD, Levy-Bercowski D, Santiago PE. Three-Dimensional Nasal Changes Following Nasoalveolar Molding in Patients with Unilateral Cleft Lip and Palate: Geometric Morphometrics. Cleft Palate Craniofac J, 42: 403–09, 2005.
10. Singh GD, Levy- Bercowski D, Yanez MA, Santiago PE. Three-dimensional facial morphology following surgical repair of unilateral cleft lip and palate in patients after nasoalveolar molding. Orthod Craniofacial Res,10:161–66, 2007.
11. Mazaheri M, Harding R, Cooper JA, Meier JA, Jones TS. Changes in arch form and dimensions of cleft patients. Am J Orthod, 60: 19–32, 1971.
12. Huddart AG. Presurgical changes in unilateral cleft palate patients. Cleft Palate J, 16: 146–57, 1979.
13. Ball JV, DiBiase DD, Sommerlad BC. Transverse maxillary arch changes with the use of preoperative orthopedics in unilateral cleft palate infants. Cleft Palate Craniofac J, 32: 483–88, 1995.
14. Prasad CN, Marsh JL, Long RE, Galic M, Huebener DV, Bresina SJ et al. Quantitative 3D Maxillary Arch Evaluation of Two Different Infant Managements for Unilateral Cleft Lip and Palate. Cleft Palate Craniofac J, 37: 562–70, 2000.

15. Baek SH, Son WS. Difference in alveolar molding effect and growth in the cleft segments: 3-dimensional analysis of unilateral cleft lip and palate patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 102: 160–68. 2006.
16. Peltomaki T, Vendittelli BL, Grayson BH, Cutting CB, Brecht LE. Associations Between Severity of Clefting and Maxillary Growth in Patients With Unilateral Cleft Lip and Palate Treated With Infant Orthopedics. Cleft Palate Craniofac J, 38: 582–86, 2001.
17. Radhakrishnan V, Sabarinath VP, Thombare P, Hazarey PV, Bonde R, Sheorain A. Presurgical Nasoalveolar Molding Assisted Primary Reconstruction in Complete Unilateral Cleft Lip Palate Infants. J Clin Pediatr Dent, 34: 267–74, 2010.
18. Nollet JPMP, Kuijpers-Jagtman AM, ChatzigianniA, Semb G, Shaw WC, Bronkhorst, Katsaros C. Nasolabial appearance in unilateral cleft lip, alveolus and palate: A comparison with Eurocleft. J Cranio Maxillofac *S*urg, 35: 278–86, 2007.
19. Barillas I, Dec W, Warren SM, Cutting CB, Grayson BH Alveolar Molding Improves Long-Term Nasal Symmetry in Complete Unilateral Cleft Lip-Cleft Palate Patients. Plast Reconstr Surg, 123: 1002–009, 2009.
20. Wood RJ, Grayson BH, Cutting CB. Gingivoperiosteoplasty and Midfacial Growth. Cleft Palate Craniofac J, 34: 17–20, 1997.
21. Mishima K, Sugahara T, Mori Y, Sakuda M. Three dimensional comparison between the palatal forms in infants with complete unilateral cleft lip, alveolus, and palate (UCLP) with and without Hotz's plate. Cleft Palate Craniofac J, 33: 77–83, 1996.
22. Prahl C, Kuijpers-Jagtman AM, van 't Hof MA, Prahl-Andersen B. A randomised prospective clinical trial into the effect of infant orthopaedics on maxillary arch dimensions in unilateral cleft lip and palate (Dutchcleft). Eur J Oral Sci, 109: 297–305, 2001.
23. Kozelj V. Changes produced by presurgical orthopedic treatment before cheiloplasty in cleft lip and palate patients. Cleft Palate Craniofac J, 36: 515–21, 1999.
24. Grayson B, Brecht LE, Cutting CB. Nasoalveolar Molding in Early Management of Cleft Lip and Palate. In, Taylor TD(ed).Clinical Maxillofacial Prosthetics. Chicago Quintessence Publishing, 63–84, 2000.
25. Cutting CB, Grayson BH Invited Discussion: Early Cleft Lip Repair in Children With Unilateral Complete Cleft Lip and Palate. Ann Plast Surg, 54: 598–99, 2005.
26. Adenwalla HS, Narayanan PV. Primary unilateral cleft lip repair. Indian J Plast Surg (Suppl1), 42: 62–70, 2009.