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Evaluation of the Midpalatal Suture Maturation in Young Koreans Using Cone-Beam Computed Tomography

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Purpose: The aim of this study was to evaluate the ossification and maturation of the midpalatal suture in young Koreans using cone-beam computed tomography (CBCT).

Materials and Methods: The study sample consisted of 40 patients with ages from 8.2 to 23.6 years who visited the Department of Orthodontics, Chung-Ang University Dental Hospital. CBCT images were taken for diagnosis. From the CBCT image, morphological stages and Hounsfield units (HU) of midpalatal suture were obtained to evaluate the midpalatal suture maturation. Spearman's correlation coefficients were calculated to analyze relationships between chronological age, morphological stage, and HU.

Result: There was a wide variation in the morphology of the midpalatal suture in each age group. It showed a modest relationship between the chronological age and the degree of morphological stages. Also there was a modest relationship between the chronological age and HU. In contrast, there was a significant relationship between morphological stages and HU of midpalatal suture ($P<0.01$).

Conclusion: CBCT images can be used for the evaluation of midpalatal suture maturation. For the estimation of the prognosis of rapid maxillary expansion, CBCT may be reliable for the assessment of the maturation of the midpalatal suture.

Key Words: Cone-beam computed tomography; Hounsfield units; Midpalatal suture

Introduction

The maturation of the midpalatal suture is an important factor in orthodontic treatment planning. Especially in young patients, it may be an indicator for the determination whether surgical approach is necessary for expanding the narrow maxilla. In general, maturation of the midpalatal suture is

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known to increase with age, but we can often find exceptions in clinical practice[1].

The aim of this study was to evaluate ossification and maturation of the midpalatal suture in young Koreans via evaluation of the morphological stages and measuring Hounsfield units (HU) using cone-beam computed tomography (CBCT).

Materials and Methods

The study sample consisted of 40 patients with a mean age of 15.2 years (range, 8.2~23.6 years), who visited the Department of Orthodontics, Chung-Ang University Dental Hospital from 2014 to 2017. They all had CBCT images taken using KaVo Dental 3D eXam® (KaVo Dental, Charlotte, NC, USA) (Table 1). Exclusion criteria were congenital malformations of suture area and the presence of supernumerary tooth near the midpalatal suture (mesiodens).

The CBCT images were obtained with an iCAT cone-beam three-dimensional imaging system. Image analysis was performed using Invivo5 (Anatomage, San Jose, CA, USA). CBCT images of the midpalatal suture were evaluated on an axial plane view from stage A to stage E according to the classification scheme of Angelieri et al.[2]. Stages were identified and defined as follows: stage A, straight high-density sutural line, with no or little interdigitation; stage B, scalloped appearance of the high-density sutural line; stage C, two parallel, scalloped, high-density lines that were close to each other, separated in some areas by small low-density spaces; stage D, fusion completed in the palatal bone, with no evidence of a suture; and stage E, fusion anteriorly in the maxilla (Fig. 1)[2,3].

The gray density ratio of midpalatal suture was measured using the HU of the CBCT image in the Invivo5 software. In order to evaluate the relative value, the HU value of the three parts (midpalatal suture, cortical bone, soft palate) was measured and the ratio was calculated (Fig. 2). Grünheid et al.[4] determined HU values of midpalatal suture using the gray density of midpalatal suture, soft palate, and palatal process of the maxilla. However it was difficult to define a specific location of palatal process. Therefore we measured the cortical bone of maxilla instead of palatal process. The midpalatal suture density ratio (HU ratio) was calculated by the following equation;

$$\text{HU ratio (midpalatal suture)} = \frac{HUm - HUs}{HUc - Hus}$$

(HUm=midpalatal suture, HUs=soft palate, HUc=cortical bone)

This ratio ranges from 0 to 1, with lower values

Table 1. Study population

	8~11 yr	12~15 yr	16~19 yr	≥20 yr	Total (n)
Male (n)	5	5	5	5	20
Female (n)	5	5	5	5	20
Total (n)	10	10	10	10	40

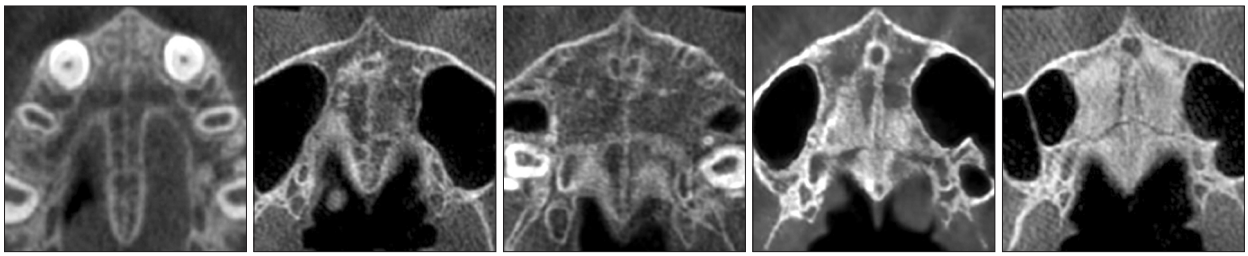

Fig. 1. Five stages of midpalatal suture maturation. Reused from the article of Angelieri et al. (Am J Orthod Dentofacial Orthop. 2013; 144: 759-69)[2] with original copyright holder's permission.

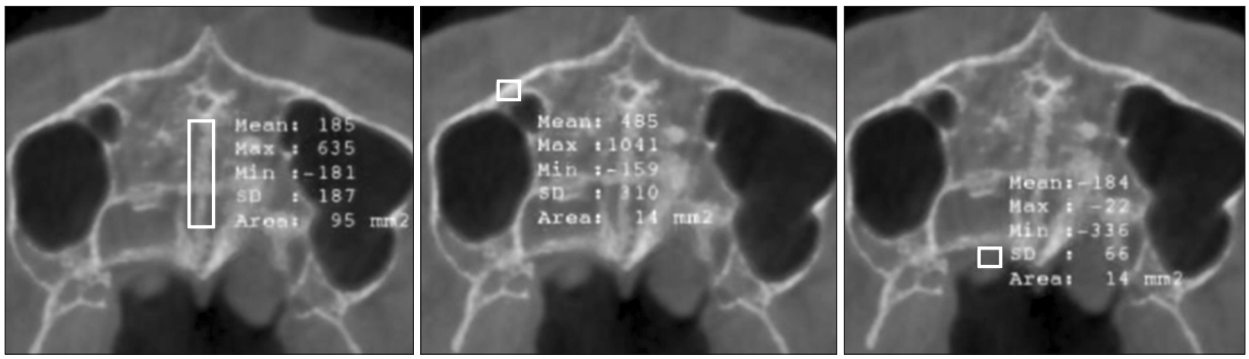

Fig. 2. Measuring the Hounsfield units of three parts using Invivo5 software (Anatomage).

Table 2. Distribution of the maturational stages of the midpalatal suture

Age (yr)	Stage A			Stage B			Stage C			Stage D			Stage E		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
8~11	3	2	5	2	1	3		2	2						
12~15				2		2	3	2	5		3	3			
16~19							1	1	2	3		3	1	4	5
≥20							1		1		1	1	4	4	8

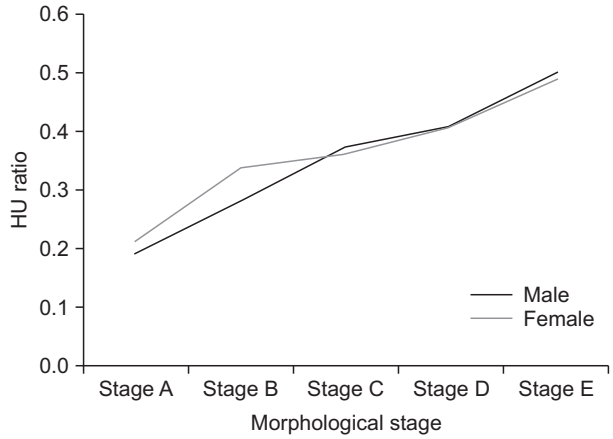

Fig. 3. Hounsfield units (HU) ratio of the morphological stages.

indicating that the suture region is less calcified. Spearman's correlation coefficients were calculated to analyze the relationships between chronological age, morphological stage, and HU value.

The use of HU value for bone density measurements in CBCT is generally estimated to be avoided because of its unreliability. However a few positive studies have been reported on the accuracy of HU values in CBCT[5,6]. Although the HU value in this study can't be used as an absolute index of bone density, it can be used to validate the reliability of HU value in CBCT while assessing bone maturation.

Table 3. Results of Spearman's correlation

	Age	HU	Stage
Age	-	0.760**	0.816**
HU	0.760**	-	0.909**
Stage	0.816**	0.909**	-

HU: Hounsfield units.
**P<0.01.

Result

There was a wide variation in the morphology of the midpalatal suture in each age group. The distributions of chronological ages and midpalatal suture maturation stages are shown in Table 2. It was shown than females tend to have fusion of midpalatal suture earlier than males.

Fig. 3 shows that HU ratio tends to increase with

morphological stage propotionally. The HU ratio was over 0.4 at stage D, when the fusion of the midpalatal suture commenced.

Correlations between morphological stages, HU ratio and chronological age were investigated (Table 3). Chronological ages showed strong correlations with morphological stages (0.816). Also strong correlation was observed between morphological stages and HU ratio (0.909). And Chronological ages and HU ratio have moderate correlations (0.760).

Discussion

Chronological age is closely related to midpalatal suture maturation but has some exceptions. It is notable that D or E (*i.e.*, fusion of the suture) was not observed in the male group before 16 years, female group before 12 years. Therefore nonsurgical maxillary expansion may be recommended before this age. But the number of samples in this study was not sufficient, it was difficult to determine specific age.

HU ratio showed a tendency to increase as midpalatal suture was matured. There was no significant difference between male and female. At stage D and E, the HU ratio value was always more than 0.380. So a surgical approach may be considered when the HU ratio value is over 0.380. However, HU values in CBCT are used only as reference values because they are less accurate.

Conclusion

The purpose of the present study was to evaluate the maturation of the midpalatal suture using CBCT. The results suggested that fusion of the midpalatal suture appears in adolescence, often between 12 and 16 years. The HU ratio obtained from CBCT images was greater than 0.380 when the fusion of midpalatal suture was anticipated.

CBCT images can be used for the evaluation of the maturation of the midpalatal suture, using the HU. It can be presumed that the prognosis of rapid maxillary expansion may be assessed using CBCT images prior to operation of the midpalatal suture expansion.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

References

1. Revelo B, Fishman LS. Maturational evaluation of ossification of the midpalatal suture. Am J Orthod Dentofacial Orthop. 1994; 105: 288-92.
2. Angelieri F, Cevidanes LH, Franchi L, Gonçalves JR, Benavides E, McNamara JA Jr. Midpalatal suture maturation: classification method for individual assessment before rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2013; 144: 759-69.
3. Angelieri F, Franchi L, Cevidanes LH, McNamara JA Jr. Diagnostic performance of skeletal maturity for the assessment of midpalatal suture maturation. Am J Orthod Dentofacial Orthop. 2015; 148: 1010-6.
4. Grünheid T, Larson CE, Larson BE. Midpalatal suture density ratio: a novel predictor of skeletal response to rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2017; 151: 267-76.
5. Pauwels R, Jacobs R, Singer SR, Mupparapu M. CBCT-based bone quality assessment: are Hounsfield units applicable? Dentomaxillofac Radiol. 2015; 44: 20140238.
6. Razi T, Niknami M, Alavi Ghazani F. Relationship between Hounsfield unit in CT scan and gray scale in CBCT. J Dent Res Dent Clin Dent Prospects. 2014; 8: 107-10.