APPLICATION OF 3D SCAN TECHNIQUES AND MEASURE SOFTWARE IN EVALUATION THE MAXILLARY ALVEOLAR MOLDING WITH NASO – ALVEOLAR –MOLDING APPLIANCE (N.A.M APPLIANCE) IN UNILATERAL CLEFT LIP AND PALATE PATIENTS

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ABSTRACT

Background: *Dental casts are an important tool for measuring jaw and teeth indicators. However, the direct measurement on the dental cast has many disadvantages, especially in cleft patients. In recent years, three-dimensional (3D) scanning technology has been very concerned, giving accurate and objective results.* ***Objectives:*** *This study applied 3D scanning technology to compare before and after treatment with Naso – Alveolar – Molding appliance in unilateral cleft lip and palate (UCLP) patients.* ***Materials and methods:*** *Compare the maxillary alveolar morphology before and after treatment with Naso – Alveolar – Molding appliance in 15 unilateral cleft lip and palate (UCLP) patients. A retrospective longitudinal study, collect the intraoral casts before and after treatment with N.A.M appliance, scan 3D, measure and compare the differences of the cleft gap, arch length, the rotation of the cleft and noncleft segment, labial frenum deviation.* ***Results:*** *After NAM treatment, the cleft gap was reduced from 13.68 ± 2.59 mm to 7.25 ± 3.91 mm, the posterior maxillary arch was maintained, the growth of cleft and non-cleft segment toward the midline, the maxilla midline was corrected.* ***Conclusions:*** *After treatment with N.A.M appliance in UCLP, the morphology of maxillary alveolar is improved. In the study, the application of modern 3D scanning techniques to clearly analyze the impact on alveolar bone and the growth direction with Naso – Alveolar – Molding appliance in unilateral cleft lip and palate (UCLP) patients.*

Keywords: *3D scanning; Cleft gap; Midline deviation; Naso–alveolar–molding appliance; The rotation of the cleft segment.*

I. INTRODUCTION

Cleft lip and palate (CLP) have been one of the most common congenital deformities that required adequate and prospective planning with the participation of an interdisciplinary team. Pre-surgical orthopedic treatment, especially nasoalveolar molding (N.A.M) appliance, was necessary to be used before lip surgery to achieve maximum esthetic and functional results with minimal scar tissue [1]. N.A.M appliance has been used to reduce the size of the cleft or palate deformity of the lip, gum and nose before surgical repair [3]. The N.A.M appliance was first described by Grayson and many researches show that the N.A.M produces positive clinical effects such as helping with breastfeeding [9], guiding the growth and development of the palatal region, normalize the position of the tongue, giving good results in later pronunciation [7], reducing the difficulty of palate surgery [6], improve the shape of the nose [3], creating positive psychology for the child's parent [9].

To evaluate the treatment protocol, dental casts are a vital tool for documenting the original maxilla-tooth status. Landmarks of maxillary plaster models were used as a useful method for analysis of the development and growth in patients with cleft lip and palate (CLP patients). The outcome of patients undergoing different treatment protocols was also accessed by using this tool. However, landmarks on the dental casts of patients with cleft lip and palate were more complicated to identified in compared to those on the casts of non-cleft patients.

In recent years, the three-dimensional (3D) scanner was presented in literature as a potential technology for accurate analysis of arch dimensions and landmarks on maxillary casts. In this study, this method was applied to digitalize dental cast and 3D image measuring software was used to evaluate the effectiveness of using N.A.M appliance in UCLP patients. The objective of this study was to compare the change of morphological measurements of anterior and posterior alveolar bone before and after utilizing N.A.M appliance with the assistance of 3D images.

II. MATERIALS AND METHODS

2.1. Study population and setting

Dental casts of non-syndromic complete UCLP were collected and analyzed before and after using N.A.M appliance. Inclusion criteria were dental cast of non-syndromic complete UCLP, regular attendance of the patients for all treatment visits with good-quality records.

2.2. Study design: A retrospective longitudinal study.

2.3. Study contents

Step 1: Dental casts were scanned by 3Shape TRIOS color pod (3Shape company, Denmark). Then, the scanned images were imported into 3D 3Shape Viewer software program (3Shape company, Denmark) for analysis and measurement.

Step 2: A total 10 points were identified and marked on the digital dental cast (Figure 1A, 1B). **Table 1** and **Table 2** showed the name of landmarks and their definitions.

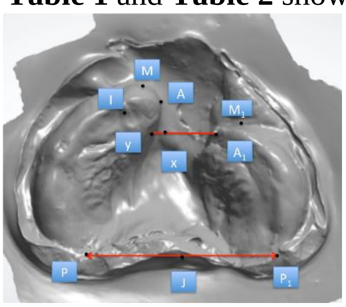

Figure 1A. Identified landmarks on the digital dental cast

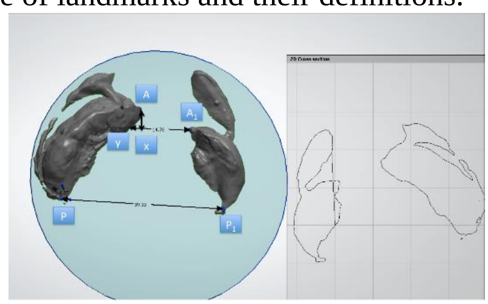

Figure 1B. Identified landmark X on the digital dental cast

Step 3: Measurement of landmarks on the digital dental cast.

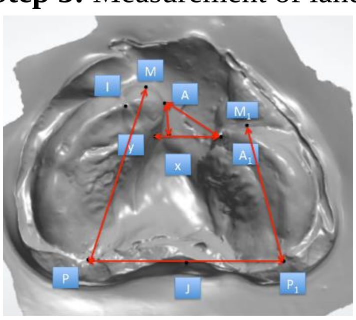

Figure 2A. Measurement of landmarks on the digital dental cast

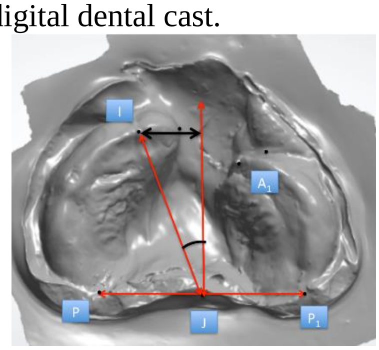

Figure 2B. Measurement angle of landmarks on the digital dental cast

Table 1. The name of landmarks and their definitions

Landmark	Definition
P	The most posterior of the alveolar crest of the greater segment (GS)
P_1	The most posterior of the alveolar crest of the lesser segment (LS)
A	The most anterior of the alveolar crest of the greater segment (GS)
A_1	The most anterior of the alveolar crest of the lesser segment (LS)
I	Incisal point: intersection of the crest of the alveolar ridge and the line drawn from the labial frenulum to the incisive papilla
M	The most anterior of the alveolar crest of the greater segment (GS) compare to $P\text{-}P_1$
M_1	The most anterior of the alveolar crest of the lesser segment (LS) compare to $P\text{-}P_1$
Y	From A_1 draw a line parallel to $P\text{-}P_1$ that cuts the proximal edge of the alveolar crest of the greater segment
X	From A draw perpendicular $A_1\text{-}X$, meet $A_1\text{-}X$ at Y
J	Midpoint of $P\text{-}P_1$
Line referance	**Definition**
$P\text{-}P_1$	Horizontal reference plane
Sagital line	The line is perpendicular to $P\text{-}P_1$ and passes through point J

Table 2. The definition and quantitative of measurements

Measurement	Quantitative	Definition
$A_1\text{-}X$	mm	Horizontal correlation of the lesser side versus the greater side
$A\text{-}A_1$	mm	Cleft width
$P\text{-}P_1$	mm	Posterior width
I – Sagital line	mm	Midline deviation
$M\text{-}PP_1$	mm	Width of alveolar crest of the greater segment (GS)
$M_1\text{-}PP_1$	mm	Width of alveolar crest of the lesser segment (LS)
A-X	mm	The anterior – posterior relationship between the GS and LS
Angle APP_1	Degree	Rotation degree of alveolar crest of the greater segment (GS)
Angle A_1P_1P	Degree	Rotation degree of alveolar crest of the lesser segment (LS)
Angle (IJ – Sagital line)	Degree	Midline deviation of upper

Step 4: Comparison of the measurement before and after using N.A.M. appliance

2.4. Statistical Analysis

All statistical analyses were performed using SPSS 16.0. Descriptive statistics (mean, standard deviation) were performed. Measurements of pre-and post-treatment data were analyzed using paired *t*-tests. A *p*-value of 5% was considered statistically significant.

2.5. Ethics Approval

The research is conducted with the consent of the parents of the child, the personal information is kept confidential and only for the research.

And the research has been approved by the hospital's scientific committee.

III. RESULTS

The treatment group included 15 patients with UCLP (5 girls and 10 boys) who underwent NAM. The mean ages before and after applying NAM were 53.27 ± 23.15 days, respectively. Average treatment time was 86 ± 12.38 days.

3.1. Evaluation of alveolar cleft

Table 3. Evaluation of alveolar cleft.

	Before treatment		**After treatment**		**Difference**		**Paired t – test**	**p***
	X	SD	X	SD	X	SD		
A1-X	12.32	3.04	6.13	4.00	6.18	3.25	7.36	<0.001
A-A1	13.68	2.59	7.25	3.91	6.42	3.05	8.14	<0.001
A-X	5.6	1.29	3.44	1.61	2.16	2.47	3.38	0.004

Table 3 showed that the cleft width (A-A1) was significantly reduced after treatment (p <0.001). Average A-A1 width before treatment was 13.68 ± 2.59mm. After treatment, average A-A1 width was reduced to 7.25 ± 3.91mm. The horizontal correlation of the lesser side versus the greater side (A1-X) was significantly reduced after treatment (p <0.001). The anterior-posterior relationship between the greater segment and lesser segment (A-X) also decreased after treatment (p <0.001).

The reduction of cleft gap from 13.68 ± 2.59 mm to 7.25 ± 3.91 mm, which indicated an apparent effect of the N.A.M. appliance in narrowing the alveolar cleft. After treatment, there was a significant change in horizontal and anterior-posterior relationship between the greater segment and lesser segment.

3.2. Evaluation of palatal area

Table 4. Evaluation of palatal cleft.

	Before treatment		**After treatment**		**Difference**		**Paired t – test**	**p***
	X	SD	X	SD	X	SD		
P-P1	36.22	3.11	37.37	3.63	-1.15	2.15	-2.08	0.056
M->PP1	26.14	2.37	27.07	1.49	-0.93	2.05	-1.76	0.1
M1->PP1	17.94	1.96	20.02	1.95	-2.08	2.26	-3.57	0.003

According to **Table 4**, the average posterior width (P-P1) before and after treatment was 36.22 ± 3.11 mm and 37.37 ± 3.63 mm, respectively. The difference of the P-P1 length on average was 1.15 ± 2.15 mm. The lesser alveolar bone length increased significantly after treatment (p<0.001). The average length of the greater alveolar bone (M-PP1) before treatment was 26.14 ± 2.37 mm, and the mean length after treatment was 27.07 ± 1.49 mm. There was no significant change of M-PP1 between pre- and post-treatment (p> 0.05). Nevertheless, the average length of the lesser alveolar bone (M1-PP1) before treatment (17.94 ± 1.96 mm) was statistically smaller than that after treatment (20.02 ± 1.95 mm) (p <0.05).

The rotation of the alveolar bone was expressed through the change of angle APP1, A1P1. The greater segment lateral alveolar bone rotation (angle APP1) before treatment had a mean value of 62.92 ± 5.08 degrees. After treatment, the greater segment alveolar bone was rotated toward the midline direction with the angle APP1 with new value of 49.34 ± 6.550. The change in angle APP1 showed statistically significant (p<0.001).

The result showed that the lesser segment alveolar bone rotation (angle A1P1P) before treatment had the mean value of 66.18 ± 7.32 degrees. After treatment, the angle of A1P1P decreased significantly (59.45 ± 5,91 degrees) (p<0.01).

3.3. Evaluation of midline area

Table 5. Evaluation of midline area

	Before treatment		**After treatment**		**Difference**		**Paired t-test**	**p***
	X	SD	X	SD	X	SD		
I-> Sagittal line	7.94	1.65	5.27	2.42	2.66	2.44	4.22	<0.001
Angle (IJ – Sagital line)	19.93	4.62	13.35	5.89	6.58	5.16	4.93	<0.001

Figure 3. Case N.T.T.H before and after using N.A.M appliance

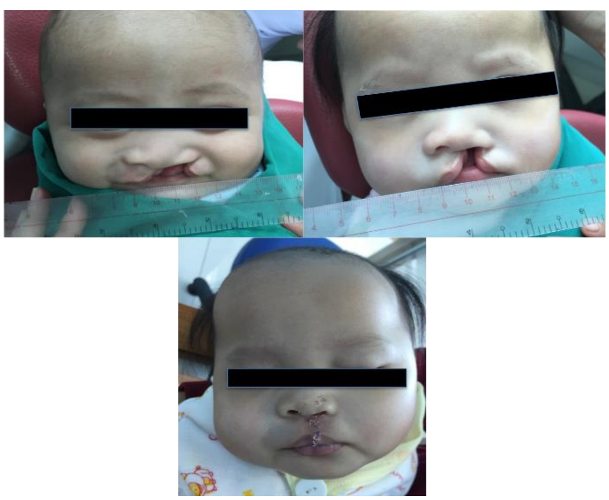

Figure 4. Case T.B.Y before, after N.A.M appliance and after lip surgery

The midline deviation was shown at the distance from I to sagittal line and the angle IJ and the sagittal line.

The distance from the point I to the vertical line was 7.94 ± 1.65 mm before treatment and 5.27 ± 2.42 mm after the treatment, respectively. This difference (2.66 ± 2.44 mm) was statistically significant (p<0.001). The angle between IJ and the sagittal line showed a statistically significant change pre- and post-treatment (p<0.001). The average values were recorded in **Table 5**. The distance from the point I to the sagittal line between the palate and the angle IJ line and the sagittal line decreased significantly after treatment with N.A.M. (p<0.001) (**Figure 3** and **Figure 4**).

IV. DISCUSSION

The change of cleft width was similar to the results obtained in the following studies [1,2, 8, 10]. One of the main goals of N.A.M. appliance was to straighten the alveolar ridge and narrow the alveolar cleft [1,8,10]. Correlation of the two points of the most anterior of the alveolar crest of both sides come together both horizontally and anterior – posterior relationship.

Narrowing the cleft gap obviously decreased lip tension, which facilitated the lip surgery phase because excessive muscle contraction was avoided. According to Rau et al. [8], long-term follow-up results of N.A.M. appliance showed that early treatment leads to the recovery of a beautiful lip shape. Additionally, muscle contraction around cleft lip position was also shown to affect the maxillary growth. Overstretched lips would inhibit the forward direction of maxillary growth. Therefore, narrowing the cleft gap helps to limit the narrowing of the upper jaw later. Many studies had shown that the reduction of alveolar cleft lessen the need for secondary alveolar bone grafting [8]. Sixty percent of patients did not need a secondary alveolar bone graft in the mixed dentition with the help of presurgical orthopedics and gingivoperiosteoplasty [10].

Narrowing the cleft gap after treatment with N.A.M. appliance can be explained by the guidance of the inner plate of the appliance, which enhances proper alveolar formation. The appliance was adjusted to fit the maxillary arch shape by adding and removing soft plastic lining after each visit.

There was no significant change of P-P1 between pre- and post-treatment with a N.A.M (p> 0.05). According to Beak et al., [1] the posterior arch size was stable after treatment with N.A.M.

The distance from the point I to the vertical line; the angle between IJ and the sagittal line before and after treatment was statistically significant (p<0.001). Overall, the midline deviation in upper jaw (I -> sagittal line, the angle IJ-sagittal line) was improved after the treatment. Therefore, midline deviation could be avoided with the appropriate eruption of the future incisors.[1]

Application of 3D scanning techniques

Kriens and colleagues used 3-D data to measure the morphological gap. The results showed highly accurate measurement in 3-D evaluation results with not only detailed descriptions but also explainable information of morphological deformations.[4] This study concluded that three-dimensional analysis increased understanding of the diagnosis of CLP patient in specific developmental stages.

Application of 3D scanning techniques showed several superior characteristics compared to conventional direct measurement on the dental cast. Direct measurement took more time, and each measurement must mark a landmark, easily deform dental cast and increase error when measuring with a conventional ruler. Additionally, direct measurement did not mark a point in space such as a projection of a landmark, draw a line parallel to the plane, or cut into a two-dimensional shape. Those disadvantages were solved by using three-dimensional measurement. In our research, using three-dimensional scanners to scan dental cast, this might be the first step towards the digitalization of treatment phases such as: digital impression, designing by software and printing by a printer [10].

Moreover, the 3Shape Viewer measurement software used in the study had an accurate electronic ruler, integrated drawing tools for convenient and quick measurement.

V. CONCLUSIONS

In the study, using modern 3D scanning technique to clearly analyze the impact on alveolar bone and growth direction after treatment with N.A.M. appliance in patients with unilateral CLP. The study results showed that after the treatment, the alveolar bone morphology was improved, which help to narrow cleft gap while stabilizing the posterior arch length. The direction of growth is in the direction of regeneration of the maxilla as usual, the main change is the middle rotation of the greater segment and the anterior growth on the lesser segment. The effects of the N.A.M appliance might be further studied with the start of our study. This device will be widely and soon applied to children with disabilities with cleft lip and palate.

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