Morphological alveolar changes with pre-surgical orthopedic treatment of the unilateral cleft lip and palate

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We report the morphological alveolar changes in 10 patients with unilateral cleft lip and palate after pre-surgical orthopedic treatment. Plaster casts of the maxilla made at the initial examination and just before cheiloplasty were measured and analyzed using a VIVID-910 three-dimensional laser scanner (Minolta Co., Tokyo, Japan). The pre-surgical orthopedic treatment was based on the method of Hirakawa et al. whereby a palatal plate is used prior to cheiloplasty. The palatal plates were placed for an average of 99 days.

Use of the palatal plate reduced the alveolar cleft in all 10 cases. The major segment and minor segment cleft side stumps were moved toward the alveolar cleft, reducing the distance between the stumps (B-B’) significantly. In addition, because the distance between the medial surfaces of both segments (C-C’) was significantly reduced, it appeared that bone apposition was occurring toward the cleft palate site in the anterior region of the alveolar arch. The fact that the distance between the bilateral maxillary tuberosities (T-T’) and the distance between the regions corresponding to the deciduous molar eruption (D-D’) increased significantly suggests that the palatal plate did not inhibit growth in the maxillary alveolus.

The above suggests that pre-surgical orthopedic treatment using a palatal plate does not inhibit lateral growth in either segment. It also suggests that narrowing of the alveolar cleft width occurs by medially induced growth and that narrowing of the cleft alveolar site and cleft palate site are caused by medial bone apposition in the alveolar site. (J Osaka Dent Univ 2012; 46: 201–206)

Key words: Pre-surgical orthopedic treatment; Palatal plate; Unilateral cleft lip and palate; Maxillary alveolar arch form; Three-dimensional analysis

INTRODUCTION

Having a malformed maxilla at birth is the cardinal symptom of patients with cleft lip and palate. Because this malformation impairs function, it is essential to improve function while at the same time restoring morphology. Generally, cheiloplasty is performed 3 to 6 months after birth and palatoplasty is performed at around 1 year and 6 months. Although plastic surgery has made great advances in the area of cleft surgery, surgery repair alone cannot solve the multiple problems encountered with the deformities that result from clefts of the lip and palate. It is well known that early surgical intervention influences the maxillofacial growth and occlusion of child patients.¹ A basic treatment objective for patients with cleft lip, alveolus and palate is to restore normal anatomy. Pre-surgical infant orthopedics has been employed since the 1950 s as an adjunctive neonatal therapy for the correction of
the cleft lip and palate. Pre-surgical orthopedic treatment for infants began with McNeil\(^2\) in 1956. Since the 1970’s, Hotz plates\(^3\) have been used at many medical institutions.

Intraoral installation of a Hotz plate or a palatal plate immediately after birth can improve the sucking disorder, prevent indentation by the tongue of the cleft alveolar and cleft palate sites, and improve maxillary alveolus morphology in the infant with cleft lip and palate. Until now, studies that analyzed the effect of the Hotz plate on maxillary alveolus morphology employed two-dimensional measurements.\(^4,5\) The development of three-dimensional measuring systems have recently led to publication of studies on three-dimensional measurement of morphological changes over time.\(^6,7\) Hirakawa \textit{et al.}\(^8\) reported that the morphology of the maxillary alveolus could be restored and favorable jaw growth could be induced by covering the cleft site with a palatal plate during the early stages in patients with cleft lip and palate. It has been reported previously that pre-surgical orthopedic treatment using Hotz plates or other palatal plates results in narrowing of the alveolar cleft in these patients. However, few reports have included three-dimensional analysis of maxillary alveolar morphological changes resulting from the reduced alveolar cleft width.\(^9\) We used the three-dimensional laser scanner to analyze the maxillary plaster casts of patients with unilateral cleft lip and palate fitted with palatal plates based on the method of Hirakawa \textit{et al.}, and compiled this report.

**MATERIALS AND METHODS**

**Materials**

The subjects for this study were 10 infants with unilateral cleft lip and palate who had requested a consultation at the Department of Oral and Maxillofacial Surgery, Osaka City General Hospital, from October 2005 to March 2007. All 10 subjects undertook pre-surgical orthopedic treatment using a palatal plate prior to cheiloplasty, and none had complications such as heart malformation. Plaster casts of the maxilla obtained at the initial consultation (10 to 38 days after birth, average 17 days, hereafter referred to as the initial consultation), that were used to fabricate the palatal plates were also used for measurements (Fig. 1). Maxillary plaster casts made prior to cheiloplasty were also used for measurements. The appliances were placed between 98 and 136 days after birth (average 99 days).

**Fabrication of the palatal plate devices**

The palatal plate devices used in pre-surgical orthopedic treatment were fabricated based on the method of Hirakawa \textit{et al.} In brief, they were made of hard orthodontic resin on the plaster casts with the alveolar cleft and palate region blocked out (Fig. 2). In order to allow natural growth of the alveolar arch, the resin on the inner surface was reduced on average once every two weeks. Cheek straps were used to maintain stability when fitting the palatal plate devices (Fig. 3).
Fig. 2 A palatal plate device that was fabricated with hard orthodontic resin on plaster casts with the alveolar cleft and palate region blocked out.

Fig. 3 Cheek straps were used to maintain stability when fitting the palatal plate devices.

Specified points of measurements, coordinate axes and coordinate planes
Twelve reference points were used as points of measurement on the three-dimensional model of the alveolar region in addition to coordinate axes and planes. Each point of measurement was projected onto a base plane composed of the bilateral maxillary tuberosities and the alveolar crest of the sulcus terminalis at the equivalent point of the maxillary deciduous canines on the side of the major segment.

Measurement points (Fig. 4)
B, B': Points facing the alveolar cleft at the tip of the alveolar crest of the lateral segment where B is the major segment and B' is the minor segment.
C, C': Points at the alveolar crest of the distal sulcus terminalis which are equivalent to the maxillary deciduous canine where C is the major segment and C' is the minor segment.
D, D': Widest point on the alveolar crest where D is the major segment and D' is the minor segment.

Analysis of alveolar morphology
The maxillary plaster casts made at the initial consultation and prior to cheiloplasty were laser scanned with the VIVID-910 three-dimensional laser scanner (Minolta Co., Tokyo, Japan), creating 3D images. These images were uploaded to a 3D-Rugle (Medic Engineering Co., Kyoto, Japan) and the distances between the reference points were configured.20 21
Fig. 4 Measurement points.

Fig. 5 Origin points, coordinate axes and coordinate planes.

T, T': Maxillary tuberosity points where T is the major segment and T' is the minor segment.
C, C': Points at margin of cleft palate on a plane parallel with the X-Z plane that passes through the points C and C'.
D, D': Points at margin of cleft palate on a plane parallel with the X-Z plane that passes through points D and D'.

Origin point, coordinate axes, coordinate planes (Fig. 5)
Origin point: Midpoint of line segment TT'.

Fig. 6 A 3D-Rugle image of the initial plaster cast.

X axis: Straight line passing through points T, T'.
X-Y plane: Plane determined by X-axis and point C.
Y-axis: Straight line on the X-Y plane that passes through the origin point and is perpendicular to the X-axis.
Z-axis: Straight line that passes through the origin point and is perpendicular to the X-Y plane.

Items of analysis
Distances between B-B', C-C', D-D' and T-T'
Distances between C1-C1 and D1-D1
B-XY, B'-XY: Lengths of perpendicular lines from points B and B' to the X-Y plane.
B- TT': Length of perpendicular line from point B to the straight line TT'.
B' - TT': Length of the perpendicular line from point B' to the straight line TT'.
Distances were measured on the maxillary plas-
ter casts made at the initial consultation (Fig. 6) and prior to cheiloplasty (Fig. 7). Measurement values represent a mean value of measurements taken 5 times by one person.

RESULTS

Figure 8 shows that the width of the alveolar cleft B- B' was significantly reduced from a mean value of 10.5 mm at the initial consultation to 8.6 mm prior to cheiloplasty. The measurement value of C 1- C'1 decreased significantly from 12.7 mm to 9.9 mm. B' -XY also exhibited a significant reduction from a mean value of 4.75 mm to 4.25 mm. A significant increase was observed in T- T' from a mean value at the initial consultation of 32.4 mm to 34.6 mm prior to cheiloplasty. D-D' increased significantly from 34.9 mm to 36.8 mm. No significant changes were observed in other measurement items.

DISCUSSION

Measurement points
C, T, T': These points were selected because they are least influenced by the presence of the alveolar cleft or orthopaedic treatment and are reproducible as anatomical points. Point C is on the alveolar crest of the lateral sulcus. In addition, it is an anatomical point where the depression situated directly above the buccal frenum could be observed until the eruption of the deciduous teeth. Therefore, we assumed that the influence of the alveolar cleft would be relatively small when observed from the non-alveolar cleft side. Points T and T' are the posterior ends of the palato-alveolar groove and are known to correspond with the opening into the oral cavity of the greater palatine foramen. Kozelij also used the same points of measurement for morphological evaluation of pre-surgical orthopedic treatment.

Morphological changes
The palatal plates used in this study can eliminate factors that inhibit growth, such as nipples and the fingers or tongue of the child, that can be pushed into the alveolar cleft or cleft palate area. In addition, the palatal plates are passive devices that prepare a space for growth and do not have the capacity to actively narrow the distance between the
deciduous canine teeth. It was found that using this palatal plate to eliminate these factors up until 3 to 4 months after birth narrowed the distance between level stumps at the cleft side in both segments. In addition, the cleft stumps descended perpendicularly. Furthermore, in the anterior region of the alveolus, apposition occurred toward the medial side of the segment, suggesting that it was approaching the ideal three dimensional alveolar morphology (Fig. 9).

CONCLUSIONS

The results of this study are similar to those of previous studies. However, although pre-surgical orthopedic treatment had a significant impact on some children, it led to hardly any change in others. In the future, in addition to alveolar morphological changes, the relationship between other factors and alveolar morphological changes needs to be investigated.

A part of this study was presented at the 66th annual meeting of the Japanese Orthodontic Society, September 20, 2007, Osaka, Japan.

REFERENCES