ORIGINAL RESEARCH

Relationship between Dental Maturity and Cervical Vertebral Maturity in North Karnataka (India) Children: A Hospital-based Retrospective Study

[1]Syeda Arshiya Ara, [2]Vini Arora, [3]Syed Zaka Ullah

ABSTRACT

Aims: The aim of the study was to investigate the relationship between stages of calcification of teeth and the cervical vertebral maturity stages in North Karnataka population.

Materials and methods: Digital panaromic radiographs and lateral skull cephalograms of 50 patients (26 girls and 24 boys from 7 to 16 years of age) were examined.

Dental maturity was assessed by calcification stages of the mandibular canines, first and second premolars, and second molars, whereas skeletal maturity was estimated by the cervical vertebral maturation (CVM) stages.

Statistical analysis used: The Spearman rank-order correlation coefficient was used to measure the association between CVM stage and dental calcification stage of individual teeth.

Results: The mean chronologic age of girls was significantly lower than that of boys in each CVM stage. The Spearman rank-order correlation coefficients between dental maturity and cervical vertebral maturity ranged from 0.403 to 0.531 for girls and from 0.461 to 0.512 for boys. In girls, the mandibular second molar had the highest and the canine the lowest correlation. In boys, the mandibular second premolar had the highest and canine the lowest correlation.

Conclusion: Tooth calcification stage was significantly correlated with CVM stage. The development of the mandibular second molar in females and that of the mandibular second premolar in males had the strongest correlations with CVM.

Clinical significance: It is practical to consider the relationship between dental and skeletal maturity when planning orthodontic treatment.

Keywords: Cervical vertebral maturity, Dental maturity, Growth prediction, Orthodontics.

How to cite this article: Ara SA, Arora V, Ullah SZ. Relationship between Dental Maturity and Cervical Vertebral Maturity in North Karnataka (India) Children: A Hospital-based Retrospective Study. J Orofac Res 2014;4(1):35-40.

[1]Professor, [2]Postgraduate Student, [3]Associate Professor

[1,2]Department of Oral Medicine and Radiology, Al-Badar Rural Dental College and Hospital, Gulbarga, Karnataka, India

[3]Department of Oral and Maxillofacial Surgery, Al-Badar Rural Dental College and Hospital, Gulbarga, Karnataka, India

Corresponding Author: Syeda Arshiya Ara, Professor Department of Oral Medicine and Radiology, Al-Badar Rural Dental College and Hospital, Gulbarga, Karnataka, India Phone: 9880352812, e-mail: drarshiyazaka@gmail.com

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Skeletal maturity and dental development assessment is a common clinical practice in many health professions, especially for growth modification in orthodontics and dentofacial orthopedics and for age estimation in forensic sciences. Because of the considerable variations in development among children, chronological age may have little or no role in the determination of the maturation stage of a child[1-3] and has led to the concept of biologic or physiologic age. Physiologic age is the rate of progress toward maturity and is estimated by somatic, sexual, skeletal, and/or dental maturity.[3-5]

The classical and most widely used method for skeletal-age evaluation is the highly reliable hand-wrist bone analysis. Currently, cervical vertebrae analysis is widely used by orthodontists to evaluate skeletal maturity because of the simplicity, objectivity, and repeatability of using the routine lateral cephalogram. Lamparski[6] in 1972 gave the standards of cervical vertebral maturation for boys and girls. Hassel and Farman[7] detailed these cervical vertebra maturation indexes and stated that the cervical vertebral analysis can be used in the assessment of skeletal maturity.

Dental maturity or dental age can be determined by the stage of tooth eruption but tooth formation has been proposed as a better method for determining dental maturation.[8,9] A widely used dental age assessment method was described by Demirjiyan in 1973[9] which was further revised in 1976.[10]

It has been suggested that racial variations also play a role in the relationship of dental and skeletal maturation.[1,11,12] Mappes et al[13] indicated that the predominant ethnic origin of the population, climate, nutrition, socioeconomic levels, and urbanization are causative factors of these racial variations. The dental ages of children in southern Germany were ahead of those of French-Canadian children until the age of 8, but after that the German children were behind.[14] Finnish and Norwegian children had advanced dental ages compared with French-Canadian children.

The correlation between calcification stage of individual teeth and skeletal maturity has been reported, and it was found that dental maturity is associated with skeletal maturity

in hand-wrist bone analysis. Little is known, however, about the association between tooth calcification stage and cervical vertebral maturation (CVM) stage. The aim of the present study was to investigate the association between dental and skeletal maturity by evaluating the correlation between tooth calcification stage and CVM stage.

MATERIALS AND METHODS

In this retrospective study, digital panaromic radiographs and lateral skull cephalograms of 50 North Karnataka children which included 26 girls and 24 boys, aged 7 to 16 years were selected from June 2011 to August 2011 (kodak 8000C digital panoramic and lateral cephalometric system). The images were viewed on a flat screen compaq TFT-LCD monitor with a resolution of 2906 × 2304 pixels in JPEG format with 24- bit grayscale. Inclusion criteria were availability of digital panaromic radiographs and lateral cephalograms with high clarity and good contrast and children of North Karnataka. Exclusion criteria included image deformity affecting the estimation of tooth development, hypodontia, gross pathology and missing mandibular permanent teeth except the third molars, any systemic disease that could affect general development and history of orthodontic treatment.

DENTAL MATURITY ASSESSMENT

Dental maturity was assessed according to the calcification stages of individual teeth.[9]

The developmental stages of the left mandibular permanent canines, first and second premolars, and second molars were rated on an 8-stage scale from (Figs 1 A to H).

A. Calcification of single occlusal points without fusion of different calcifications.
B. Fusion of mineralization points; the contour of the occlusal surface is recognizable.
C. Enamel formation is complete at the occlusal surface, and dentin formation has commenced. The pulp chamber is curved, and no pulp horn is visible.
D. Crown formation is complete to the level of the cementoenamel junction. Root formation has commenced. The pulp horns are beginning to differentiate, but the walls of the pulp chamber remain curved.
E. The root length remains shorter than the crown height. The walls of the pulp chamber are straight, and the pulp horns are more differentiated than in the stage D. In molars, the radicular bifurcation has started to calcify.
F. The walls of the pulp chamber form an isosceles triangle, and the root length is equal to or greater than the crown height. In molars, the bifurcation has developed sufficiently to give the roots a distinct form.
G. The walls of the root canal are parallel, but the apical end is partially open. In molars, only the distal root is rated.
H. The root apex is completely closed (distal root in molars). The periodontal membrane surrounding the root and apex is uniform in width throughout.

SKELETAL MATURITY ASSESSMENT

Skeletal maturity was evaluated by the CVM method.[15,16] According to the CVM method, the morphology of the bodies of the second (C2), third (C3), and fourth (C4) cervical vertebrae are rated on a 6-level scale from cervical stage CS1 to CS6: (Fig. 2).

CS1: The lower borders of all 3 vertebrae (C2-C4) are flat. The bodies of both C3 and C4 are trapezoid in shape.

CS2: A concavity is present at the lower border of C2. The bodies of both C3 and C4 are still trapezoid in shape.

CS3: Concavities at the lower borders of both C2 and C3 are present. The bodies of C3 and C4 may be either trapezoid or rectangular-horizontal in shape. The growth peak occurs the year after this stage.

CS4: Concavities at the lower borders of C2, C3 and C4 are present. The bodies of both C3 and C4 are rectangular-horizontal.

CS5: At least 1 of the bodies of C3 and C4 is square. If not square, the body of the other cervical vertebra is rectangular-horizontal.

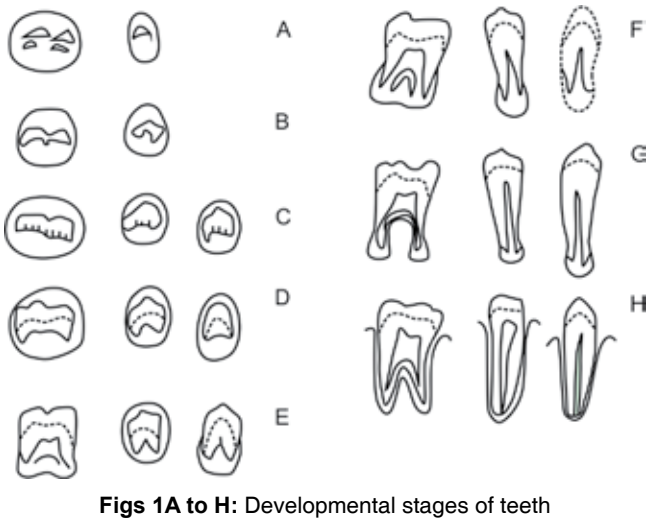
CS6: At least 1 of the bodies of C3 and C4 is rectangular-vertical in shape.

ASSESSMENT OF THE STUDY SAMPLE

All digital radiographs were viewed on the same computer. The stages of cervical vertebra development and tooth formation of each subject were assessed.

STATISTICAL METHOD

All statistical analyses were performed with SPSS for Windows, version 11.5. The mean age of each CVM stage and



Figs 1A to H: Developmental stages of teeth

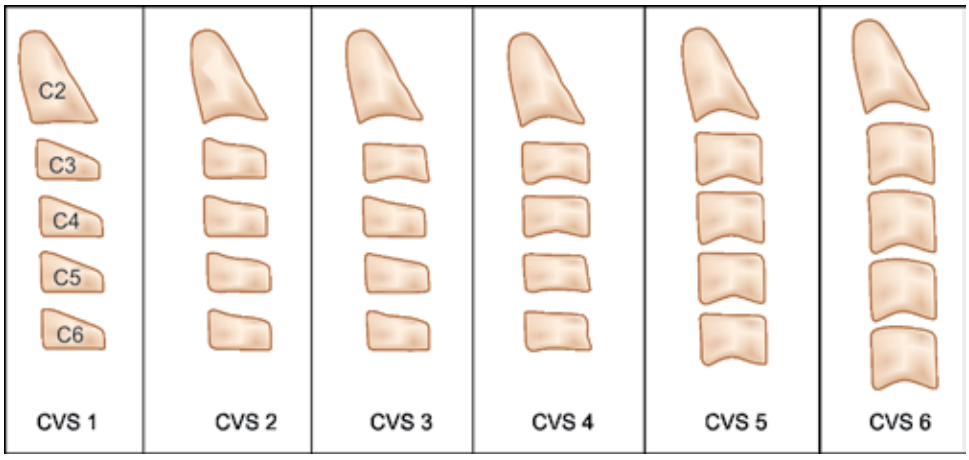


Fig. 2: Morphology of cervical vertebral bodies

each gender was calculated. Spearman rank-order correlation coefficients were used to measure the association between the skeletal maturity and dental maturity of individual teeth, and the statistical significance of the correlation was tested. To assess the associations between the stages of tooth mineralization and the stages of cervical vertebral maturation, cross tabulations were created and the percentages of patients for the combinations of stages determined. Separate cross tabulations were created for mandibular canines, first premolars, second premolars and second molars.

RESULTS

Distribution of the chronological ages of the subjects according to cervical vertebra maturation indexes is shown in Table 1. Mean and standard deviations of the chronological ages of the sexes according to cervical vertebral maturation indexes are listed. In the first five stages of the cervical vertebral maturity indexes, girls were younger than boys. In stage CS3, the mean chronologic age was 11.14 ± 1.46 years for girls and 12.5 ± 1.11 years for boys. There were no patients with CS6 stage in this study.

Spearman rank-order correlation coefficients between the cervical vertebral maturation stages and developmental stages for the 4 teeth are given in Table 2. All correlations between cervical vertebral and dental maturity stages were statistically significant ($p<0.05$). The correlation coefficients ranged from 0.403 to 0.531 for girls and from 0.461 to 0.512 for boys. For girls, the tooth sequence in order from the lowest to the highest correlation was canine (0.403), first premolar (0.452), second premolar (0.508) and second molar (0.531). For boys, the sequence was canine (0.461), second molar (0.491), first premolar (0.496) and second premolar (0.512).

The percentages of patients for the calcification stages and stages of CVM for each tooth are presented in Tables 3 and 4.

At CS1 (*see* Table 3), there was a wide variation in tooth calcification stages for all teeth in boys and girls. In both groups, the second premolar stage F had the highest percentage: 62.5% for boys and 50% for girls. In contrast, the second molar stage H had the lowest percentages: 0 for both girls and boys.

At CS2 the lower second molar stage F had the highest percentages: 66.7% for girls and 66.7% for boys (*see* Table 4).

At CS3, all of the studied teeth were calcified. During this period, for females stage G of canine had highest percentage (66.7%) and for males the second molar stage F had the highest percentage (66.7%) (Table 5).

At CS4, the calcification of the canine was nearly complete. As listed in Table 6, stage H canines were present in 66.7% of girls and 62.5% of boys.

Most of the studied teeth were well-formed by CS5. The canine stage H, first premolar stage H, second premolar

Table 1: Distribution of ages and genders (F/M) in the sample based on cervical vertebral maturity stages (CVS)

CVS	*Gender*	*N*	*Age (mean ± SD)*
1	M	6	9.16 ± 1.34
	F	8	8.37 ± 1.57
2	M	3	11.23 ± 0.44
	F	3	10.34 ± 1.68
3	M	6	12.5 ± 1.11
	F	6	11.14 ± 1.46
4	M	6	13.43 ± 1.35
	F	8	12.5 ± 2.23
5	M	2	16.03 ± 0.57
	F	2	15.33 ± 0.47

Table 2: Spearman correlation coefficients between cervical vertebral and dental maturity stages (C: Canine; P1: first premolar; P2: second premolar; M2: second molar)

	Male		*Female*	
	R	*p-value*	*R*	*p-value*
C	0.461	<0.01	0.403	<0.01
P1	0.496	<0.01	0.452	<0.01
P2	0.512	<0.01	0.508	<0.01
M2	0.491	<0.01	0.531	<0.01

stage H was highest in both genders 100% for girls, 100% for boys in CS5 stage (Table 7).

DISCUSSION

Several methods have been described to determine dental age. One of these uses time of eruption as a parameter. According to Nolla,[17] dental eruption has been reported to be more variable than the calcification sequence in the dentition. Also, tooth emergence can be altered by local factors, systemic diseases, and nutritional habits and so the reliability of the method is questionable. Therefore, in the present study, calcification stages of teeth were preferred for determining dental maturation. High accuracy was noted with these methods when applied to Indian populations.[18] Methods with measurements on radiographs as the basis for the determination of dental development use length of the tooth, the crown, or the root to indicate dental age. In some methods, the ratio of the developed root to the definitive length of the root is used. The disadvantage of these methods is estimating a quarter or a third of an unknown root length. Demirjiyan et al based their dental maturity scores on objective criteria rather than on absolute lengths. Foreshortened or elongated projections of developing teeth do not affect determinations. Therefore, this method was used in this study. Again in this study, maxillary teeth were not considered, because, superimposition of the anatomic structures such as the palate, the inferior border of the zygomatic arch or the maxillary sinus septum did not always permit us to assess the accurate developmental stage of the teeth.

Besides hand-wrist radiograph evaluation, the assessment of CVM is another method of assessing skeletal maturation. One of the main reasons for the increasing popularity of this method is avoidance of additional radiation exposure

Table 3: Percentage distribution of calcification stages of individual teeth at CVM stage 1

Calcification stage	*C*		*P1*		*P2*		*M2*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
D	0	0	0	0	0	0	0	16.7
E	12.5	0	37.5	0	0	16.7	12.5	16.7
F	12.5	16.7	50	50	62.5	50	50	33.3
G	50	33.3	12.5	33.3	25	16.7	37.5	33.3
H	25	50	0	16.7	12.5	16.7	0	0

Table 4: Percentage distribution of calcification stages of individual teeth at CVM stage 2

Calcification stage	*C*		*P1*		*P2*		*M2*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
F	33.3	33.3	33.4	33.3	33.3	33.3	66.7	66.7
G	33.4	33.3	33.3	33.3	33.3	33.3	33.3	33.3
H	33.3	33.4	33.3	33.3	33.3	33.3	0	0

Table 5: Percentage distribution of calcification stages of individual teeth at CVM stage 3

Calcification stage	*C*		*P1*		*P2*		*M2*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
E	0	0	16.7	0	16.6	0	0	0
F	16.7	16.7	16.7	16.8	16.7	33.3	66.7	50
G	33.3	66.7	33.3	50	50	50	33.3	50
H	50	16.6	33.3	33.2	16.7	16.7	6	0

Table 6: Percentage distribution of calcification stages of individual teeth at CVM stage 4

Calcification stage	*C*		*P1*		*P2*		*M2*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
E	0	0	0	0	0	0	12.5	0
F	12.5	16.7	25	33.3	25	33.3	25	33.3
G	25	16.6	37.5	33.4	37.5	33.3	37.5	50
H	62.5	66.7	37.5	33.3	37.5	33.4	25	16.7

Table 7: Percentage distribution of calcification stages of individual teeth at CVM stage 5

Calcification stage	*C*		*P1*		*P2*		*M2*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*
G	0	0	0	0	0	0	50	50
H	100	100	100	100	100	100	50	50

to the patient, as cervical vertebrae can be assessed on cephalometric radiographs which are frequently used in orthodontic diagnostics. According to the CVM method, CS1-CS2 indicates the period before the peak of growth; the pubertal growth spurt comes during CS3-CS4; and CS5-CS6 is the period after this peak.

The chronological age distribution in Table 1 shows that, in the first five stages of CVM (CVS1-CVS5), girls were younger than boys. This observation agrees with preceding studies.[19-26] Boys had a higher distribution toward late dental development in this study at the same cervical maturation stage. Therefore, a sex distinction must be made in estimating facial growth according to dental maturity.

Studies on the correlation between dental maturity and skeletal maturity are inconclusive. Lack of concordance may result from differences in evaluation methods of dental and skeletal maturity apart from the racial and ethnic differences. A statistically significant correlation was observed between maturity stages of the examined teeth and skeletal maturity stages for both the genders (*see* Table 2). In the present study, the development of the mandibular second molar had the highest correlation coefficient with CVM stage among female subjects. This is in concordance with the previous studies done by Chen et al,[23] Kumar et al[24] and Basaran et al.[25] Some investigators have suggested that the development of the second premolar has the highest correlation with skeletal maturation[20,26] in girls. In CS1 to CS2, the percentage distribution of stage F was 33.3 to 66.7%; in CS3 it was 50%. In CS4-CS5, the percentages of stage G were 50%.

For boys, the calcification of the mandibular second premolar had the closest relationship with CVM stage as in the previous studies done by Krailassiri et al.[20] Some studies[23,20] have also shown that the calcification of the mandibular canine had the highest correlation with CVM. The percentages for stage F were 33.3% to 62.5% for CS1-CS2. In CS3 the percentages of stage G were 50%. For stage H, the percentages were 37.5% to 100% for CS4 to CS5. Based on these results, a preliminary conclusion is that stage F of the mandibular second molar in women and stage G of the mandibular second premolar in men signify the beginning of the pubertal growth spurt in North Karnataka children.

The present results are preliminary due to the fact that it is the first study in this region to compare the CVM method of skeletal maturity evaluation with dental development indices. Moreover, the material consisting of 50 patients is not fully representative and for epidemiological purposes the studied group should be larger. In this study only canines, first and second premolars, and second molars were considered which allowed a limited comparison of dental development stages with skeletal maturity. Nevertheless, the results are a contribution to the still inconclusive discussion on interrelationships between the two most often applied measures of development—skeletal and dental maturity of growing patients.

CONCLUSION

In the studied group of children, a consistently earlier occurrence (approximately 6 months) of each skeletal maturation stage was found in females. A statistically significant, correlation between Demirjian's dental developmental stages and the maturation stages of the cervical vertebrae was determined. The level of correlation was different for individual teeth: the teeth showing the highest relationship with CVM classification were the second premolars in male subjects and second molars in female subjects. The studied dental index has relevance only for a few stages of the cervical vertebrae maturity index.

CLINICAL SIGNIFICANCE

The results confirm that both dental maturity and skeletal maturity should be assessed if the maturity stage of a growing child is relevant to clinical practice. The findings also indicate the usefulness of dental calcification stages as a simple first-level diagnostic tests to determine skeletal maturity.

REFERENCES

1. Chertkow S. Tooth mineralization as an indication of the pubertal growth spurt. Am J Orthod 1980;77:79-91.
2. Fishman LS. Chronological versus skeletal age, an evaluation of craniofacial growth. Angle Orthod 1979;49:181-189.
3. Demirjian A, Buschang PH, Tanguay R, Patterson DK. Interrelationships among measures of somatic, skeletal, dental, and sexual maturity. Am J Orthod 1985;88:433-438.
4. Chertkow S, Fatti P. The relationship between tooth mineralization and early evidence of the ulnar sesamoid. Angle Orthod 1979;49:282-288.
5. Sierra AM. Assessment of dental and skeletal maturity. A new approach. Angle Orthod 1987;57:194-198.
6. Lamparski DG. Skeletal age assessment utilizing cervical vertebrae (thesis). University of Pittsburg; Pittsburgh 1972.
7. Hassel B, Farman A. Skeletal maturation evaluation using cervical vertebrae. Am J Orthod Dentofacial Orthop 1995;107:58-66.
8. Moorrees CFA, Fanning FA, Hunt EE Jr. Age variation of formation stages for ten permanent teeth. J Dent Res 1963; 42(12):1490-1502.
9. Demirjiyan A, Goldstein H, Tanner JM. A new system for dental age assessment. Hum Biol 1973;45(2):211-227.
10. Demirjiyan A, Goldstein H. New system for dental maturity based on seven and four teeth. Ann Hum Biol 1976;3:411-421.
11. Krailassiri S, Anuwongnukroh N, Dechkunakorn S. Relationship between dental calcification stages and skeletal maturity indicators in Thai individuals. Angle Orthod 2002;72(2):155-166.
12. Uysal T, Sari Z, Ramoglu SI, Basciftci FA. Relationship between dental and skeletal maturity in Turkish subjects. Angle Orthod 2004;74(5):657-664.

13. Mappes MS, Harris EF, Behrents RG. An example of regional variation in the tempos of tooth mineralization and hand-wrist ossification. Am J Orthod Dentofacial Orthop 1992;101(2):145-151.
14. Frucht S, Schnegelsberg C, Schulte-Mönting J, Rose E, Jonas I. Dental age in southwest Germany, a radiographic study. J Orofac Orthop 2000;61(5):318-329.
15. Baccetti T, Franchi L, McNamara JA Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthod 2002;72(4):316-323.
16. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod 2005;11:119-129.
17. Nolla CM. The development of the permanent teeth. J Dent Child 1960;27:254-266.
18. Rai B, Kaur J, Anand S, Jain R, Sharma A, Mittal S. Accuracy of the Demirjian Method for the Haryana Population. Internet J Dent Sci 2008;6(1). Available at: http://www.ispub.com/journal/the_internet_journal_of_dental_science/volume_6_number_1_7/article/accuracy_of_the_demirjian_method_for_the_haryana_population.html.
19. Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. Angle Orthod 1982;52(2):88-112.
20. Krailassiri S, Anuwongnukroh N, Dechkunakorn S. Relationship between dental calcification stages and skeletal maturity indicators in Thai individuals. Angle Orthod 2002;72(2):155-166.
21. Uysal T, Sari Z, Ramoglu SI, Basciftci FA. Relationship between dental and skeletal maturity in Turkish subjects. Angle Orthod 2004;74(5):657-664.
22. Grave KC, Brown T. Skeletal ossification and the adolescent growth spurt. Am J Orthod 1982;82(4):299-309.
23. Chen J, Hu H, Guo J, Liu Z, Liu R, Li F, Zou S. Correlation between dental maturity and cervical vertebral maturity. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;110(6):777-783.
24. Kumar S, Singla A, Sharma R, Virdi MS, Anupam A, Mittal B. Skeletal maturation evaluation using mandibular second molar calcification stages. Angle Orthod 2012 May;82(3):501-506.
25. Basaran G, Özer T, Hamamcı N. Cervical vertebral and dental maturity in Turkish subjects. Am J Orthod Dentofacial Orthop 2007;131(4):447.e13-447.e20.
26. Różyło-Kalinowska I, Kolasa-Rączk A, Kalinowski P. Relationship between dental age according to Demirjian and cervical vertebrae maturity in polish children. Eur J Orthod 2011 Feb;33(1):75-83.