3-Dimensional Analysis of Alveolar Molding Effect of Presurgical Nasoalveolar Molding Appliance and Lip Pressure after Cheiloplasty in Complete Unilateral Cleft Lip and Palate Patients

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ABSTRACT

편측성 구순구개열 환자의 술전 비치조 정형장치와 구순 봉합수술의 치조골 정형효과의 3차원 분석

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본 연구의 목적은 편측성 구순구개열 (UCLP) 환자에서 술전 비치조 정형장치 (presurgical nasoalveolar molding appliance, PNAM) 와 구순 봉합수술의 치조골 정형효과를 3차원 (3-D) 분석을 통하여 평가하는 것이다. 연구대상은 16명의 UCLP 환자 (평균 파열부거리: 10.46mm) 이며 PNAM 장치에 의한 치료와 rotation-advancement법에 의한 구순 봉합수술을 받았다. 처음 내원시 (평균연령: 37.0±27.89 일), PNAM 치료를 받고 난 후이며 구순 봉합수술 1달 전 (평균연령: 119.25±40.18 일), 구순 봉합수술 2달 후 (평균연령: 190.81±42.78 일) 에 상악의 인상을 채득하였다. 그 후 laser scanning machine (Orapix, Dimennex, Seoul, Korea) 과 3-D view software (3Dxer, Dimennex) 를 사용하여 3-D 모형을 제작하였다. 선, 각도, 정중선변이, 거리, 면적 항목을 3-D 모형상에서 계측하고, 각 시기별의 차이를 비교하기 위하여 Wilcoxon signed rank test를 사용하여 분석하였다. PNAM치료 동안과 구순 봉합수술 후에도 치조골 후방부는 안정된 구조물이었다. PNAM치료에 의한 파열부 거리의 감소는 대분절 (greater segment) 의 내측 굴곡 (bending) 에 의하여 발생하였다. 대분절 (greater segment) 의 전방 성장은 PNAM치료에 의하여 억제되었으나, 구순 봉합수술 후에 회복되었다. 구순 봉합수술 후에 대분절과 소분절 사이의 전방부 각도의 증가는 구순 반흔 (lip scar) 의 압력에 의한 치조골 정형 효과 때문으로 생각된다. 정중선변이는 PNAM치료에 의하여 개선되었다. PNAM치료 동안과 구순 봉합수술 후에 구개부 (palatal segment) 의 면적은 계속 증가하였다. 치조골 면적과 거리 항목의 증가는 후방부에서 크게 나타났다. 이러한 결과는 PNAM치료에 의한 치조골 정형효과는 주로 전방부에서 발생하며, 치조골의 성장은 구순 봉합수술 후에 후방부에서 주로 발생한다는 것을 의미한다.

Key word: 편측성 구순구개열, 치조골 정형효과, 술전 비치조정형장치, 구순열봉합수술, 3차원 분석.

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Introduction

Although there have been many advances in the field of cleft surgery [1-6], the surgical repair alone cannot solve the multiple problems encountered with the cleft patients. Because of the large amount of the cleft gap, surgeons need to make the wide soft tissue flap from the surface of the maxilla. The surgically repaired lip and palate heal under maximum tension and eventually forms scar tissue.[7] The excessive scar tissue acts as the most powerful and uncontrolled molding force, which may result in the collapse of the alveolar segments.[8]

The concept of modern pre-surgical infant orthopedics (PSIO) began with the work of McNeil.[9] Many variations in the PSIO technique have evolved during the past 40 years.[10-14] PSIO is a part of the interdisciplinary concepts of the treatment in the majority of rehabilitation centers for cleft lip and palate (CLP) patients.[15] The aims of the PSIO are to reduce the width of the cleft in infants with a CLP, to achieve an optimal alignment of the cleft palate segments within the first few months of infancy prior to any surgical intervention, and to allow a surgical cleft closure with minimal tension in addition to mobilization of the surrounding tissue.[16]

The authors used the pre-surgical naso-alveolar molding (PNAM) appliance, which was developed by the Cleft Palate team of the Institute of Reconstructive Plastic Surgery at New York University Medical Center.[17,18] It is a type of passive PSIO and has a positive influence on the outcome of the primary nasal, labial, and alveolar repair.[19,20]

The main obstacles in analyzing the alveolar molding effect of the PSIO are difficulties in taking an impression, following-up the cleft patients and obtaining proper samples.

Two-dimensional (2-D) cast analyses showed a reduction in the width of the cleft, an almost constant posterior width of the alveolar arch, an increase in the length of the alveolar arch, and an adjustment of the midline of the jaw.[19-23] However, 2-D cast analyses appear to be insufficient for observing the 3-dimensional (3-D) morphological changes in the cleft maxilla.[24-28] Obtaining precise 3-D information from the 3-D scanning method using the contact type or destructive type is time consuming and expensive. Therefore, a 3-D analysis based on a non-contact type with a laser or optical scanning method was developed to obtain of the required amount of information.[29,30]

The aim of this study was to evaluate the alveolar molding effect of the PNAM appliance and lip pressure after cheiloplasty in a complete UCLP using 3-D analysis.

Material and methods

The samples consisted of 16 complete unilateral cleft lip and palate (UCLP) infants (10 males and 6 females), who were treated with the PNAM appliance and rotation-advancement cheiloplasty in the Seoul National University Dental Hospital.

The average cleft gap was 10.46 mm and the average duration of the alveolar molding treatment was 13.10 weeks. Impressions for the maxillary casts were taken using a fast-setting alginate (Orthofast, Produits Dentaires Pierre Rolland, Merignac Cedex, France) at the initial visit (T0, mean age: 37.0±27.89 days after birth), after successful alveolar molding (T1, mean age: 119.25±40.18 days after birth), and 2months after cheiloplasty (T2, mean age: 190.81±42.78 days after birth).

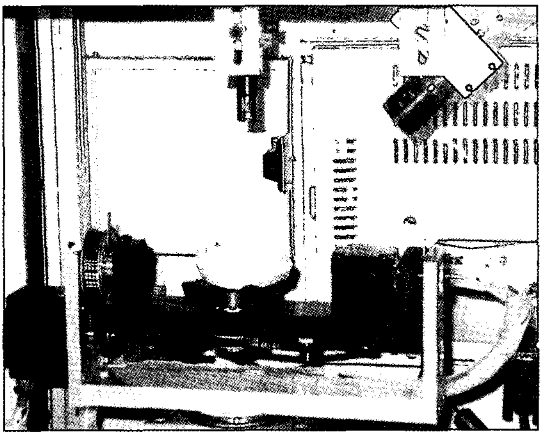

Fig. 1. Construction of the 3-Dimensional model using a laser scanning machine (Orapix, Dimennex, Seoul, Korea).

The casts were registered three-dimensionally using a laser scanning machine (Orapix, Dimennex, Seoul, Korea, Fig. 1). The registration accuracy of the individual coordinates from the measured points was 20um per 100mm according to the manufacturer. The surface was reconstructed three-dimensionally using 3-D view software (3Dxer, Dimennex, Fig. 2). Predetermined reference points, which were based on the anatomical structures, and lines were identified and marked on the 3-D model (Table 1 and Fig. 3). The linear, angular, midline deviation, distance and area variables were measured (Table 2 and Fig. 4-8).

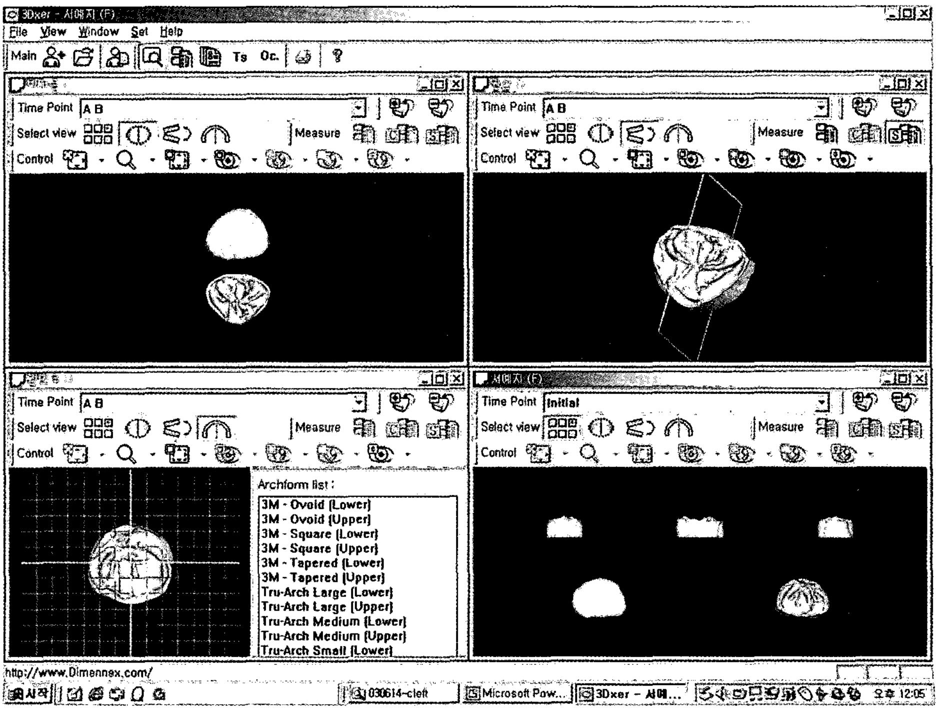

Fig. 2. 3-Dimensional view program (3Dxer, Dimennex, Seoul, Korea).

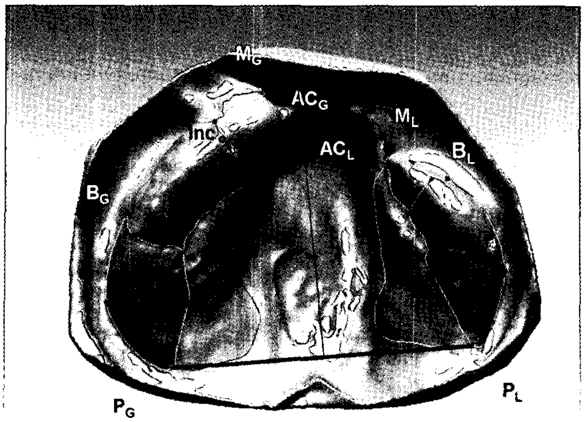

Fig. 3. Reference points and lines.

Table 1. Reference points and lines.

Reference points and lines	Definition
1. P_G	Postgingivale in the greater segment. It is the posterior end point of alveolar crest in the greater segment
2. P_L	Postgingivale in the lesser segment. It is the posterior end point of alveolar crest in the lesser segment
3. AC_G	Anterior end point of the alveolar crest in the greater segment.
4. AC_L	Anterior end point of the alveolar crest in the lesser segment.
5. B_G	Buccal frenum point of the alveolar crest in the greater segment
6. B_L	Buccal frenum point of the alveolar crest in the lesser segment
7. M_G	The most anterior point of the greater segment
8. M_L	The most anterior point of the lesser segment
9. Mid	The midpoint of the P_G-P_L line
10. Inc	Incisive point which is located in the alveolar crest of the premaxilla in the greater segment
11. P_G-P_L line	Horizontal reference line
12. Sagittal line	The perpendicular line to the P_G-P_L line. It crossed the midpoint between P_G in the greater segment and P_L in the lesser segment
13. B_G'	The cross point between the buccal sulcus and gingival sulcus in the greater segment
14. B_L'	The cross point between the buccal sulcus and gingival sulcus in the lesser segment

Table 2. Variables used in this study.

Linear variables	
1. P_G-P_L	Distance between postgingivales of the alveolar crest in the greater segment and in the lesser segment
2. B_G-B_L	Distance between buccal frenum points of the alveolar crest in the greater segment and in the lesser segment
3. trans. AC_G-AC_L	Transverse distance between anterior end points of the alveolar crest in the greater segment and in the lesser segment
4. A-P. AC_G-AC_L	Anteroposterior distance between anterior end points of the alveolar crest in the greater segment and in the lesser segment
5. dis. AC_G-AC_L	The shortest distance between anterior end points of the alveolar crest in the greater segment and in the lesser segment
6. M_G-(P_G-P_L)	Distance between the most anterior point and P_G-P_L in the greater segment
7. M_L-(P_G-P_L)	Distance between the most anterior point and P_G-P_L in the lesser segment
Angular variables	
8. (AC_G-P_G)-(P_G-P_L)	Angle between AC_G-P_G and P_G-P_L in the greater segment
9. (AC_L-P_L)-(P_G-P_L)	Angle between AC_L-P_L and P_G-P_L in the lesser segment
10. AC_G-B_G-P_G	Angle between AC_G, B_G, and P_G in the greater segment
11. AC_L-B_L-P_L	Angle between AC_L, B_L, and P_L in the lesser segment
12. (B_G-AC_G)-(B_L-AC_L)	Angle between B_G-AC_G in the greater segment and B_L-AC_L in the lesser segment
Midline deviation variables	
13. Inc-Sagittal	Perpendicular distance from incisive point to sagittal line
14. (Mid-Inc)-Sagittal	Angle between midpoint in P_G-P_L -incisive point and sagittal line
Distance variables	
15. P_G-B_G	Distance from postgingivale and buccal frenum point of the alveolar crest in the greater segment
16. P_L-B_L	Distance from postgingivale and buccal frenum point of the alveolar crest in the lesser segment
17. B_G-Inc	Distance from buccal frenum point and incisive point of the alveolar crest in the greater segment
18. B_L-AC_L	Distance from buccal frenum point and anterior end point of the alveolar crest in the lesser segment
19. Inc-AC_G	Distance from incisive point and anterior end point of the alveolar crest in the greater segment
Area variables	
20. Palatal-$_G$	Area between cleft edge and gingival groove in the greater segment
21. Palatal-$_L$	Area between cleft edge and gingival groove in the lesser segment
22. Inc	Area between labial frenum-incisive papilla line and gingival groove in the greater segment
23. Ant-$_G$	Area among labial frenum-incisive papilla line, anterior to buccal sulcus, and gingival groove in the greater segment
24. Ant-$_L$	Area between gingival groove and anterior to buccal sulcus in the lesser segment
25. Post-$_G$	Area between gingival groove and posterior to buccal sulcus in the greater segment
26. Post-$_L$	Area between gingival groove and posterior to buccal sulcus in the lesser segment

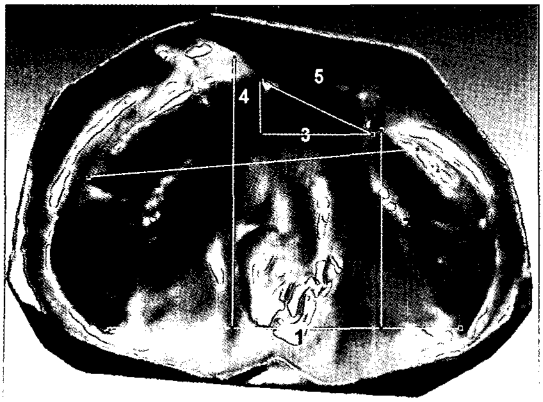

Fig. 4. Linear variables. 1.P_G-P_L; 2.B_G-B_L; 3.trans. AC_G-AC_L; 4.A-P. AC_G-AC_L; 5.dis. AC_G-AC_L; 6.M_G-(P_G-P_L); 7.M_L-(P_G-P_L)

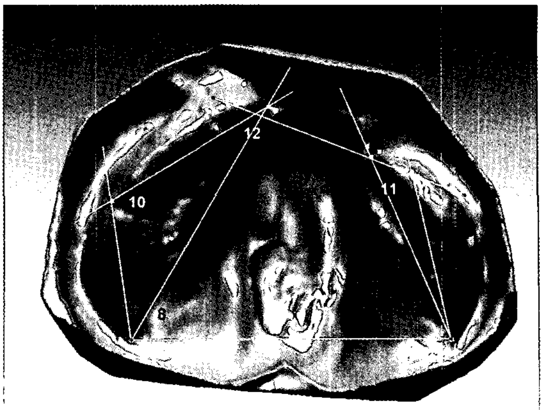

Fig. 5. Angular variables. 8.(AC_G-P_G)-(P_G-P_L); 9.(AC_L-P_L)-(P_G-P_L); 10.AC_G-B_G-P_G; 11.AC_L-B_L-P_L; 12.(B_G-AC_G)-(B_L-AC_L).

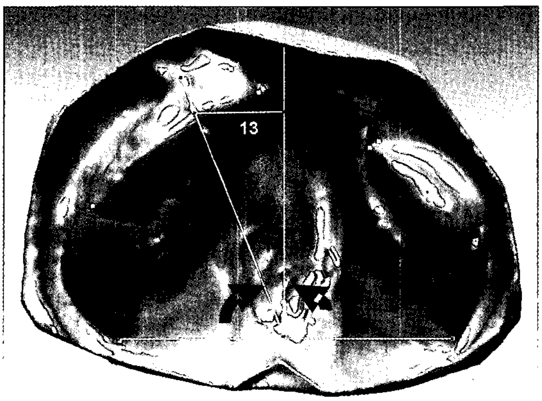

Fig. 6. Midline deviation variables. 13.Inc-Sagittal; 14.(Mid-Inc)-Sagittal.

Wilcoxon singed rank test was performed to investigate the statistical significance at the $p<0.05$ level. In order to visually assess the morphological changes in the maxilla and to confirm the statistically analyzed results, 3-D models of three consecutive casts of the perspective patient were oriented in a coordinate system using the Y-axis (P_G-P_L) and X-axis (sagittal line) and were superimposed with each other using the midpoint in P_G-P_L, B_G', and B_L' (Fig. 9). B_G' and B_L' play a role as reference points in the z-plane.

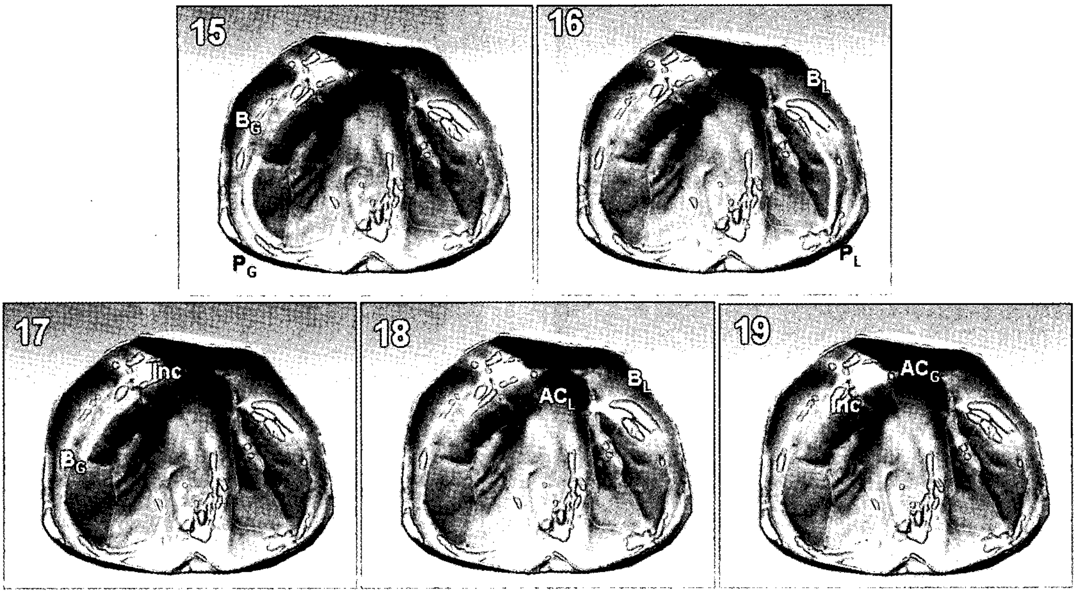

Fig. 7. Distance variables. 15.P_G-B_G; 16.P_L-B_L; 17.B_G-I; 18.B_L-AC_L; 19.I-AC_G.

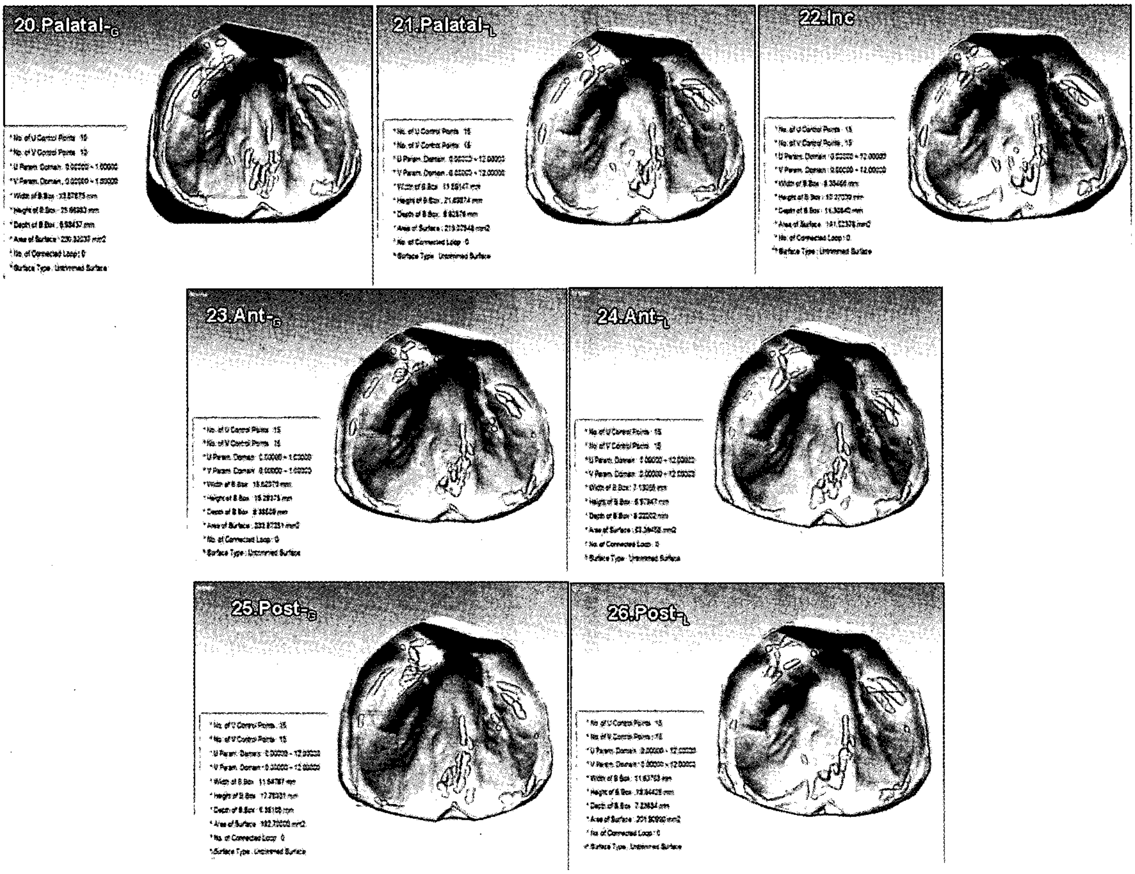

Fig. 8. Area variables. 20.Palatal-$_G$; 21.Palatal-$_L$; 22.Inc; 23.Ant-$_G$; 24.Ant-$_L$; 25.Post-$_G$; 26.Post-$_L$.

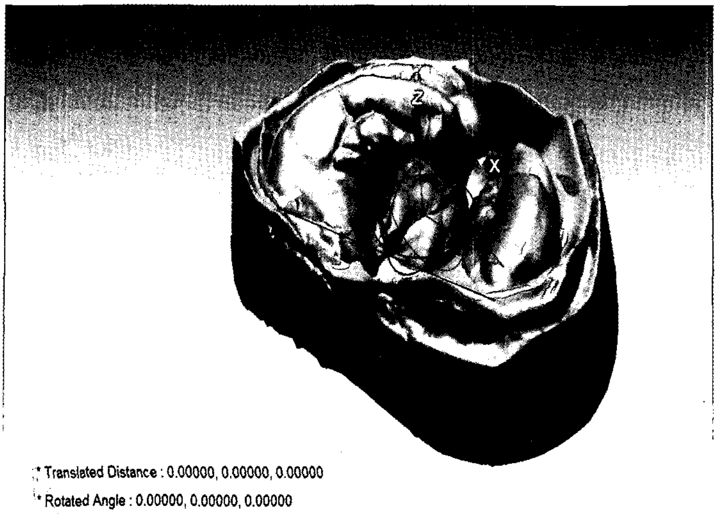

Fig. 9. Superimposition using the midpoint at P_G-P_L line, B_G' and B_L' points.

Results

(1) Linear and angular variables (Table 3 and Fig. 4 and 5)

There were no statistically significant changes in the P_G-P_L during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2). Although B_G-B_L was significantly decreased during the PNAM treatment (T0-T1, $p<0.05$), it was maintained after cheiloplasty (T1-T2). The amounts of the cleft gap were significantly reduced during the PNAM treatment (T0-T1, $p<0.001$) and after cheiloplasty (T1-T2, $p<0.01$) in the shortest distance (dis. AC_G-AC_L) and transverse distance (trans. AC_G-AC_L). After the anteroposterior distance in the cleft gap (A-P. AC_G-AC_L) was significantly decreased only during the PNAM treatment (T0-T1, $p<0.01$), which was maintained after cheiloplasty (T1-T2). The M_G-P_G was decreased during the PNAM treatment (T0-T1, $p<0.01$). After cheiloplasty, there were significant increases in the M_G-P_G (T1-T2, $p<0.001$) and in M_L-P_L (T1-T2, $p<0.01$).

There were no statistically significant changes in (AC_L-P_L)-(P_G-P_L) during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2). Although (AC_G-P_G)-(P_G-P_L) was significantly decreased during the PNAM treatment (T0-T1, $p<0.001$), it was maintained after cheiloplasty (T1-T2). There were no statistically significant changes in the AC_G-B_G-P_G and AC_L-B_L-P_L during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2) respectively. The value of (B_G-AC_G)-(B_L-AC_L) was significantly higher after cheiloplasty (T1-T2, $p<0.05$; T0-T2, $p<0.01$) due to the increase in the T2 stage.

(2) Midline deviation variables (Table 3 and Fig. 6)

Table 3. Comparison of variables at T0, T1, and T2 stages

	Variables	T0	T1	T2	Significance
Linear variables	P_G-P_L	28.97±2.85	29.29±2.84	30.07±2.73	
	B_G-B_L	26.16±2.71	24.58±3.40	24.68±2.99	(T0,T1)*, (T0,T2)*
	trans. AC_G-AC_L	6.67±3.44	3.68±2.32	2.00±1.17	(T0,T1)***, (T1,T2) **, (T0,T2)***
	A-P AC_G-AC_L	4.99±2.01	2.96±2.04	2.56±2.66	(T0,T1)**, (T0,T2)**
	dis. AC_G-AC_L	8.65±3.18	5.04±2.34	3.51±2.57	(T0,T1)***, (T1,T2) **, (T0,T2)***
	M_G-(P_G-P_L)	22.90±2.60	20.74±2.44	23.39±2.49	(T0,T1) ** ,(T1,T2) ***
	M_L-(P_G-P_L)	15.01±2.33	15.37±2.54	18.64±1.98	(T1,T2)**, (T0,T2) ***
Angular variables	(AC_G-P_G)-(P_G-P_L)	52.79±7.09	45.74±5.00	46.73±4.75	(T0,T1) ***, (T0,T2)*
	(AC_L-P_L)-(P_G-P_L)	61.81±5.37	61.74±6.36	61.54±4.30	
	AC_G-B_G-P_G	116.24±6.01	117.85±9.45	112.48±8.03	
	AC_L-B_L-P_L	132.41±12.17	134.30±11.04	127.41±24.76	
	(B_G-AC_G)-(B_L-AC_L)	124.76±11.69	132.04±12.10	134.69±10.31	(T1,T2) *, (T0,T2) **
Midline deviation variables	Inc-Sagittal	4.66±2.39	2.85±1.26	2.39±1.70	(T0,T1)**, (T0,T2)**
	(Mid-Inc)-Sagittal	14.45±7.56	9.29±4.14	7.08±4.93	(T0,T1)**, (T0,T2)**
Distance variables	P_G-B_G	16.76±2.80	17.3±92.88	18.0±02.92	(T1,T2) *, (T0,T2) *
	P_L-B_L	17.41±3.17	17.8±61.95	20.5±92.28	(T1,T2) **, (T0,T2) **
	B_G-Inc	15.21±1.47	15.3±32.08	16.2±41.71	
	B_L-AC_L	12.29±1.65	11.8±73.46	12.3±22.79	
	Inc-AC_G	13.74±2.47	13.0±13.83	14.8±52.45	
Area variables	Palatal-$_G$	197.19±40.74	227.2±138.79	255.31±49.22	(T0,T1) **, (T1,T2) **, (T0,T2) ***
	Palatal-$_L$	156.45±41.89	183.47±30.05	209.89±39.30	(T0,T1)*, (T1,T2) **, (T0,T2)**
	Post-$_G$	154.16±37.38	166.36±32.99	193.58±35.77	(T1,T2) *, (T0,T2)**
	Post-$_L$	147.71±40.12	137.53±45.58	190.59±34.70	(T1,T2) ***, (T0,T2) **
	Ant-$_G$	171.17±33.77	156.09±36.09	155.67±47.19	
	Ant-$_L$ + Inc	190.72±46.96	183.61±73.30	166.22±49.64	(T0,T2) *

Wilcoxon signed rank test, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The degree of midline deviation was significantly lower during the PNAM treatment (T0-T1, $p<0.01$) and it was maintained after cheiloplasty (T1-T2).

(3) Distance variables (Table 3 and Fig. 7)

After cheiloplasty, there were significant increases in the P_G-B_G (T1-T2, $p<0.05$) and in P_L-B_L (T1-T2, $p<0.01$). However, there were no significant changes in the B_G-Inc, B_L-AC_L, Inc-AC_G during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2) respectively.

(4) Area variables (Table 3 and Fig. 8)

During the PNAM treatment and after cheiloplasty, increase of the palatal segment areas in the Palatal-$_G$ (T0-T1, $p<0.01$; T1-T2, $p<0.01$) and in the Palatal-$_L$ (T0-T1, $p<0.05$; T1-T2, $p<0.01$) were significantly higher. However, the pattern of increase the posterior segment area was different. Only after cheiloplasty, increase of were the posterior segment areas in Post-$_G$ (T1-T2, $p<0.05$) and in Post-$_L$ (T1-T2, $p<0.001$) were significantly higher. There were no significant differences between the Ant-$_G$ and Ant-$_L$ + Inc during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2).

Discussion

(1) Leaner and angular variables (Table 3 and Fig. 4 and 5)

The distance between the most posterior parts of the alveolar segments (P_G-P_L) was correlated with the distance between the pterygoid processes[27,31] and are considered to be stable structures during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2). The distance between the middle parts of the alveolar segments (B_G-B_L) was reduced by the PNAM treatment (T0-T1, $p<0.05$) and was maintained after cheiloplasty (T1-T2). This might be because the force was balanced among the lip, tongue, buccinator muscle after cheiloplasty (T1-T2).

The cleft gap at T0 was exaggerated due to a contraction of the orbicularis oris muscle and a lateral displacement of the segments coupled with the pushing forces of the tongue fitting into the cleft area. The cleft gap (dis. AC_G-AC_L and trans. AC_G-AC_L) might be significantly reduced as a result of the PNAM treatment (T0-T1, $p<0.001$) and cheiloplasty (T1-T2, $p<0.01$). Since the anteroposterior distance in the cleft gap (A-P. AC_G-AC_L) was already decreased by the PNAM treatment (T0-T1, $p<0.01$), cheiloplasty could not effectively reduce the A-P. AC_G-AC_L.

Although forward growth of the greater segment (M_G-P_G) was hindered by the PNAM treatment (T0-T1, $p<0.01$), it resumed after cheiloplasty (T1-T2, $p<0.001$). The fact that forward growth of the lesser segment (M_L-P_L) was prominent after cheiloplasty (T1-T2, $p<0.01$) suggests that cheiloplasty did not prevent the forward growth of the lesser segment.

The closure of the cleft gap during PNAM treatment was mainly due to the inward bending of the whole part of the greater segment ((AC_G-P_G)-(P_G-P_L), T0-T1, $p<0.05$). However, the morphology of the whole part of the lesser segment ((AC_L-P_L)-(P_G-P_L)) was not changed during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2). The anterior parts of the greater segment (AC_G-B_G-P_G) and of the lesser segment (AC_L-B_L-P_L) were slightly bent inward after cheiloplasty (T1-T2), even though they did not show statistically significance. An increase in the angle between the anterior alveolar segments ((B_G-AC_G)-(B_L-AC_L)) was due to the inward bending of the anterior parts of the greater (AC_G-B_G-P_G) and lesser (AC_L-B_L-P_L) segments as a result of the molding effect of the lip scar pressure after cheiloplasty (T1-T2, $p<0.05$).

(2) Midline deviation (Table 3 and Fig. 6)

The laterally displaced incisive point (Inc-Sagittal and (Mid-Inc)-Sagittal) was corrected mesially during the PNAM treatment (T0-T1, $p<0.01$) as a result of inward bending of the greater segment, which was maintained after cheiloplasty (T1-T2).

(3) Distance variables (Table 3 and Fig. 7)

Significant increases in P_G-B_G (T1-T2, $p<0.05$) and in P_L-B_L (T1-T2, $p<0.01$) on the 3-D surface suggest that the posterior alveolar crest grew more than the anterior part after cheiloplasty (T1-T2).

(4) Area variables (Table 3 and Fig. 8)

Since the growth of the cleft palate segments was not expected to be uniform, the reconstructed surfaces were segmented according to the anatomical structure for the analysis. This study selected not volume variables to evaluate the segment growth but area variables. The reasons are summarized as follows:

1. Simple linear segmentation cannot guarantee that a real volume of the anatomical structure can be obtained. Because of software limitations, the segments could only be divided in a straight line.

2. Segmentation using area can divide the palatal segment and alveolar segment.

Subsequently, the areas induced by the segment surfaces were calculated and compared with each other.

During the PNAM treatment and after cheiloplasty, the palatal segment areas continued to grow significantly in the Palatal-$_G$ (T0-T1, $p<0.01$; T1-T2, $p<0.01$) and in the Palatal-$_L$ (T0-T1, $p<0.05$; T1-T2, $p<0.01$). It helps if the cleft gap in the palate is narrowed by palatal growth.

The anterior and posterior segments contain the deciduous and permanent tooth germs. The enamel formation of the deciduous incisors is completed within two month after birth.[32] During the PNAM treatment and before cheiloplasty, the anterior segment area remains almost stable. However, enamel formation of the deciduous canine and molars continue from 6 to 11 months after birth.[32] After cheiloplasty, the posterior segment area continues to increase in the Post-$_G$ (T1-T2, $p<0.05$) and in Post-$_L$ (T1-T2, $p<0.001$) (Table 3). This means that different stages of dental development may influence the increase in area.

The amounts of increase in the area and distance of the posterior segment are more influenced by the crown formation than those of the anterior segment during the PNAM treatment (T0-T1) and after cheiloplasty (T1-T2).

This suggests that alveolar molding effects took place mainly in the anterior alveolar segments, and the growth of the cleft maxilla occurred mainly in the posterior alveolar segments.

Misinterpretations of the 3D results were caused by the choice of the incorrect reference system and by an inaccurate determination of the landmarks.[16] The reproducibility of the landmark positioning is subject to considerable variation, which depends to a considerable extent on the investigator's experience as well as the quality of the casts.[33] Braumann et al.[16] used the middle parts of the alveolar segments, which cross from the anterolateral sulcus to the lateral sulcus on the crest of the ridge as reference points for the superimposition. Superimposition in these middle parts of the alveolar segments could not be selected because B_G-B_L was reduced as a result of the PNAM treatment (T0-T1, $p<0.05$).

In this study, the superimposition of consecutive models of each patient was done using the midpoint in P_G-P_L, B_G', and B_L' (Table 1 and Fig. 9). Serial superimposition using these points gave the appearance of a retrusion of the premaxilla during the PNAM treatment and the ventral development of the maxilla after cheiloplasty (Fig. 10).

Conclusion

The alveolar molding effect of the PNAM appliance and lip pressure after a cheiloplasty in the UCLP was assessed three-dimensionally and analyzed quantitatively using consecutive maxillary casts. The results from this study suggest that alveolar molding effects take place mainly in the anterior alveolar segments and growth occurs mainly in the posterior alveolar segments. This study should serve as the starting point for a longitudinal study on the efficacy of PSIO and cheiloplasty procedures.

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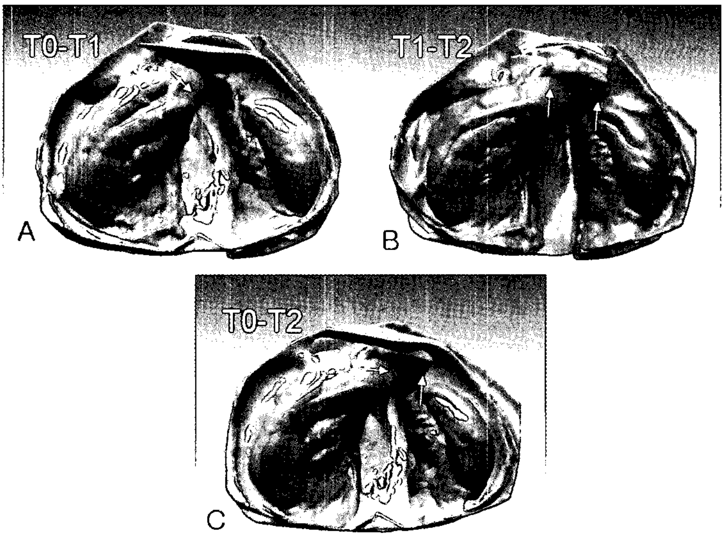

Fig. 10. Superimposition.
A. The arrow indicates a retrusion of the premaxilla during the PNAM treatment. B. The arrows indicate the ventral development of the maxilla after cheiloplasty. C. The arrows indicate the direction of the cleft gap closure from T0 to T2. T0 means an initial vist; T1, after the successful alveolar molding and 1 month before cheiloplasty; T2, 2 months after cheiloplasty.

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