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Research Article

What are Aberrations in Dentoalveolar Structure in the Vicinity of the Clefts?

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Abstract

Purpose: Of the 12 children (mean aged 6.5) with unilateral cleft lip and palate, we examined morphological features of alveolar process, aiming to determine the patterns and magnitudes of the aberrations in dentoalveolar structure in the vicinity of the clefts prior to surgical therapy for maxillary and alveolar clefts, by retrospectively comparing the differences in the morphology of the maxillary alveolar process between the cleft and non-cleft sides.

Patients and methods: Twelve Japanese children (7 girls and 5 boys) with unilateral cleft lip and palate at start of orthodontic treatment mean aged 6.5 years were examined. They were surgically treated by the Millard technique at the ages of 6 months and the push-back procedure at the ages of 18 months. None of them had received surgical therapy for maxillary and alveolar clefts. The whole surfaces of the maxillary dental casts of all cases were measured using the system for the shape measurement of dental cast which we had developed. Paired t-tests were used to compare the differences in morphology of alveolar process between the cleft and non-cleft sides using paired measurements from only those maxillary dental casts.

Results: On the cleft side, the alveolar process length and the alveolar process height diameter were significantly less in the deciduous maxillary central incisors and deciduous maxillary canines regions, respectively; while in the deciduous molar regions, no significant differences in morphology of alveolar process were observed between the cleft and non-cleft sides.

Conclusions: We confirmed that the presence of maxillary and alveolar cleft itself substantially restricts the vertical size of the alveolar process in the vicinity of clefts in unilateral cleft lip and palate child.

Keywords: Unilateral cleft lip and palate; Alveolar process; Alveolar cleft; Dental casts; Shape measurement.

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Introduction

For lack of structural continuity on the maxillary dentoalveolar process and the palate region, dentoalveolar aberrations of the maxillary arch with different severities on the cleft and non-cleft sides are a well-recognized feature characterizing repaired complete unilateral clefts of the lip and palate (UCLP) patients. Especially, in the vicinity of the alveolar clefts, it is pointed out that teeth malposition such as rotation or displacement is characteristically manifested [1-18]. It is said that several explanations have been given as to the dentition dimensional aberration causes, including surgical interference or the primary tissue deficiency in the congenital clefts [10].

With regard to the teeth malposition in the vicinity of the alveolar clefts, it is reported that the cleft side permanent maxillary central incisor, which was the terminal tooth in the greater hemimaxilloalvolar segment, was distally inclined toward the cleft with high frequency [19,20], and that there was a great chance of palatal inclination or displacement of the cleft side permanent maxillary canine along with supporting alveolar process [10]. In these published literatures, it is interesting to note that there seem the different teeth malposition patterns in the vicinity of the alveolar clefts, based on whether the tooth is in the greater hemimaxilloalvolar segment or the lessor hemimaxilloalveolar segment.

To solve those teeth malposition problems caused by cleft alveolar, comprehensive orthodontic treatment following surgical therapy for maxillary and alveolar cleft, including the secondary alveolar bone graft surgery [21,22], has been performed. Hence, in order to enhance the clinical judgment and improve treatment outcomes for the alveolar cleft, it would be desirable if we could collect, recognize, and better understand valid information of the intrinsic features of the alveolar process in the vicinity of the alveolar clefts.

For the morphological analysis of the dentoalveolar region in clefts the lip and palate patients, it is said that the dental cast has significant advantage of an entity possible to carefully observe and evaluate in terms of study materials [8]. Furthermore, valid information could be provided objectively and quantitatively, from processing that can be carried out on the digital data obtained from the whole surfaces of the dental cast only, that is, a single information source [23].

The aim of the current study was to determine the patterns and magnitudes of the aberrations in dentoalveolar structure in the vicinity of the clefts prior to surgical therapy for maxillary and alveolar clefts, by retrospectively comparing the differences in the morphology of the maxillary alveolar process between the cleft and non-cleft sides in the 12 children with unilateral cleft lip and palate in the deciduous dentition to examine morphological features of alveolar process.

Patients and methods

Following Research Ethics Board approval, 7 Japanese girls and 5 Japanese boys with right unilateral cleft lip and palate were examined. They were surgically treated by the Millard technique at the ages of 6 months at Hokkaido University Hospital Plastic Surgery Department, Japan, by any of the department's five staff surgeons, and the push-back procedure which accompanied posterior shifting of palatal flap at the ages of 18 months by one surgeon (Motonori Kudo) at Oral Surgery Department of the same hospital. None of them had undergone surgical therapy for maxillary and alveolar clefts, and any orthodontic treatment.

Maxillary dental casts were used for exploration their morphological features of alveolar process in the vicinity of the cleft. The mean age of the children in the current study at which the casts had been taken was 6.5 years (range: 6.0-6.9 years) in the deciduous dentition stage (Hellman's dental age IIC), and the cleft side deciduous lateral incisors of all of them were absent, that is, the cleft side deciduous maxillary central incisors were the terminal teeth in the greater hemimaxilloalvolar segment and the cleft side deciduous maxillary canines were the terminal teeth in the lessor hemimaxilloalvolar segment.

The whole surface of the maxillary dental cast was measured by the optical measurement apparatus which we had developed [24-26]. This apparatus employs a 0.6 mW He-Ne laser and a 2048-element CCD line image sensor optical system. An X-Y table and reflection mirrors were used for scanning. The depth of measurement points on the cast surface was determined by the triangular method, with an accuracy of 0.02 mm. Scanning pitch was adjusted to the minimum level of the apparatus, which was 0.24 mm in the current study.

The maxillary dental casts were mounted on the X-Y table, which was referred to as the horizontal reference plane for the maxillary alveolar structures analysis, with their occlusal planes parallel to the table. The occlusal plane was constructed by three points on the teeth, the mesioincisal edges of the cleft side deciduous maxillary central incisor and the mesiolingual cusp tips of the right and left second deciduous maxillary molars.

Figure 1 shows an image of the maxillary dental cast obtained from the one child of the 12 children. 157,500 points were recorded from the maxillary cast surface. The two points, that is, the apical base point and the crest point of the alveolar process, used for the maxillary alveolar structures analysis were determined on a sagittally sectioned image passing through the midpoint of the mesiodistal anatomic crown width of an erupted tooth of the dental cast surface for identification on a computer display (Figure 1 (a straight arrow)). As shown Figure 2 (left), the apical base point defined as the deepest point on labial or buccal contour of the alveolar process and oral vestibule. As shown in Figure 2 (right), the crest point was determined as follows: on a sagittally sectioned image of the dental cast surface, the tooth was disregarded and the midportion of the ridge was interpolated by the spline function [27]. Next, the most prominent point of the ridge was established as the crest point.

Figure 3 shows the measurements of the maxillary dental casts used in the current study. Three linear variables were measured.

As shown in Figure 4, on the noncleft side, the maxillary dental cast was measured: 61, at the deciduous central incisor; 62, at the deciduous lateral incisor; 63, at the deciduous canine; 64, at the deciduous first molar; 65, at the deciduous second molar, and on the cleft side, it was measured: 51, at the deciduous central incisor; 53, at the deciduous canine; 54, at the deciduous first molar; 55, at the deciduous second molar.

Paired t-tests were used to compare the differences in morphology of maxillary alveolar process between the cleft and non-cleft sides using paired measurements from only those maxillary dental casts. P<.05 was considered statistically significant. For statistical analysis, the SPSS statistical program v14.0 (SPSS Inc, Chicago, IL) was used.

Results

Figure 5 shows the mean plots of the basal arch and the alveolar arch of the 12 children. The basal arch (illustrated in red for the greater hemimaxilloalveolar segment and in yellow for the lesser hemimaxilloalveolar segment) was constructed using the apical base points and the alveolar arch (illustrated in green for the greater hemimaxilloalveolar segment and in white for the lesser hemimaxilloalveolar segment) was drawn by connecting points on the crest of the alveolar process. From horizontal view projected to the horizontal reference plane, noncleft side lateral view, cleft side lateral view, and frontal view, respectively, morphological features in visual impression were examined. From the horizontal view: overall, the alveolar arch was palatally seen relative to the basal arch; in the deciduous central incisor region, the crest of the alveolar process on the cleft side deviated labially when compared with the noncleft side; whereas, in the deciduous canine region, that on the cleft side deviated palatally. From the lateral views and the frontal view: in the deciduous both central incisor and canine regions, the crest height of the alveolar from the apical base point was lower on the cleft side than on the noncleft side.

Table 1 gives a comparison of alveolar process morphology on the cleft side vs the noncleft side. In the deciduous central incisor and canine regions, distance between the apical base point and the crest point of the alveolar process (ABP-CPAP) on the cleft side were significantly smaller than on the noncleft side (p<0.05 in the deciduous central incisor regions, p<0.01 in the deciduous canine regions) and height to the crest point of the alveolar process from the apical base point (CHAP) on the cleft side were also significantly smaller than on the noncleft side (p<0.05 in the deciduous central incisor regions, p<0.01 in the deciduous canine regions). As to horizontal distance between the apical base point and the crest point of the alveolar process (LBWAP) in the deciduous central incisor regions, no significant difference was found in the comparison between the cleft side and the noncleft side; however, that on the cleft side showed a small but definite reduction than on the noncleft side; while, in the deciduous canine regions, no significant difference was found in the comparison between the cleft side and the noncleft side; however, that on the cleft side showed a small but definite increase than on the noncleft side. In the deciduous first and second molar regions, there were no clear differences between the alveolar process morphology of the 2 sides in the current study.

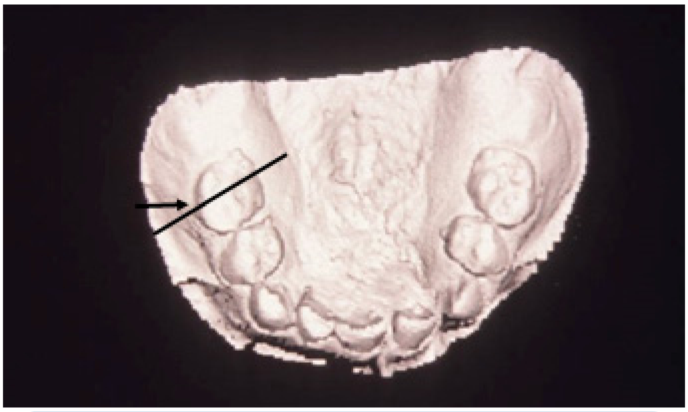

Figure 1: Computer graphics display of the maxillary dental cast obtained from the one child of the 12 children and the midpoint of the mesiodistal anatomic crown width of an erupted tooth of the dental cast surface for identification on it.

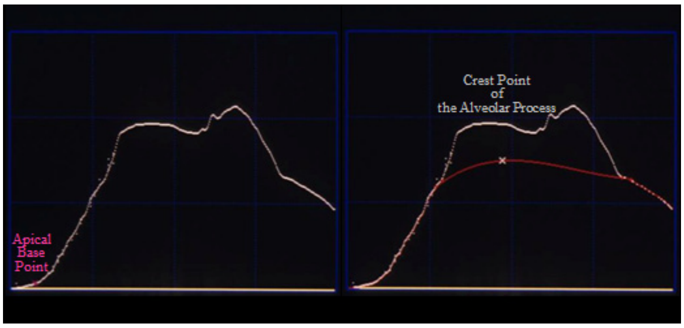

Figure 2: The landmarks for the maxillary alveolar process variables.
1. ABP (The apical base point): the deepest point on labial or buccal contour of the alveolar process and oral vestibule.
2. CPAP (The crest point of the alveolar process): on a sagittally sectioned image of the dental cast surface, the tooth was disregarded and the midportion of the ridge was interpolated by the spline function 27). Next, the most prominent point of the ridge was established as the crest point.

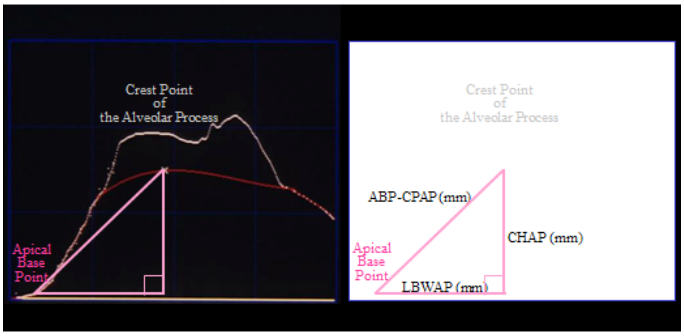

Figure 3: The linear maxillary alveolar process variables.
1. ABP-CPAP (mm): distance between the apical base point and the crest point of the alveolar process;
2. CHAP (the crest height of the alveolar process) (mm): height to the crest point of the alveolar process from the apical base point;
3. LBWAP (the labiobuccal width of the alveolar process) (mm): horizontal distance between the apical base point and the crest point of the alveolar process.

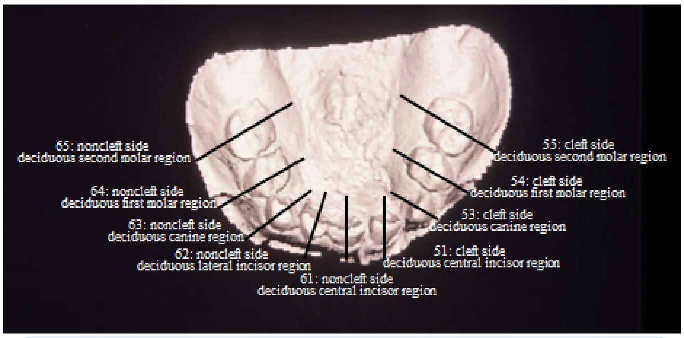

Figure 4: Measurement regions of the maxillary dental cast.

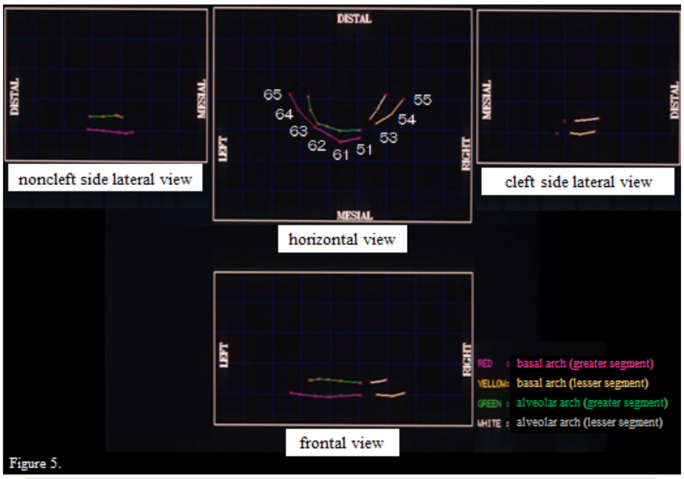

Figure 5: Mean dentoalveolar structures of the 12 children. Red=the basal arch for the greater hemimaxilloalveolar segment; yellow=the basal arch for the lesser hemimaxilloalveolar segment; green=the alveolar arch for the greater hemimaxilloalveolar segment; white=the alveolar arch for the lesser hemimaxilloalveolar segment on the clef side. From horizontal view projected to the horizontal reference plane (Top center), noncleft side lateral view (Top left), cleft side lateral view (Top right), and frontal view (Bottom), morphological features in visual impression were examined.

Table 1: Comparison of alveolar process morphology on the cleft side vs the non cleft side.

	Deciduous central incisor region		Deciduous canine region		Deciduous first molar region		Deciduous second molar region	
	Noncleft Side	Cleft Side	Noncleft Side	Cleft Side	Noncleft Side	Cleft Side	Noncleft Side	Cleft Side
	*		**		NS		NS	
ABP-CPAP (mm)	10.6±0.7	9.0±0.5	12.0±0.4	9.4±0.7	11.5±0.6	11.7±0.6	12.9±0.7	12.3±0.8
	*		**		NS		NS	
CHAP (mm)	9.5±0.7	7.8±0.3	11.3±0.4	8.3±0.6	9.5±0.5	9.2±0.5	8.6±0.4	8.3±0.5
	NS		NS		NS		NS	
LBWAP (mm)	4.5±0.5	3.8±0.8	3.6±0.6	4.0±0.7	6.4±0.5	7.2±0.5	9.4±0.9	8.9±0.9

mean±S.D. (mm)

**: p<0.01; *: p<0.05; NS: not significant

Discussion

The current study focused on outcomes of maxillary alveolar process morphology as a result of primary lip repair in UCLP children with unrepaired maxillary and alveolar clefts. To measure maxillary alveolar process morphology in detail, we used the whole surface of the maxillary dental cast. Thus, we could conduct the study to obtain the reliable and intriguing findings from a single information source.

The conception of the apical base, which is foundation for analysis of alveolar process morphology, was originated with the apical base theory proposed by Lundström [28-33]; the apical base would in the horizontal plane coincide with the region in which the apices of the teeth roots were located. Therefore, the apical base should be anatomically defined including bony substance immediately surrounding the apices of the teeth roots. In orthodontic practice, based on the apical base theory [28-33], using the deepest point on labial or buccal contour of the alveolar process and oral vestibule, which is regarded as an immediate surrounding region of the apices of the teeth roots, the basal arch width and length were measured on the plaster model analysis [34]. In this regard, we believe it appropriate that we determined the apical base point: point defined as the deepest point on labial or buccal contour of the alveolar process and oral vestibule, and analyze morphology of the alveolar process based on the line passing through the point in the current study.

In the current study, both distance between the apical base point and the crest point of the alveolar process (ABP-CPAP) and the crest height of the alveolar process (CHAP) in the cleft side deciduous both central incisor and canine regions, that is, at the distal terminal end of the greater hemimaxilloalveolus and the medial terminal end of the lesser hemimaxilloalveolus, were significantly smaller than in the noncleft side that regions; in accordance [35,36], these findings suggest that the presence of maxillary and alveolar cleft itself substantially restricts the vertical size of the alveolar process in unilateral cleft lip and palate children. Explained that the reduction in vertical development was ascribed to the cleft malformation [20]. Paulin pointed out that the aberration of the alveolar process would give insufficient bony support to the teeth in the cleft region for eruption in their correct position [37]. It is reported, as mentioned above, that there seem characteristic teeth malposition in the vicinity of the alveolar cleft with high frequency in clefts the lip and palate patients; suspected that the particular morphologic aspect of alveolar cleft itself is a factor involving the malposition [10,18]. We assume, therefore, that inadequate vertical growth of the alveolar process in the vicinity of the alveolar cleft, as seen in the current study, accompanied with the characteristic teeth malposition, would be attributed to the intrinsic effects of congenital alveolar cleft itself, apprehended to cause the characteristic teeth malposition in the stage of permanent dentition, which is another subject we must deal with in the future.

As to horizontal distance between the apical base point and the crest point of the alveolar process (LBWAP), in the current study, we observed in the comparison between the cleft side and the noncleft side that the crest of the alveolar process in the vicinity of the cleft at the distal terminal end of the greater hemimaxilloalveolus deviated labially; conversely, that at the medial terminal end of the lesser hemimaxilloalveolus deviated palatally. From these findings, it seems reasonable to assume that the patterns of the labiopalatal inclination of the alveolar process in the vicinity of the cleft are probably different between at the distal terminal end of the greater hemimaxilloalveolus and the medial terminal end of the lesser hemimaxilloalveolus.

Determined the local deformation (strain) of the upper lip using ultrasound elastography in unilateral cleft lip and palate patient that underwent a surgical reconstruction of a unilateral cleft lip [38], and revealed asymmetric muscular strain between on the cleft side and the noncleft side, with greater strain on the noncleft side. Furthermore, noted the influence of asymmetric muscular contraction and pull on the alveolar process toward the noncleft side and suggested that the asymmetric muscular strain should be one of the factors that could influence maxillary dentoalveolar formation in cleft lip and palate patients [18]. Considering these views, we assume that the effects of muscular function are among the most important factors involved in our finding, that is, the pattern differences of the labiopalatal inclination of the alveolar process in the vicinity of the cleft between between at the distal terminal end of the greater hemimaxilloalveolus and the medial terminal end of the lesser hemimaxilloalveolus.

In contrast, in the deciduous first and second molar regions, there were no clear differences between the alveolar process morphology of the cleft side and the noncleft side in the current study. Therefore, we are confident that we could determine the morphological features of alveolar process in the vicinity of the cleft prior to surgical therapy for maxillary and alveolar clefts in the deciduous dentition in unilateral cleft lip and palate children.

We hope that the findings of our current study would be useful information for those specializing in treating cleft palate patients, in establishing a guideline on treatment planning for optimal orthodontics or surgical treatment and its appropriate time, and in qualitatively improving the treatments.

Conclusion

(1) The current study suggests that the presence of maxillary and alveolar cleft itself substantially restricts the vertical size of the alveolar process in the vicinity of cleft in unilateral cleft lip and palate child.

(2) In the current study, it seems reasonable to assume that the patterns of the labiopalatal inclination of the alveolar process in the vicinity of the cleft are probably different between at the distal terminal end of the greater hemimaxilloalveolus and the medial terminal end of the lesser hemimaxilloalveolus.

Declarations

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The authors have no conflict of interest to disclose.

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