http://dx.doi.org/10.5933/JKAPD.2014.41.3.225
J Korean Acad Pediatr Dent 41(3) 2014
ISSN (print) 1226-8496 ISSN (online) 2288-3819

Comparison of Dental Age and Skeletal Maturity in Korean Children with Skeletal Malocclusion

Jeeyoun Kim, Sohee Oh

Department of Pedodontics, Hallym University Sacred Heart Hospital

Abstract

The purpose of this study was to compare skeletal maturity index and dental developmental stages based on skeletal malocclusion.

A total of 192 patients (89 male and 103 female) between 6 to 14 years old were selected for this study and underwent cephalograms, panorama radiographs, and hand-wrist radiographs. Any syndromic cases were excluded. Selected clinical parameters were dichotomised for statistical analysis. Chi-square, logistic regression analysis, and independent t-tests were used for the statistical evaluation.

Canine, first molar, and second molar calcification were significantly associated with skeletal maturity in the logistic regression model ($p < 0.05$). In addition, patients who had higher skeletal maturity index were 11.43 times more likely to be female than those who had lower skeletal maturity index ($p < 0.001$). The patients with skeletal class II malocclusion displayed significantly higher dental developmental stage in canines, first premolars, first molars, and second molars than the patients with class III malocclusion ($p < 0.05$).

The dental developmental stage of the patients was significantly associated with skeletal maturity. In addition, there was a significant difference between class II and class III malocclusion with some types of tooth calcification.

Key words : Skeletal maturity index, Chronological age, Dental developmental stage, Skeletal malocclusion, Korean children sample

Ⅰ. Introduction

Determining skeletal maturity index and dental developmental stage are essential when form a scheme the orthodontic treatment plans for young patients[1]. Since use of functional appliance or extraoral appliances can be used until growth stops, it is important to know development stages to form a scheme for orthodontic treatment[2]. The success and failure on early orthodontic treatment is doing the treatment at an appropriate time, especially for growing children. As this paper is mainly based on comparing and analyzing the relationship between skeletal maturity index and dental developmental stage, this research will be very useful on finding out the adequate point of time on growth stage. To determine precise developmental stages, chronological age, skeletal maturity index and tooth calcification are used. Within a similar chronological age range, children may display individual discrepancies in their skeletal maturity index and dental developmental stage[3]. Because variability of

Corresponding author : Sohee Oh
Department of Pedodontics, Hallym University Sacred Heart Hospital, 896 Pyeongan-dong, Dongan-gu, Anyang-si, Gyeonggi-do, 431-070, Republic of Korea
Tel: +82-31-380-3870 / Fax: +82-31-380-4118 / E-mail: pedopia@hallym.ac.kr
Received April 24, 2014 / Revised August 5, 2014 / Accepted August 7, 2014

chronological ages are larger, skeletal stages are often used to determine the developmental stage. Skeletal maturation development stages of Fishman is commonly used because of its oraganized and simple way to determine the level of maturation[4]. Tooth developmental stages are determined by erupting stage or calcification stage. Since variation of tooth eruptions are often observed by delayed eruption of permanent tooth, ankylosis and other local factors, Demirjian's method based on stages of tooth development is widely used because of its simplicity and accuracy[5].

Even though Demirjian found that dental developmental stage and skeletal development are irrelevant, there have been many reports on the association between dental developmental stage and skeletal maturity index. There are other report that calcifications stage of lower canine and pubertal age has a close relationship[6]. In addition, the chronological age of patients also has a close association with skeletal maturity index and dental developmental stage[2,7]. As growth and development accompany both skeletal maturity index and dental developmental stage, a close association between these parameters is expected and observed.

There was a lot of studies about comparing and analyzing the relationship between skeletal maturity index and dental development stage, but studies about comparing and analyzing the relationship between skeletal maturity index and dental developmental stage, depending on skeletal malocclusion are very few. The different growth velocity between skeletal class II and other was observed, which tells us that late eruption of the mandibular molars has a close relation with class II malocclusion[8]. In addition, long face has a trend to have an advanced dental maturation than short face among same chronological age people[9] and skeletal open bite has earlier development tendency than skeletal deep bite[10].

However, there is almost no report on dental development stages association with skeletal class I, II, III determined by APDI (anteroposterior dysplasia indicator) value which demonstrates maxilla and mandible overgrowth or undergrowth differenciation. Many studies about comparing and analyzing the relationship between skeletal maturity index and dental developmental stage have been introduced, but this paper will probably be the one of the first research with Korean children and so will provide a significant information to other paediatric dentists. The purpose of this study was to compare skeletal maturity index and dental developmental stage based on skeletal malocclusion.

Ⅱ. Materials and Methods

1. Subjects

This study was approved by our local institutional review board and was performed in accordance with the Helsinki Declaration. A total of 237 patients were reviewed for this study. The inclusion criteria were (1) patient age between 6 and 14 years old, (2) patients visiting for orthodontic consultation from 2010 to 2012 years, and (3) patients having radiographic evaluation. The exclusion criteria were (1) patients with medical histories that included injuries to the face or hands that disturb proper growth, (2) patients with any missing teeth in the left mandible, (3) patients who have syndromic disease, and (4) patients with poor-quality radiographs. After exclusion, a total of 192 patients, consisting of 89 males and 103 females, were enrolled in this study. All patients underwent cephalograms, panorama radiographs, and hand-wrist radiographs. Skeletal malocclusion was evaluated based on lateral cephalogram tracing. The classification criteria were based on a previous publication. Briefly, the anterior posterior skeletal relationship of the maxilla and mandible was classified as skeletal class I, II, or III using the APDI value (class II: APDI < 76.69, class I: APDI 76.69–85.39, and class III: APDI > 85.39).

2. Evaluation of dental developmental stage progress

For this particular study, Demirjian's method was utilized for analysis of dental developmental stage (Fig. 1)[5]. Using Demirjian's method, it was concluded that the growth stages of the left and right teeth appeared to have been the same, allowing the experimenter to examine the left mandiblar teeth for evaluation of dental developmental stage.

3. Analysis of skeletal maturity index

In this experiment, the growth stages of patient skeletal maturity index were determined using Fishman's method. Hand-wrist radiographs of the skeletal maturity index taken from a total of 192 experiment subjects were sorted using Fishman's method and then subsequently categorised into 11 different stages using Skeletal Maturity Indicators (Fig. 2)[11].

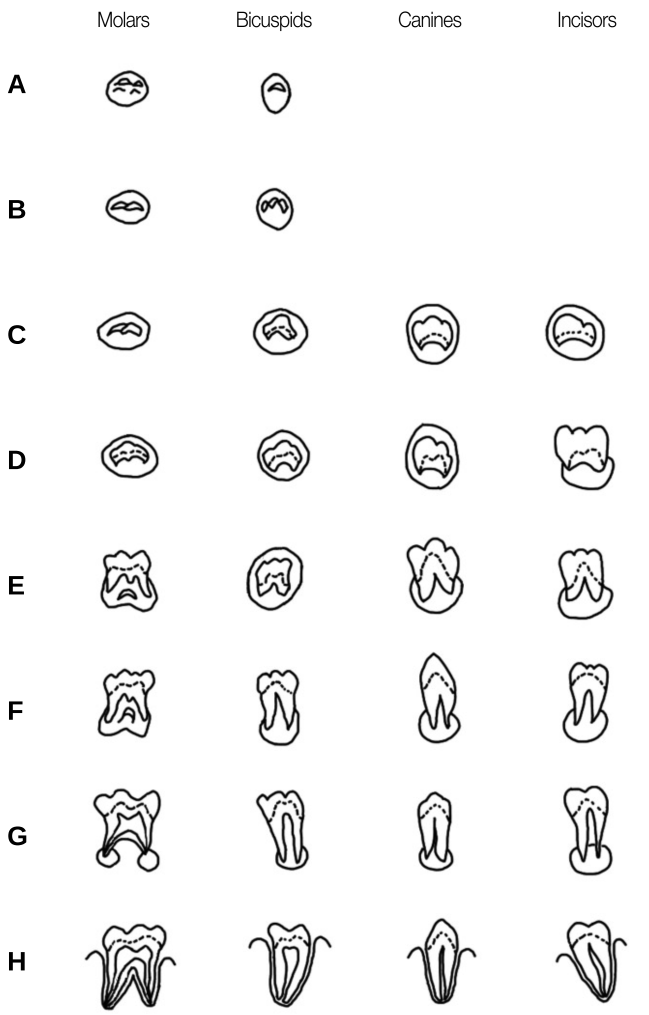

Fig. 1. Developmental stages of the permanent dentition.
A: There is no fusion, but there is calcification at the superior crypt.
B: Calcified points are fused to unite the occlusal surface.
C: At the occlusal surface, enamel formation is completed. Dentinal deposition is observed.
D: Crown formation is completed at the cementoenamel junction. The pulp horns are beginning to differentiate. Root formation is observed.
E: Pulp chamber is now observed by straight lines except for the pulp horn. Crown height is longer than the root length.
F: The pulp horn is beginning to display a semi-lunar figure for bifurcation teeth and a triangle form for uniradicular teeth. Crown height is equal or less than root length.
G: Root formation is almost complete,but its apical end is still open.
H: Both root formation and periodontal ligament formation is completed.

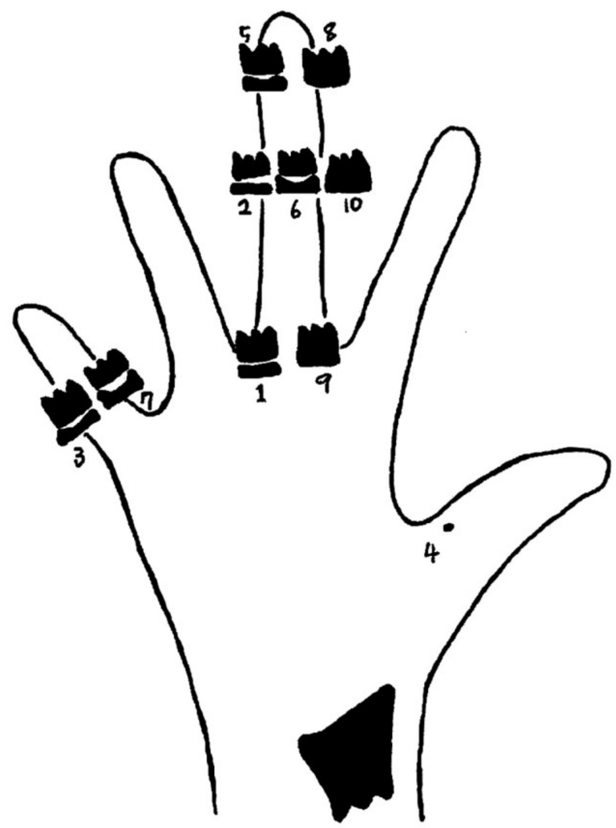

Fig. 2. Eleven skeletal maturity indicators (SMIs).
1: The width of the epiphysis of the third finger proximal phalanx is as wide as the diaphysis.
2: The width of the epiphysis of the third finger middle phalanx is as wide as the diaphysis.
3: The width of the epiphysis of the fifth finger middle phalanx is as wide as the diaphysis.
4: Ossification of the sesamoid of the thumb is observed.
5: Capping of the epiphysis of the third finger distal phalanx.
6: Capping of the epiphysis of the thirdfinger middle phalanx.
7: Capping of the epiphysis of the fifth finger middle phalanx.
8: Fusion of the epiphysis and diaphysis at the third finger distal phalanx.
9: Fusion of the epiphysis and diaphysis at the third finger proximal phalanx.
10: Fusion of the epiphysis and diaphysis at the third finger proximal phalanx.
11: Fusion of epiphysis and diaphysis at the radius.

4. Statistical methods

The samples were analysed using the chi-square test, logistic regression models, and the independent sample t test. The recorded data were analysed using the SPSS (Statistical Package for the Social Sciences) program. The indices allocated to reflect the dental developmental stage, chronological age, and the others were dichotomised based on the average value for bivariate analysis and logistical regression analysis. A chi-square test was used to determine the association between each of the independent variables and the dichotomous dependent variables. Stepwise logistical regression was then used to determine the factors associated with skeletal maturity index. The statistical significance of the coefficients in the logistic regression models was tested using Wald statistics. The odds ratios and confidence intervals were calculated from the regression coefficients. The differences of selected clinical parameters between the class II malocclusion and class III malocclusion groups were compared with an independent sample t test. The significance level was set as $p < 0.05$.

Ⅲ. Results

The average of each variable is listed in Table 1. The skeletal maturity index was 5.97 ± 3.65 years. The dental developmental stage of the lower left canine was 7.00 ± 1.07 years. The lower left first premolar dental developmental stage was 6.78 ± 1.24 years. The lower left second premolar dental developmental stage was 6.51 ± 1.30 years. The lower left first molar dental developmental stage was 7.71 ± 0.50 years, and the lower left second molar dental developmental stage was 6.03 ± 1.40 years.

The bivariate analysis revealed a significant difference between selected clinical parameters and skeletal maturity index (Table 2). The multivariate logistic regression model indicated some relation between skeletal maturity index and selected clinical parameters (Table 3). The patients who had higher skeletal maturity index were 11.43 times more likely to be female than those having a lower skeletal maturity index. The patients who had higher skeletal maturity index were 20.62 times more likely to have canine calcification than those patients with a lower skeletal maturity index. The patients who had higher skeletal maturity index were 6.32 times more likely to have first molar calcification than patients with a lower skeletal maturity index. The patients who had higher skeletal maturity index were 9.78 times more likely to have second molar calcification than patients having a lower skeletal maturity index. There was no relation between skeletal maturity index and premolar calcification.

Table 1. The number of groups by skeletal malocclusion and mean age of subject by gender and skeletal maturity

Skeletal maturity index		5.97 ± 3.65 years
Age (years)		10.87 ± 2.11 years
Class	I	108 (56.2%)
	II	36 (18.7%)
	III	50 (26.2%)
Sex	Male (n)	89
	Female (n)	103
Dental age	Canine	7.00 ± 1.07 years
	First premolar	6.78 ± 1.24 years
	Second premolar	6.51 ± 1.30 years
	First molar	7.71 ± 0.50 years
	Second molar	6.03 ± 1.40 years

Mean ± standard deviation

Table 2. Chi square analysis of bone age and skeletal Class II and III malocclusion in the clinical variables

Variables		Bone age				Class III compared to Class II			
		n	% Persons	Chi-square	*p*-value	n	% Persons	Chi-square	*p*-value
Age	10.87 >	18	21.69			16	44.44		
	10.87 ≤	65	78.31	74.81	*	20	55.56	1.84	NS
Sex	Male	54	65.06			14	38.89		
	Female	29	34.94	19.20	*	22	61.11	2.63	NS
Canine	7.00 >	56	67.47			8	22.22		
	7.00 ≤	27	32.53	97.71	*	28	77.78	7.36	0.007*
First premolar	6.78 >	64	77.11			10	27.78		
	6.78 ≤	19	22.89	96.34	*	26	72.22	6.81	0.009*
Second premolar	6.51 >	69	83.13			16	44.45		
	6.51 ≤	14	16.87	92.14	*	20	55.56	2.5	NS
First molar	7.71 >	51	61.45			8	22.23		
	7.71 ≤	32	38.55	80.94	*	28	77.78	8.43	0.004*
Second molar	6.03 >	72	86.75			14	38.89		
	6.03 ≤	11	13.25	93.34	*	22	61.11	4.3	0.038*

Chi-square test (* : $p < 0.05$)
NS : no significant

Table 3. Association between selected variables and the bone age

Variables		Beta Coefficient (SE)	Odd ratio	*p*-value	95% CI	
					Lower	Upper
Sex		2.436 (0.692)	11.43	< 0.001	2.941	4.405
Dental age	Canine	3.026 (1.177)	20.62	0.010*	2.052	207.191
	First premolar	0.252 (0.936)	1.29	NS	0.205	8.063
	Second premolar	0.205 (0.959)	1.23	NS	0.187	8.030
	First molar	1.843 (0.926)	6.32	0.046*	1.029	38.755
	Second molar	2.281 (0.938)	9.78	0.015*	1.556	61.513

multivariate logistic regression analysis (* : $p < 0.05$)
NS : no significant

Table 4. Comparison of Class II and Class III in the clinical variables

Variables		Class II	Class III	*p*-value
Sex		0.61 ± 0.49	0.46 ± 0.50	NS
Age		11.05 ± 1.94	10.28 ± 2.61	NS
Bone age		6.44 ± 3.06	5.08 ± 3.95	NS
Dental age	Canine	7.20 ± 0.79	6.74 ± 1.27	0.044*
	First premolar	7.11 ± 0.88	6.44 ± 1.45	0.010*
	Second premolar	6.70 ± 1.11	6.24 ± 1.53	NS
	First molar	7.8 ± 0.40	7.56 ± 0.54	0.022*
	Second molar	6.40 ± 1.14	5.73 ± 1.60	0.029*

Regression analysis (* : $p < 0.05$)
NS : no significant

The bivariate analysis indicated significant differences between some dental developmental stages and class II and III classifications (Table 2). The difference in dental developmental stage between groups is listed in Table 4. The dental developmental stage of the canines was significantly different between the class II and class III groups. The dental developmental stage of the canines in the class II group was 7.29 ± 0.79 years and in the class III group was 6.74 ± 1.27 years. The dental developmental stage of the first premolars in the class II group was 7.11 ± 0.88 years, but it was 6.44 ± 1.45years in the class III groups. There was also a significant difference between groups in the first molar and second molars. The dental developmental stage of the first molars in the class II group was 7.80 ± 0.40 years, but it was 7.56 ± 0.54 years in the class III group. The dental developmental stage of the second molars in the class II group was 6.40 ± 1.14 years, but it was 5.73 ± 1.60 years in the class III group. However, there was no significant difference between groups in the dental developmental stage of the second premolars.

Ⅳ. Discussion

In this study, the association between the dental developmental stage of each tooth and selected clinical parameters was examined. The dental developmental stages of the canine, first molar, and second molar were significantly associated with skeletal maturity index in the multivariate logistic regression mode. The dental developmental stages of the canine, first premolar, first molar, and second molar were significantly different between the class II and class III groups.

The relation between skeletal maturity and dental development has been controversial. Hagg *et al*. claimed that skeletal maturity and dental development do not have a significant association[12]. However, Suma[13] and Krailassisi[14] reported there is a significant association between skeletal maturity index and dental developmental stage. In our study, there was significant association between the skeletal maturity index and the chronological age. Chertkow[6] reported that males have a higher skeletal maturity index than females. In this study, there was a significant association between sex and skeletal maturity index. The patients who had a higher skeletal maturity index were 11.43 times more likely to be female than those having a lower skeletal maturity index. The conflicting results with previous studies might be due to earlier increases in skeletal maturity index in female patients than in male patients. The peak high velocity in females occurs earlier than that in males[15].

There have been few reports examining dental developmental stage and skeletal maturity index. The maxillary second molar may erupt earlier with class II malocclusion compared with class I malocclusion[16]. In the same study, there was no association between skeletal malocclusion and calcification except for the second molar[16]. The early calcification of the teeth may be an indicator of early termination of skeletal growth. In some syndromic cases, such as cleidocranial dysplasia, patients display delayed eruption of teeth, short stature and an underdeveloped mandible[17]. However, it is very hard to explain the relation between the first premolar calcification and the facial skeletal growth. Therefore, we analysed the difference between the patients having mandibular undergrowth and the patients having mandibular overgrowth in regards to tooth calcification.

A comparison of the chronological age between the class II and class III groups revealed no significant difference. Therefore, there was no sampling bias between the class II and class III groups in terms of chronological age. As skeletal maturity index is a similar concept to chronological age, it also did not display any significant difference between the groups. Interestingly, there was a significant difference between groups in canine, first premolar, first molar and second molar calcification. The ANB angle (Angle between A point, Nasion, B point) and the distance between the ANS (anterior nasal spine) and PNS (posterior nasal spine) have positive correlation to earlier calcification of the maxillary molars18). As the ANB angle is larger in class II patients than class III patients, class II patients display earlier calcification and higher dental developmental stage than class III patients. Our results also indicated that class II patients displayed significantly higher dental developmental stage than class III patients except for the second premolars.

As chronological age increases, skeletal maturity index will also be accordingly higher. Therefore, the sampling bias has a high impact on the final statistical results. For example, if the class III group had many elderly patients, the skeletal maturity index and dental developmental stage in the class III group would be higher than the other groups. In this study, chronological age was significantly associated with skeletal maturity index expected. However, there was no significant difference between the class II group and class III group in chronological age. Thus, there was no significant sampling bias between the class II group and class III group. The main limitation of our current preliminary study was the size of the sample in each group, which was insufficient to avoid sampling bias. This limitation should be considered in interpreting the results.

The data of tooth maturity of canine, first premolar, second premolar, first molar, and second molar shows that the skeletal maturation stage is significantly related to skeletal class III group as well as skeletal class II malocclusion group.

The results of this research shows correlation between skeletal maturity index and the chronological age which is similar to previous reports. Furthermore, there was a difference between gender. Patients who had a higher skeletal maturity index were 11.43 times more likely to be female than those having a lower skeletal maturity index. The tendency of earlier occurrence of peak high velocity in females may have affected the result.

A comparison of the chronological age between the class II and class III groups revealed no significant difference. However, class II patient displayed higher dental developmental stage than class III patients in all teeth except for the second premolars.

Even though the dental developmental stages of the canine, first molar, and second molar were significantly associated with skeletal maturity index, there was no significant relationship between skeletal maturity index and premolar calcification. We may assume that younger samples might be the cause.

Ⅴ. Conclusion

In conclusion, dental developmental stage was significantly associated with skeletal maturity. In addition, there was significant difference between class II and class III malocclusion with some types of tooth calcification.

References

1. Sachan K, Sharma VP, Tandon P : A correlative

study of dental developmental stage and skeletal maturation. *Indian J Dent Res*, 22:882, 2011.
2. Bjork A : Timing of interceptive orthodontic measures based on stages of maturation. *Trans Eur Orthod Soc*, 48:61-74, 1972.
3. Tanner JM, Whitehouse RH : Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty. *Arch Dis Child*, 51:170-179, 1976.
4. Alkhala HA, Wongb RWK, Rabiec ABM : Correlation between chronological age, cervical vertebral maturation and fishman's skeletal maturity indicators in southern Chinese. *Angle Orthod*, 78:591-6, 2008.
5. Demirjian A, Goldstein H, Tanner JM : A new system of dental developmental stage assessment. *Hum Biol*, 45:211-227, 1973.
6. Chertkow S : Tooth mineralization as an indicator of the pubertal growth spurt. *Am J Orthod*, 77:79-91, 1980.
7. Cha DS, Cha KS : A study on the comparisons between dental calcification and skeletal maturity. *Korea J Orthod*, 24:841-849, 1994.
8. Anderson DL, Popovich F : Association of relatively delayed emergence of mandibular molars with molar reduction and position. *Am J Phys Anthropol*, 54:369-76, 1981.
9. Janson GRP, Martins DR, Tavano O, Dainesi E : Dentalmaturation in subjects with extreme vertical facial types. *Eur J Orhod*, 20:73-78, 1998.
10. Nanda SK : Patterns of vertical growth in the face. *Am J Orthod Dentofacial Orthop*, 93:103-116, 1988.
11. Fishman LS : Radiographic evaluation of skeletal maturation. A clinical oriented method based on hand wrist films. *Angle Orthod*, 57:178-193, 1987.
12. Hagg U, Taranger J : Maturation indicators and the pubertal growth spurt. *Am J Orhod*, 82:299-309, 1982.
13. Suma G, Rao BB, Goel S, *et al.* : Radiographic correlation of dental and skeletal age: Third molar, an age indicator. *J Forensic Dent Sci*, \30007.:14-18, 2001.
14. Krailassiri S, Anuwongnukroh N, Dechkunakorn S : Relationships between dental calcification stages and skeletal maturity indicators in Thai individuals. *Angle Orthod*, 72:155-166, 2002.
15. Roqol AD, Roemmich JN, Clark PA : Growth at puberty. *J Adolesc Health*, 31:192200, 2002.
16. Brin I, Camasuvi S, Dali N, Aizenbud D : Comparison of second molar eruption patterns in patients with skeletal class II and skeletal class I malocclusion. *Am J Orthod Dentofacial Orthop*, 130:746-751, 2006.
17. Dorotheou D, Gkantidis N, Karamolegkou M, *et al.* : Tooth eruption: altered gene expression in the dental follicle of patients with cleidocranial dysplasia. *Orthod Craniofac Res*, 16:20-27, 2013.
18. Haruki T, Kanomi R, Shimono T : The differences in the chronology and calcification of second molars between angle class III and class II occlusions in Japanese children. *ASDC J Dent Child*, 64:400-404, 1997.

국문초록

한국 어린이의 골격적 부정교합에 따른 골 성숙도와 치아의 성숙도 비교

김지연 · 오소희

한림대학교 성심병원 소아치과

이 논문의 목적은 골 성숙도와 치아의 성숙도를 골격적 부정교합에 따라 관련성을 알아보는 것이다.

6세에서 14세에 이르는 총 192명의 환자(89명의 남자, 103명의 여자)를 대상으로 하였으며 측모 두부 방사선 사진, 파노라마 방사선 사진, 수완부 방사선 사진을 사용하였고 심한 질환을 가진 경우는 제외하였다. 통계는 이분법, chi-square, logistic regression analysis, independent t-test를 사용하여 분석하였다.

견치, 제1대구치, 제2대구치의 석회화는 골 성숙도와 연관성($p < 0.05$)을 보였고 또한 골 성숙도가 높은 경우, 여자어린이일 경우가 11.43배 높았다($p < 0.001$). class II 부정교합일 경우, 견치, 제1소구치, 제1대구치, 제2대구치의 치아 석회화 정도가 class III 부정교합자에 비해 높았다($p < 0.05$).

치아의 석회화와 골 성숙도의 연관성은 높았으며 class II와 class III 부정교합환자의 치아의 성숙도는 치아에 따라 다른 성숙도를 보였다.

주요어: 골 성숙도, 역령, 치아의 성숙도, 골격적 부정교합, 한국 어린이