Submitted: 27 March, 2023 Accepted: 19 May, 2023 Published: 03 November, 2023 DOI:10.22514/jocpd.2023.090

ORIGINAL RESEARCH

Journal of Clinical Pediatric Dentistry

Influence of presurgical nasoalveolar molding (PNAM) treatment in maxillary dental arch width and nasolabial symmetry in patients with unilateral complete cleft lip and palate

Le Chang[1,2,†], Qianqian Huang[1,2,†], Zhanping Ren[1,3,†], Yanhao Wang[1,2], Yuhua Jiao[1,2], Yongwei Tao[1,3], Huaxiang Zhao[1,2,*], Yuxia Hou[1,2,*]

[1]Key Laboratory of Shaanxi Province for Craniofacial Precision Medicine Research, College of Stomatology, Xi'an Jiaotong University, 710004 Xi'an, Shaanxi, China
[2]Department of Orthodontics, College of Stomatology, Xi'an Jiaotong University, 710004 Xi'an, Shaanxi, China
[3]Department of Cleft Lip and Palate Surgery, College of Stomatology, Xi'an Jiaotong University, 710004 Xi'an, Shaanxi, China

***Correspondence**
huaxiangzhao@xjtu.edu.cn (Huaxiang Zhao);
houyuxia@mail.xjtu.edu.cn (Yuxia Hou)

† These authors contributed equally.

Abstract

Unilateral complete cleft lip and palate (UCCLP) is one of the most severe clinical subphenotypes among nonsyndromic cleft lip and/or palate (NSCL/P), that complicates surgical repair operations. Presurgical nasoalveolar molding (PNAM) is a technique used to reshape the nose, lip and alveolar bone of infants with UCCLP before surgery (the modified Mohler rotation advancement cheiloplasty and two flap palatoplasty), with the potential to facilitate surgical repair. However, the effectiveness of PNAM treatment is still a matter of debate. In this paper, the 3Shape scanning system and 3dMD stereophotography were used to assess the short-term and long-term effects of PNAM treatment on the dental arch morphology and nasolabial features of patients with UCCLP, respectively. The findings indicated that PNAM treatment negatively affects both short-term and long-term dental arch shape compared to the treatment without PNAM, particularly in terms of limiting the transverse width of the maxillary canine-to-midline. Regarding the nasal and labial symmetry, PNAM improves the symmetry of the nasal alae in patients over 7 years old and the symmetry of the lip in patients under 7 years old. Moreover, UCCLP patients who received PNAM treatment exhibited a shorter and wider shape of the nostril on the cleft side compared to those without PNAM treatment. In clinical practice, the multidisciplinary team should carefully consider the advantages and disadvantages of the outcomes of PNAM treatment when treating infants with cleft lip and palate.

Keywords

Presurgical nasoalveolar molding; Cleft lip and palate; Unilateral complete cleft lip and palate; Dental arch morphology; Nasolabial features

1. Introduction

Nonsyndromic cleft lip and/or palate (NSCL/P) is the primary type of orofacial clefts and one of the most prevalent congenital craniofacial disorders, affecting 1.00 and 2.06 per 1000 births worldwide and in China, respectively [1, 2]. NSCL/P may induce serious concerns with appearance, dental function and mental health, lowering the quality of life for affected persons and their relatives [3]. Among NSCL/P subphenotypes, unilateral complete cleft lip and palate (UCCLP) is considered one of the most serious clinical conditions. UCCLP typically results in a gap between the upper lip and the base of the nose that extends beyond the bones of the upper jaw, making surgical repair particularly challenging [4].

Presurgical nasoalveolar molding (PNAM) is a therapeutic technique applied to infants with cleft lip and palate (CLP), particularly those with UCCLP. PNAM aims to reshape the nose, lip and alveolar bone of the affected infants before surgery (typically performed using the modified Mohler rotation advancement cheiloplasty and two flap palatoplasty), along with the purpose of improving surgical outcomes and rendering surgical repair relatively simple [5]. Currently, there is still ongoing debate regarding the effectiveness of PNAM treatment. Some studies suggested that PNAM can reduce the severity of the cleft, improve the symmetry of the nose, and enhance the symmetry and stability of the dental arch [6, 7]. However, other researchers found no significant effects during PNAM treatment and even suggested that it may restrict facial development, and induce negative effects on the size of the maxillary dental arch [8]. Therefore, there is a need for further research to investigate the effects of PNAM on infants with CLP.

In recent years, three-dimensional measurement methods such as digital modeling and 3D stereophotography have become increasingly popular for evaluating the efficiency of treatments in orthopedic surgery and orthodontics [9, 10].

These methods are considered more accurate and less technically sensitive than traditional methods [11].

In this study, the 3Shape scanning system and 3dMD stereophotography were employed to evaluate the impact of PNAM treatment on the dental arch morphology and nasolabial features of patients with UCCLP, respectively, both in the short-term and long-term, providing evidence for the clinical effectiveness of PNAM in managing UCCLP.

2. Materials and methods

UCCLP patients hospitalized to the Hospital of Stomatology, Xi'an Jiaotong University between 2011 and 2017 were screened according to precise selective (inclusion and exclusion) criteria for this retrospective analysis.

The inclusion criteria were: (1) Participants between 2 and 13 years of age who had undergone cleft lip repairment within 3–6 months and cleft palate repairment within 10–30 months after birth. (2) Patients who had received the same type of PNAM treatment, which had started within four weeks after birth. (3) All procedures of treatments were performed by the same lead surgeon and orthodontist. (4) The cleft lip and palate repairment techniques were consistent among all UCCLP patients (the modified Mohler rotation advancement cheiloplasty and two flap palatoplasty, respectively).

The exclusion criteria were: (1) Patients who had received orthodontic treatments other than PNAM before the study assessment. (2) Patients with skin or soft tissue diseases in the orofacial region. (3) Patients with other orofacial abnormalities or facial trauma. (4) Patients unable to comply with PNAM treatment. (5) Patients who were unable to attend regular follow-up appointments or the data of the treatment were incomplete.

The patients were categorized into two distinct groups based on whether they had undergone PNAM treatment or not. Additionally, each group was subdivided into "under 7 years" and "over 7 years" categories based on the legal school age in the local region to assess the short-term and long-term effects of PNAM treatment.

In this study, the oral impressions of participants were obtained, and plaster models were created. These models were then scanned using a 3Shape scanner (E4, 3Shape, Copenhagen, Denmark) to generate digital three-dimensional data. The digital model was imported into Geomagic Studio 2013 software (Geomagic, Morrisville, North Carolina), where a 3D coordinate system of the dental arch model was constructed, and landmarks were identified [12].

To determine the center point of each tooth (Fig. 1A–C), the intersection point between the proximal and distal midpoint of teeth was identified (Line MN in Fig. 1A) along with the line between the buccal and lingual points of the tooth (Line RS in Fig. 1A). Subsequently the following landmarks were identified (Fig. 1): (1) Point "In" is the apex of the incisor papilla; (2) Point "Mi", represents the intersection of the line between the palatal raphe and bilateral palatine foveola; (3) Line "In-Mi", representing the midline of the dental arch; (4) Ce/Ce' are the central points of the unaffected and cleft side canines, respectively; (5) P1/P1' are the central points of the unaffected and cleft side permanent first premolars (or first deciduous molars), respectively; (6) P2/P2', are the central points of the unaffected and cleft side permanent second premolars (or second deciduous molars), respectively; (7) Point D, E, F/D', E', F' are the vertical junctions between Ce, P1, P2/Ce', P1', P2' and Line In-Mi, respectively.

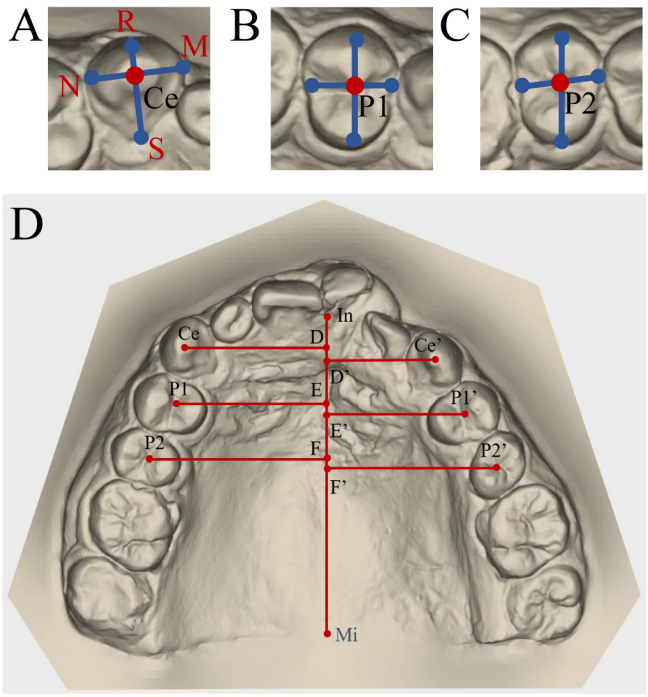

FIGURE 1. Illustration of measurements of dental arch morphology in patients with UCCLP. (A–C) The center point of canines (A), permanent first premolars (or first deciduous molars) (B) and permanent second premolars (or second deciduous molars) (C) are identified the intersection points between the proximal and distal midpoints of the tooth (Line MN) and the line between the buccal and lingual points of the tooth (Line RS). (D) Point "In" is the apex of the incisor papilla, Point "Mi" is the intersection of the line connecting the palatal raphe and bilateral palatine foveola, and Line In-Mi is the midline of the dental arch. Ce/Ce' are the central points of the unaffected and cleft side canines, respectively. P1/P1' are the central points of the unaffected and cleft side permanent first premolars (or first deciduous molars). P2/P2' are the central points of the unaffected and cleft side permanent second premolars (or second deciduous molars). Point D, E, F/D', E', F' are the vertical junctions between Ce, P1, P2/Ce', P1', P2' and Line In-Mi, respectively.

The 3dMDface system (3dMd, Atlanta, GA) was used to capture the nasolabial morphology of the individuals [13]. The patients were photographed 1.5 m away from the Medium Close-up lens of the 3dMDface system. The nasolabial characteristics were measured using the front view and nasal base scan. Landmarks were identified as follows (Fig. 2): (1) En(L/R), the inner canthus points; (2) Ah, the peak point of alae; (3) Ac, the outermost point of the nasal alar base; (4) Sbal, the innermost point of the nasal alar base; (5) Cph, the point of lip peak; (6) Ch(L/R), the corner of the mouth; (7) Nl/Nm, the outmost/innermost point of the nostril; (8)

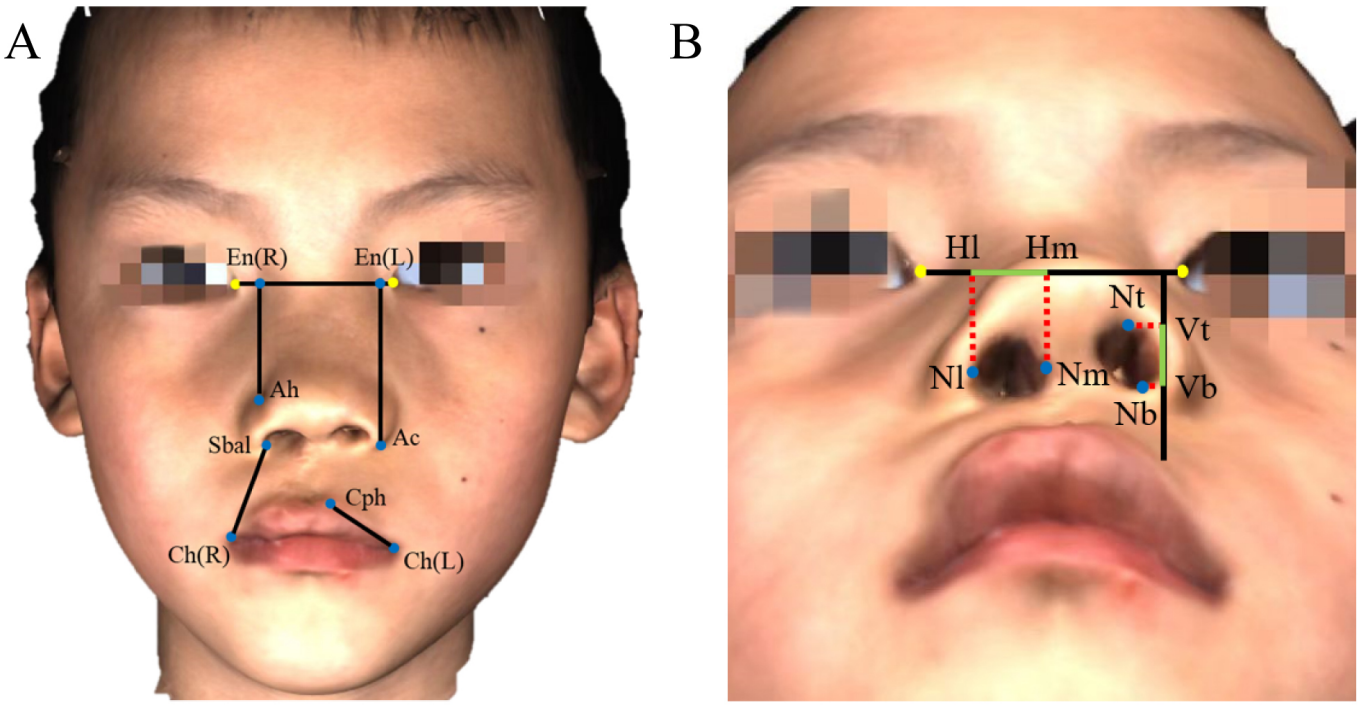

FIGURE 2. Illustration of measurements of nasolabial features of patients with UCCLP. (A) "En(L/R)" are the inner canthus points and "Ah" is the peak point of alae. "Ac" is the outermost point of the nasal alar base and "Sbal" is the innermost point of the nasal alar base. "Cph" is the point of lip peak, and "Ch(L/R)" are the corners of the mouth. (B) "Nl/Nm" are the outmost/innermost points of the nostril and "Nt/Nb" are the top/bottom points of the nostril. "Hl" and "HM" are projections of "Nl" and "Nm" in the horizontal direction, representing the width of the nostril. "Vt" and "Vb" are the projections of "Nt" and "Nb" in the vertical direction, representing the height of the nostril.

Nt/Nb, the top/bottom point of the nostril; (9) Hl-Hm, the width of the nostril, the projection of the line Nl-Nm in the horizontal direction; and (10) Vt-Vb, the height of the nostril, the projection of the line Nt-Nb in the vertical direction.

Each index was measured three times, and the average of the measurements was used for analysis.

We used SPSS statistical software (v25.0, IBM, Armonk, NY, USA) to analyze the data. First, the Shapiro-Wilk (S-W) test was performed to confirm whether the data meet normal distribution and homogeneity of variance conditions. For the analysis between the cleft and normal side, the paired sample *t*-test was used. If the data did not follow normal distribution, the Wilcoxon rank sum test was used. For the analysis between the PNAM and non-PNAM groups, the independent sample *t*-test was used. If the data did not follow normal distribution, the Mann-Whitney U test was used.

A consistency test was performed to evaluate the replicability and reliability of the measurements. 10 patients were randomly selected and measurements repeated three times after a two-week interval. The intragroup correlation coefficient (ICC) was used to assess the consistency of the measurements.

3. Results

A total of 32 patients with UCCLP were included in the study. Of these, 27 patients had clear and complete models of the dental arch, and 30 patients had complete 3D facial photos. Therefore, 27 and 30 patients were enrolled in the analysis of dental arch morphology and nasolabial features, respectively. 13 patients were in the PNAM group (7 were under 7 years and 6 were older than 7 years), and 14 patients in the non-PNAM group (7 were under 7 years and 7 were older than 7 years) for the analysis of dental arch morphology. 18 patients were included in the PNAM group (11 were under 7 years and 7 were older than 7 years), and 12 patients were included in the non-PANM group (7 were under 7 years and 5 were older than 7 years) for the analysis of nasolabial features (Table 1).

The ICC values ranged between 0.999 and 1, and the *p*-value was higher than 0.05.

Regarding the differences of dental arch width between the unaffected and cleft side, the findings suggest that the length of Ce-D on the unaffected side was significantly higher than that of Ce'-D' on the cleft side, except for the non-PNAM group over 7 years old category (Tables 2 and 3).

In the category under 7 years old, although the canine-to-midline transverse width on the cleft side (Ce'-D') was smaller than that on the unaffected side (Ce-D) in both the PNAM and non-PNAM groups, PNAM resulted in a larger difference between the cleft side and the non-cleft side, as shown in the significant difference between Ce'-D' and Ce-D measurements of the PNAM group (15.37 ± 1.71 *vs.* 10.67 ± 2.42) and the non-PNAM group (14.13 ± 0.86 *vs.* 11.42 ± 1.76) (Table 2). Furthermore, in the non-PNAM group over 7 years old, no significant difference was found in canine-to-midline transverse width between the cleft and unaffected sides ($p = 0.343$) (Table 3).

TABLE 1. Baseline characteristics of the UCCLP children included in this study.

Characteristics	Gender		Side of the cleft		Patient's age	
	Male	Female	Left	Right	<7	≥7
The analysis of dental arch morphology						
PNAM (n = 13)	7	6	11	2	7	6
non-PNAM (n = 14)	11	3	11	3	7	7
The analysis of nasolabial features						
PNAM (n = 18)	9	9	14	4	11	7
non-PNAM (n = 12)	9	3	9	3	7	5

PNAM: Presurgical nasoalveolar molding.

TABLE 2. Analysis of dental arch symmetry between cleft and unaffected side under 7 years old.

Measurement	PNAM			non-PNAM		
	Unaffected (mm)	Cleft (mm)	*p*	Unaffected (mm)	Cleft (mm)	*p*
Ce-D or Ce'-D'	15.37 ± 1.71	10.67 ± 2.42	0.009**	14.13 ± 0.86	11.43 ± 1.76	0.009**
P1-E or P1'-E'	17.56 ± 2.63	14.26 ± 3.39	0.124	16.13 ± 1.44	15.33 ± 1.85	0.350
P2-F or P2'-F'	20.35 ± 3.13	18.34 ± 3.88	0.402	19.23 ± 1.08	19.42 ± 1.85	0.790

***: $p < 0.01$. PNAM: Presurgical nasoalveolar molding.*

TABLE 3. Analysis of dental arch symmetry between cleft and unaffected side over 7 years old.

Measurement	PNAM			non-PNAM		
	Unaffected (mm)	Cleft (mm)	*p*	Unaffected (mm)	Cleft (mm)	*p*
Ce-D or Ce'-D'	14.90 ± 2.33	11.66 ± 1.64	0.028*	15.43 ± 2.22	14.52 ± 1.82	0.343
P1-E or P1'-E'	17.56 (med.)	15.66 (med.)	0.343	17.12 ± 2.83	17.43 ± 2.08	0.499
P2-F or P2'-F'	21.61 ± 2.81	20.20 ± 3.48	0.338	19.99 ± 4.32	21.04 ± 2.02	0.557

**: $p < 0.05$; med.: Median; PNAM: Presurgical nasoalveolar molding.*

No statistically significant difference was observed between P1-E and P1'-E' (the width from the midline to the permanent first premolars/first deciduous molars), or between P2-F and P2'-F' (the width from the midline to the permanent second premolars/second deciduous molars) for both the PNAM and non-PNAM groups (Tables 2 and 3).

Moreover, the findings suggest there was no significant difference across all ages (Tables 4 and 5) with reference to the dental arch width between the PNAM and non-PNAM group.

In UCCLP patients under the age of seven, there was no statistically significant difference in the ratio of the height of the nasal alae on the cleft side (HCNA) compared to the healthy side (HHNA); regardless of whether they received PNAM treatment or not. However, as patients got older (≥7 years old), the ratio of HCNA/HHNA in the non-PNAM group was found to be smaller than that in the PNAM group (Table 6).

The results of the symmetric analysis of the nasal base indicated that there was no significant difference in the ratio of the height of the nasal base on the cleft side (HCNB) to that on the healthy side (HHNB), for patients under or over 7 years old (Table 6).

The nasal-labial symmetry was subsequently assessed and

TABLE 4. Analysis of dental arch width between PNAM and non-PNAM groups under 7 years old.

Measurement	PNAM	non-PNAM	*p*
Ce-D (mm)	15.37 ± 1.71	14.13 ± 0.86	0.492
Ce'-D' (mm)	10.67 ± 2.42	11.43 ± 1.76	0.073
P1-E (mm)	17.56 ± 2.63	16.13 ± 1.44	0.246
P1'-E' (mm)	14.26 ± 3.39	15.33 ± 1.85	0.196
P2-F (mm)	20.35 ± 3.13	19.23 ± 1.08	0.321
P2'-F' (mm)	18.34 ± 3.88	19.42 ± 1.85	0.640

PNAM: Presurgical nasoalveolar molding.

the findings suggest that the distance between the nasal alae and the angulus oris (D-NA-AO) on the cleft side was significantly lower than that on the healthy side in both the PNAM and non-PNAM groups, respectively (p = 0.007 and 0.019, reps.). However, in the category of patients over 7 years old, there was no statistically significant difference of D-NA-AO between the cleft and unaffected sides, in either the PNAM or non-PNAM group (Tables 7 and 8). The analysis of the D-NA-

TABLE 5. Analysis of dental arch width between PNAM and non-PNAM groups over 7 years old.

Measurement	PNAM	non-PNAM	*p*
Ce-D (mm)	14.90 ± 2.33	15.43 ± 2.22	0.112
Ce'-D' (mm)	11.66 ± 1.64	14.52 ± 1.82	0.620
P1-E (mm)	17.56 (med.)	17.12 ± 2.83	0.231
P1'-E' (mm)	15.66 (med.)	17.43 ± 2.08	0.474
P2-F (mm)	21.61 ± 2.81	19.99 ± 4.32	0.398
P2'-F' (mm)	20.20 ± 3.48	21.04 ± 2.02	0.526

med.: Median; PNAM: Presurgical nasoalveolar molding.

AO shows that there is no statistical difference between the PNAM and non-PNAM groups, at all ages (Tables 9 and 10). Particularly, in patients under 7 years old under PNAM treatment, the length of the lip on the cleft side was similar to that on the non-cleft side ($p = 0.381$), while in the non-PNAM group, the length of the lip on the cleft side was significantly shorter than that on the unaffected side ($p = 0.036$). This difference decreased as the age of patients increased (Tables 7 and 8). In the group comparison, the results show that patients over 7 years old in the PNAM group had a significantly shorter lip length compared to the non-PNAM group ($p = 0.014$ and 0.033) (Table 10).

The morphology of nostrils was assessed using 3D facial photographs obtained from a nasal base view. In the age group of under 7 years old, no significant difference was found in the nostril height and the nostril width, between the cleft and non-cleft sides, regardless of whether the UCCLP patients received PNMA treatment or not. However, in patients under PNMA treatment of over 7 years old, a shorter and wider shape of the nostril on the cleft side was observed, compared to the unaffected side (Tables 7 and 8). For the group comparison, no significant difference was observed between the PNAM and non-PNAM groups at all ages (Tables 9 and 10).

4. Discussion

The effectiveness of PNAM treatment for CLP patients has been the subject of debate despite being regularly used in clinics for many years [14]. To investigate this issue, digital techniques were employed to evaluate the dental arch form and nasolabial morphological characteristics of UCCLP patients who received PNAM treatment or not.

After the birth of infants with CLP, a palate guard is applied within four weeks to guide the shape of the separated alveolar bone segments and reduce the gap between them [15]. PNAM treatment can significantly render surgery less difficult, but the development of the dental arch can be negatively impacted [16]. Some researchers have suggested that the effects of PNAM on dental arch were temporary [17]. However, the findings in this paper indicated that PNAM treatment has a lasting negative impact on dental arch form, both in the short and long term. In patients under the age of 7, it was observed that although the canine-to-midline transverse width on the cleft side was smaller than that on the non-cleft side in both the PNAM and non-PNAM groups, the ratio of cleft side to non-cleft side was greater in the non-PNAM group compared to the PNAM group (80.87% *vs.* 69.44%). The disparity between the non-PNAM and PNAM groups remained even when patients age surpassed 7 years old, with a ratio of cleft side to non-cleft side of 94.09% against 78.3%, respectively.

The findings suggest that PNAM treatment has more impact on the anterior dental arch than the posterior dental arch. Regardless of whether the patients were under or over the age of 7 and received the PNAM treatment, no significant difference was observed in the width from the midline to the permanent first premolars (or first deciduous molars) and the width from the midline to the permanent second premolars (or second deciduous molars), between the cleft side and the unaffected side. These findings are consistent with previous research, indicating that PNAM treatment had adverse effects on the width of the anterior dental arch, but not the posterior dental arch [18].

While the shape of the dental arch is important for dentists, parents and patients are more concerned with the appearance of the children, particularly with regards to nasal and labial symmetry [19]. This study found that PNAM treatment resulted in short-term improvements in lip symmetry and long-term improvements in the symmetry of the height of the nasal alae. Al-Rudainy *et al*. [20] have also reported that UCCLP patients who did not receive PNAM intervention may experience severe nasal and labial asymmetry during maxillofacial growth and development. Nayak *et al*. [21] performed a study on the long-term outcome of PNAM in patients with unilateral CLP and reported that the PNAM group displayed significant improvements in nasal and lip anatomy. These results reported in these studies are consistent with the findings in this paper.

Although the PNAM treatment can improve the appearance of CLP patients in some respects, the results are not always favorable. Although all patients in the PNAM group in this study received nasal braces to reshape the nasal cartilage, their nostril shape appeared worse than that of the non-PNAM group, with a shorter and wider shape. The cause of this outcome is currently unknown, and requires further investigation in future studies.

The current study has limitations that should be addressed in future research. The sample size is limited and should be increased to ensure the generalizability of the findings. Moreover, some factors including the socioeconomic status of the families, parental education level, and parental compliance may influence the outcome of the study, and thus, a prospective study should be considered to investigate the effects of these potential factors.

5. Conclusions

In this study, three main findings were reported. PNAM has a negative impact on dental arch form, specifically limiting the transverse width of the maxillary canine-to-midline. PNAM can improve short-term and long-term indices of nasal and labial symmetry. PNAM results in a shorter and wider nostril morphology on the cleft side. In clinical practice, the treatment of infants with cleft lip and palate, it is critical for multidisciplinary clinicians to thoroughly evaluate the advantages and disadvantages of PNAM treatment outcomes.

TABLE 6. Symmetry analysis of nasal alae and nasal base between PNAM and non-PNAM groups.

Measurement	Age <7			Age ≥7		
	PNAM	non-PNAM	*p*	PNAM	non-PNAM	*p*
HCNA/HHNA	0.95 ± 0.16	1.00 ± 0.11	0.452	0.95 ± 0.08	0.84 ± 0.09	0.038*
HCNB/HHNB	0.96 ± 0.06	1.02 ± 0.23	0.860	0.97 ± 0.07	0.98 ± 0.10	0.922

**: $p < 0.05$; PNAM: Presurgical nasoalveolar molding; HCNA: The height of the nasal alae on the cleft side; HHNA: The height of the nasal alae on the healthy side.*

TABLE 7. Symmetry analysis of nasal and labial between cleft and unaffected side under 7 years old.

Measurement	PNAM			non-PNAM		
	Unaffected (mm)	Cleft (mm)	*p*	Unaffected (mm)	Cleft (mm)	*p*
D-NA-AO	26.28 ± 1.85	24.99 ± 2.46	0.007**	25.64 ± 2.38	24.47 ± 2.04	0.019*
Length of the Lip	17.93 ± 2.28	17.15 ± 2.59	0.381	19.45 ± 2.95	17.05 ± 2.11	0.036*
Nostril Height	9.13 ± 1.04	8.41 ± 1.00	0.117	9.44 ± 1.36	8.38 ± 0.90	0.065
Nostril Width	7.86 ± 1.36	8.95 ± 1.05	0.064	8.38 ± 1.30	9.55 ± 0.84	0.176

**: $p < 0.05$; **: $p < 0.01$; PNAM: Presurgical nasoalveolar molding. D-NA-AO: The distance between the nasal alae and the angulus oris.*

TABLE 8. Symmetry analysis of nasal and labial between cleft and unaffected side over 7 years old.

Measurement	PNAM			non-PNAM		
	Unaffected (mm)	Cleft (mm)	*p*	Unaffected (mm)	Cleft (mm)	*p*
D-NA-AO	26.21 ± 1.90	25.14 ± 1.64	0.083	27.46 ± 1.61	26.41 ± 0.67	0.297
Length of the Lip	18.77 ± 1.90	17.18 ± 2.81	0.169	22.54 ± 2.16	20.11 ± 0.50	0.095
Nostril Height	8.94 ± 0.87	7.81 ± 1.68	0.027*	9.56 ± 1.03	8.04 ± 1.56	0.107
Nostril Width	7.69 ± 0.89	9.29 ± 1.70	0.029*	9.13 ± 2.41	9.15 ± 1.83	0.974

**: $p < 0.05$; PNAM: Presurgical nasoalveolar molding. D-NA-AO: The distance between the nasal alae and the angulus oris.*

TABLE 9. Symmetry analysis of nasal and labial between PNAM and non-PNAM groups under 7 years old.

Measurement	PNAM	non-PNAM	*p*
D-NA-AO (unaffected side)	26.28 ± 1.85	25.64 ± 2.38	0.559
D-NA-AO (cleft side)	24.99 ± 2.46	24.47 ± 2.04	0.740
Length of the Lip (unaffected side)	17.93 ± 2.28	19.45 ± 2.95	0.211
Length of the Lip (cleft side)	17.15 ± 2.59	17.05 ± 2.11	0.781
Nostril height (unaffected side)	9.13 ± 1.04	9.44 ± 1.36	0.313
Nostril height (cleft side)	8.41 ± 1.00	8.38 ± 0.90	0.301
Nostril width (unaffected side)	7.86 ± 1.36	8.38 ± 1.30	0.411
Nostril width (cleft side)	8.95 ± 1.05	9.55 ± 0.84	0.317

PNAM: Presurgical nasoalveolar molding. D-NA-AO: The distance between the nasal alae and the angulus oris.

TABLE 10. Symmetry analysis of nasal and labial between PNAM and non-PNAM groups over 7 years old.

Measurement	PNAM	non-PNAM	*p*
D-NA-AO (unaffected side)	26.21 ± 1.90	27.46 ± 1.61	0.258
D-NA-AO (cleft side)	25.14 ± 1.64	26.41 ± 0.67	0.137
Length of the Lip (unaffected side)	18.77 ± 1.90	22.54 ± 2.16	0.014*
Length of the Lip (cleft side)	17.18 ± 2.81	20.11 ± 0.50	0.033*
Nostril height (unaffected side)	8.94 ± 0.87	9.56 ± 1.03	0.288
Nostril height (cleft side)	7.81 ± 1.68	8.04 ± 1.56	0.876
Nostril width (unaffected side)	7.69 ± 0.89	9.13 ± 2.41	0.172
Nostril width (cleft side)	9.29 ± 1.70	9.15 ± 1.83	1.000

**: $p < 0.05$; PNAM: Presurgical nasoalveolar molding. D-NA-AO: The distance between the nasal alae and the angulus oris.*

ABBREVIATIONS

NSCL/P, Nonsyndromic cleft lip and/or palate; UCCLP, Unilateral complete cleft lip and palate; PNAM, Presurgical nasoalveolar molding; CLP, Cleft lip and palate; MN, The line t between he proximal and distal midpoint of the tooth; RS, The line between the buccal and lingual points of the tooth; In, The apex of the incisor papilla; Mi, The intersection of the line connecting the palatal raphe and bilateral palatine foveolar; Ce/Ce', The central points of the unaffected/cleft side canines; P1/P1', The central points of the unaffected/cleft side permanent first premolars (or first deciduous molars); P2/P2', The central points of the unaffected/cleft side permanent second premolars (or second deciduous molars); D, E, F/D', E', F', The vertical junctions between Ce, P1, P2/Ce', P1', P2' and the line In-Mi; En(L/R), The inner canthus points; Ah, The peak point of alae; Ac, The outermost point of the nasal alar base; Sbal, The innermost point of the nasal alar base; Cph, The point of lip peak; Ch(L/R), The corner of the mouth; Nl/Nm, The outmost/innermost point of the nostril; Nt/Nb, The top/bottom point of the nostril; Hl-Hm, The width of the nostril, the projection of the line Nl-Nm in the horizontal direction; Vt-Vb, The height of the nostril, the projection of the line Nt-Nb in the horizontal direction; S-W, Shapiro-Wilk; ICC, Intragroup correlation coefficient; HCNA, The height of the nasal alae on the cleft side; HHNA, The height of the nasal alae on the healthy side; HCNB, The height of the nasal base on the cleft side; HHNB, The height of the nasal base on the healthy side; D-NA-AO, The distance between the nasal alae and the angulus oris.

AVAILABILITY OF DATA AND MATERIALS

The data are contained within this article.

AUTHOR CONTRIBUTIONS

ZPR, HXZ and YXH—designed research; YHJ, YWT, LC, QQH and YHW—performed research; HXZ, YXH and ZPR—analyzed the data; LC, QQH and HXZ—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors have read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Ethics Committee in Hospital of Stomatology, Xi'an Jiaotong University (No. xjkqll [2019] NO. 003), and informed consent was obtained from the participants or their guardians.

ACKNOWLEDGMENT

We thank the patients participating in this study.

FUNDING

This work was supported by National Natural Science Foundation of China (No. 82001030 to Huaxiang Zhao).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Le Chang, Qianqian Huang, Zhanping Ren, Yanhao Wang, Yuhua Jiao, Yongwei Tao, *et al*. Influence of presurgical nasoalveolar molding (PNAM) treatment in maxillary dental arch width and nasolabial symmetry in patients with unilateral complete cleft lip and palate. Journal of Clinical Pediatric Dentistry. 2023; 47(6): 155-162. doi: 10.22514/jocpd.2023.090.