Three dimensional measurements of the palate using the semiconductor laser

3. Changes in the palate section areas, palate projection areas and palate volumes in the early permanent dentition according to age

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Abstract
The objective of the study was to examine changes in palate section area, palate projection area and palate volume according to age. Using the maxillary dentition models, the palates of 10-, 12- and 14-year old children, who were in the early permanent dentition period, were measured three-dimensionally using the semiconductor laser. Palate section areas between canines, the first premolars, second premolars and first molars became greater as children aged because the palate enlarged vertically with the growth and development of the maxilla. The palate projection area became greater as children aged because the palate enlarged laterally with the growth and development of the maxilla. The palate volume became greater as children aged because the palate enlarged laterally and vertically.

Key words
Early permanent dentition, Palate, Semiconductor laser, Three dimensional measurements

Introduction
It is a very important matter in the clinical aspect of pediatric dentistry to promote a normal occlusion of deciduous, mixed and permanent dentitions during childhood. Especially, for the prediction and diagnosis of the normal growth of the maxillary dentition, the normal morphological changes of the palate must be understood and accurate measurement and analysis of the palate are required(1-7). In the past, techniques used for morphological measurement of palate include moiré topography for the measurement of the area and volume of palate and three dimensional measuring apparatus for the width and height of palate(8-10).

We have investigated measurements of the palate section area, palate projection area and palate volume of deciduous as well as mixed dentition periods using the semiconductor laser(11). In the present study, changes in the area and volume of the palate were explored in the early permanent dentition period as children aged.

Materials and Methods
Materials
Out of 10-, 12- and 14-year old children who were seen at the Pediatric Dentistry Clinic, Osaka Dental University Hospital, selected for the study were the maxillary permanent dentition of those hardly had any dental caries and in whom the right and left central incisors, lateral incisors, canines, first premolars, second premolars and first molars of the maxilla had erupted and whose occluding relation of the first molar was class 1. And they were not recognized the dysfunction of the circumoral muscles including the oral habits. The maxillary
permanent dentitions of these children were examined. The impression of their maxillary permanent dentitions was taken by alginic acid impression material to prepare the maxillary permanent dentition models for study. Measured were the distance between the lowest points of the cervical portion of bilateral maxillary canines at the palatal side (3-3), the distance between the lowest points of the cervical portion of the bilateral maxillary first premolars at the palatal side (4-4), and the distance between the lowest points of the cervical portion of the bilateral maxillary second premolars at the palatal side (5-5). Out of measured models, selected as study subjects were models taken from 18 children (6 each of 10-, 12- and 14-year) which were within mean ± standard deviation of measured values in each age group\(^1\).

**Methods**

First, the whole of the maxillary permanent dentition was recognized by the semiconductor laser as the digital data of three-dimensional configuration. Next, using the morphologic measurement program of the semiconductor laser, 10 points; the lowest points of the cervical portion of bilateral maxillary central incisors at the palatal side (A, A'), the right and left 3-3 (B, B'), 4-4 (C, C'), 5-5 (D, D') and the lowest points of the cervical portion of bilateral maxillary first molars at the palatal side (E, E'), were plotted as standard points. Thereafter, using the morphologic analysis program, palate section areas, palate projection areas and palate volumes were calculated.

1) Palate section areas

(1) Palate section area of the width of the primary canines

The area composed by the straight line B, B' connecting the lowest points of the cervical portion of bilateral maxillary canines at the palatal side and the straight line right under B, B' on the palatal surface, or the area surrounded by —— in Fig. 1. (hereinafter referred to as S3.)

(2) Palate section area of the width of the primary first molars

The area composed by the straight line C, C' connecting the lowest points of the cervical portion of bilateral maxillary first premolars at the palatal side and the straight line right under C, C' on the palatal surface, or the area surrounded by —— in Fig. 1. (hereinafter referred to as S4.)

(3) Palate section area of the width of the primary second molars

The area composed by the straight line D, D' connecting the lowest points of the cervical portion of bilateral maxillary second premolars at the palatal side and the straight line right under D, D' on the palatal surface, or the area surrounded by —— in Fig. 1. (hereinafter referred to as S5.)
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(4) Palate section area of the width of the first molars
The area composed by the straight line E, E’ connecting the lowest points of the cervical portion of bilateral maxillary first molars at the palatal side and the straight line right under E, E’ on the palatal surface, or the area surrounded by —— in Fig. 1. (hereinafter referred to as S6.)

2) Palate projection areas
The area composed by points A, B, C, D, E, E’, D’, C’, B’, A’ and A. (hereinafter referred to as S.)

3) Palate volumes
The volume composed by S and the palatal surface area right under S. (hereinafter referred to as V.)

Changes in configuration of the maxillary palate were investigated by comparing with section area, projection area and volume of palate at the normal maxillary permanent dentition.

Results

1) Palate section areas
(1) Palate section area of the width of the permanent canines (S3) (Fig. 2)
S3 was 62 mm² in 10-year-olds, 69 mm² in 12-year-olds and 73 mm² in 14-year-olds, indicating that the palate section area became greater as children aged.

The two-tailed $P$ value showed that there was no significant difference in palate section area among different age groups.

Fig. 2 Results are expressed as the mean ± standard deviation of the measurements of the palate section area of S3
There were no significant differences between each age groups.

Fig. 3 Results are expressed as the mean ± standard deviation of the measurements of the palate section area of S4
There were no significant differences between each age groups.

Fig. 4 Results are expressed as the mean ± standard deviation of the measurements of the palate section area of S5
There were no significant differences between each age groups.
(2) Palate section area of the width of the first premolars (S4) (Fig. 3)

S4 was 220 mm² in 10-year-olds, 237 mm² in 12-year-olds and 249 mm² in 14-year-olds, indicating that the palate section area became greater as children aged. The two-tailed $P$ value showed that there was no significant difference in palate section area among different age groups.

(3) Palate section area of the width of the second premolars (S5) (Fig. 4)

S5 was 336 mm² in 10-year-olds, 342 mm² in 12-year-olds and 358 mm² in 14-year-olds, indicating that the palate section area became greater as children aged. The two-tailed $P$ value showed that there was no significant difference in palate section area among different age groups.

(4) Palate section area of the width of the first molars (S6) (Fig. 5)

S6 was 303 mm² in 10-year-olds, 340 mm² in 12-year-olds and 389 mm² in 14-year-olds, indicating that the palate section area became greater as children aged. The two-tailed $P$ value showed that there was a significant difference in palate section area between 10-year-olds and 14-year-olds ($P<0.01$).

2) Palate projection areas (S) (Fig. 6)

S was 781 mm² in 10-year-olds, 818 mm² in 12-year-olds and 825 mm² in 14-year-olds, indicating that the palate projection area became greater as children aged. The two-tailed $P$ value showed that there was a significant difference in palate projection areas.

Fig. 5 Results are expressed as the mean ± standard deviation of the measurements of the palate section area of S6

Mann-Whitney test, **: $P<0.01$, 10 age (n = 6); 14 age (n = 6)

Fig. 6 Results are expressed as the mean ± standard deviation of the measurements of the palate projection area of S

Mann-Whitney test, *: $P<0.05$, 10 age (n = 6); 14 age (n = 6)

Fig. 7 Results are expressed as the mean ± standard deviation of the measurements of the palate volume of V

There were no significant differences between each age groups.
between 10-year-olds and 14-year-olds ($P<0.05$).

3) Palate volumes (V) (Fig. 7)

V was 4,775 mm$^3$ in 10-year-olds, 5,021 mm$^3$ in 12-year-olds and 5,358 mm$^3$ in 14-year-olds, indicating that the palate volume became greater as children aged. The two-tailed $P$ value showed that there was no significant difference in palate volumes among different age groups.

**Discussion**

1) Palate section areas (S3, S4, S5, S6)

We have found that whereas in deciduous dentition period, the section area of deciduous anterior dentition becomes smaller, as the gingiva of the palate distends when maxillary permanent incisors erupt, the section area in the mixed dentition period and the S3, S4, S5 and S6 in the early permanent dentition period become greater as children aged. The rates of increases in 12- and 14-year-olds against 10-year-olds as a standard were, respectively, 11% and 18% in S3, 8% and 13% in S4, 2% and 7% in S5 and 12% and 28% in S6. Reasons of these increases in S3, S4, S5 and S6 were thought that as permanent canines, first premolars, second premolars and first molars erupt, alveolar bones grow caudally, deepening the maxillary palate further vertically. There was a significant difference only in S6 between 10-year-olds and 14-year-olds, suggesting that in the eruption period of the second molars, the posterior portion of the palate considerably deepens vertically$^{13,14}$.

2) Palate projection areas (S)

The palate projection area became greater as children aged in the deciduous and mixed dentition periods. Similarly, the palate projection area became greater as children aged in the early permanent dentition period. The rates of increases of the palate projection area in 12- and 14-year-olds against 10-year-olds as a standard were 5% and 6% respectively. The increase rate of the palate in the early permanent dentition period was nearly the same as in the mixed dentition period. It was thought that as both the palate section area in the vertical direction and the palate projection area in the horizontal direction expanded, the palate as a whole increased in volume.

The present study made it clear that the growth and development of the maxillary palate were greatly affected morphologically by the growth and development of the jaw, face and cranium$^{15}$.

However, the growth and development of the dentition is affected functionally by mastication, deglutition and phonation etc. Future studies will examine the functional growth and development of the palate.

The above findings suggest that measurement and analyses of the maxillary palate in the deciduous, mixed and early permanent dentition periods are very important methods in pediatric dentistry of examination, diagnosis and treatment in the deciduous, mixed and early permanent dentition periods for understanding of the normal growth and development of dental arches of the upper and lower jaws and management of pediatric occlusion guidance.

**References**


