Journal section: Clinical and Experimental Dentistry *doi:10.4317/jced.3.e18*
Publication Types: Research

Establishing a diagnostic tool for assessing optimal treatment timing in Indian children with developing malocclusions

Kanu Priya Gupta[1], Shalini Garg [2], Partapjot S. Grewal [3]

[1] B.D.S., M.D.S. Pedodontics & Preventive Dentistry, Senior Lecturer, National Dental College, Derabassi, Punjab.
[2] B.D.S., M.D.S. Pedodontics & Preventive Dentistry, Professor & Head of Department, M.M. College of Dental Sciences & Research, Mullana, Ambala.
[3] B.D.S., M.D.S. Prosthodontics. Senior Lecturer, BRS Dental College & Hospital, Sultanpur, Barwala

Correspondence:
H. No. 535, Sector-10, Panchkula,
Haryana India.
Email: dentico_kanupriya@yahoo.com

Received: 12/10/2010
Accepted: 05/01/2011

Gupta KP, Garg S, Grewal PS. Establishing a diagnostic tool for assessing optimal treatment timing in Indian children with developing malocclusions. J Clin Exp Dent. 2011;3(1):e18-24.
http://www.medicinaoral.com/odo/volumenes/v3i1/jcedv3i1p18.pdf

Article Number: 50416 *http://www.medicinaoral.com/odo/indice.htm*

eMail: jced@jced.es

Abstract

Objective: To interrelate chronological age, cervical vertebrae maturational stage and dental calcification stages and to establish latter as first level diagnostic tool to estimate timing of pubertal growth spurt.

Materials and Methods: Sample derived from pretreatment panaromic and lateral cephalometric radiographs of patients 8-14 years old. Study sample divided into three groups depending upon Angle's molar relation: Group I, Group II, Group III. According to chronological age, into: Group A: 8-11 years Group B:11-14 years, further separating males and female subjects in each group. Demirjian et al method was used to assess dental maturity and for skeletal maturity the New Improved Version of Cervical Vertebrae Maturation Method by Baccetti, Franchi and Mc Namara. Statistical analysis was performed using SPSS software package. Chi Square test and Spearman rank-order correlation coefficients measured the association between skeletal maturity indicators and dental calcification stages and statistical significance tested.

Results&Conclusions: In females, permanent mandibular second molar Stage E signified circumpubertal phase corresponding with skeletal age CVMS II and for males, it was permanent mandibular first premolar stage E. Early orthodontic interventions for Angle's Class I and Class II malocclusions should be performed at the circumpubertal period represented by CVMS II in Indian children and for Angle's Class III malocclusion, facemask therapy beneficial in the prepubertal phase. Females showed higher significant correlation among skeletal and dental calcification stages compared to males.

Key Words: *Chronological age, skeletal age, dental age, developing malocclusion, optimal treatment timing.*

Introduction

It has been well established till date that timing forms a fundamental part of any kind of treatment planning in orthodontics, with special regard to dentofacial orthopedics. This relation becomes even more important in various malocclusion groups where difference in intervention time has been documented.(1) Starting treatment in a growing patient significantly effects the correction of disharmonies in sagittal, transverse, and vertical planes. (2,3)

The relationship between the development of dentition and skeletal maturation has been investigated, studies referring mainly to the correlations between formation of teeth (mandibular permanent canines and second molars) and onset of pubertal growth spurt have led the way.(4-6) Unfortunately, little is known for this relationship in Indian boys and girls and earlier studies strongly strengthen the concept that growth and maturation standards differ widely in Indian children and Western population due to climatic, nutritional, socioeconomic and racial influences.(7,8) This difference and its clinical applicability need to be studied in relation to skeletal as well as dental maturity for Indian boys and girls to assess treatment timings in both sexes for various malocclusion groups. This study is unique in its sense that we have evaluated the correlation for all the three malocclusion groups as formulated by Angle separately, keeping in mind the different growth pattern and different intervention time for all the three malocclusion groups (Class I, Class II and Class III malocclusion). The issue of growth in these subjects has become more relevant because of the increasing interest in optimizing treatment timing in dentofacial orthopedics. But no study in recent literature has evaluated this correlation in these malocclusion groups with scanty data available in context of Indian children. Information on growth trends in malocclusion groups is needed for both effective treatment planning and reasonable expectations in terms of stability of treatment outcomes.

The aim of our study is thus to evaluate the interrelationship of chronological age, cervical vertebrae maturational stages and dental calcification stages as growth indicators in different malocclusion cases reported for dental treatment. Another important parameter, the sexual variation will be considered for population group of 8-14 year children, as literature suggests different pubertal timings for males and females.(9-11)

Thus a more clinically relevant method of assessment of puberty growth spurt by dental calcification stages of teeth in routine dental radiographs is established and applied to determine the optimal treatment timing in various malocclusion groups of Indian children. It will be valuable in the fields of diagnostic, preventive and interceptive orthodontics, planning of growth modification treatments in developing malocclusions, pediatric forensic odontology and pediatric endocrinology.

Material and Method

The sample for the study was derived from pretreatment panaromic and lateral cephalometric radiographs of patients visiting our dental outpatient department with chief complaint of irregular teeth with different malocclusions. Sample selection criteria was strictly based on the pretreatment diagnostic radiographs of patients who have reported with different malocclusions and required orthodontic intervention after obtaining the informed consent from their parents/guardians regarding use of the radiographs for the study. Radiographs of good quality and high contrast were included. The sample consisted of 100 pretreatment panaromic and lateral cephalometric radiographs each of patients of chronological age 8-14 years.The sample distribution into the three groups was totally dependent on patients reporting with various malocclusion problems. The distribution of the study subjects according to the Angle's molar relationship, chronological age and sex is shown in *Table 1*.

Exclusion criteria were:

i.Radiographs of poor quality

ii.Radiographs showing obvious dental pathology.

Sample Distribution

The study sample was divided into three groups depending upon the molar relation according to Angle's classification as:

Group I – Angle's Class I molar relationship

Group II – Angle's Class II molar relationship

Group III – Angle's Class III molar relationship

Type of molar relation	Age Group	Sex	No. of subjects	Total subjects
Class I	8-11	Males	12	34
		Females	07	
	12-14	Males	07	
		Females	08	
Class II	8-11	Males	16	56
		Females	11	
	12-14	Males	15	
		Females	14	
Class III	8-11	Males	06	10
		Females	01	
	12-14	Males	03	
		Females	-	

Table 1. *Distribution of all subjects grouped by type of molar relation according to Angle's classification*

Following this, sample was distributed according to the chronological age of child into two groups:
Group A : 8-11 years and Group B : 12-14 years. These groups were further subdivided separating the males and female subjects in each group.

Assessment of dental calcification stage

Tooth calcification was rated according to Demirjian et al(12), one of 8 stages of calcification, A to H, was assigned for each tooth, permanent left mandibular canine, first premolar, second premolar, second molar and third molar were traced from the orthopantomograms (Figure 1) In case of any missing left mandibular teeth or any rotations, the right teeth corresponding to the particular tooth was examined.

Fig. 1. *A representative OPG from the study sample showing dental calcification stages assigned to left permanent mandibular teeth on tracing according to Demirjian et al 1973*

Assessment of skeletal age

The lateral profile changes of the second, third and fourth cervical vertebrae were assessed and assigned the cervical vertebrae maturation stage(CVMS) using the New Improved Version of the Cervical Vertebral Maturation (CVM) Method given by Baccetti, Franchi and Mc Namara in 2002(13) (Figure 2)

All statistical analysis was performed using the SPSS software package (SPSS for Windows 07, version 13.0, SPSS Inc, ChicagoIII). Chi Square test was used to study the relationship between the chronological age and sex with the stage of skeletal maturation and the stage of calcification of the teeth for a particular group.

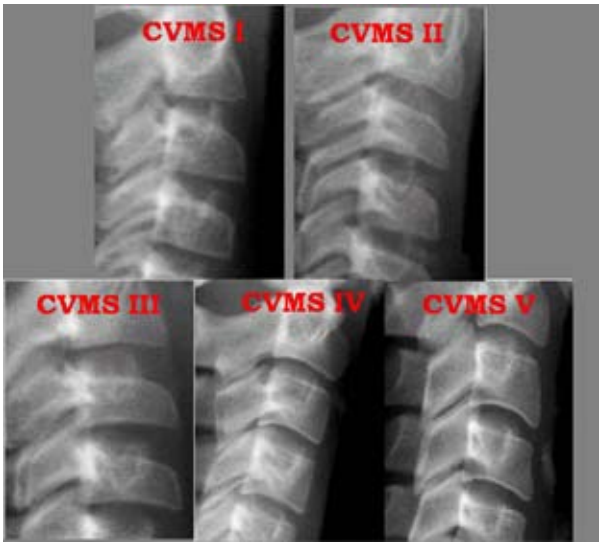


Fig. 2. *The New improved CVM Method (five developmental stages,CVMS I through CVMS V) as given by Baccetti, Franchi and Mc Namara in 2002*

The Spearman rank-order correlation coefficients were estimated to measure the association between skeletal maturational indicators and dental calcification stages of individual teeth, and the statistical significance of the correlation tested.

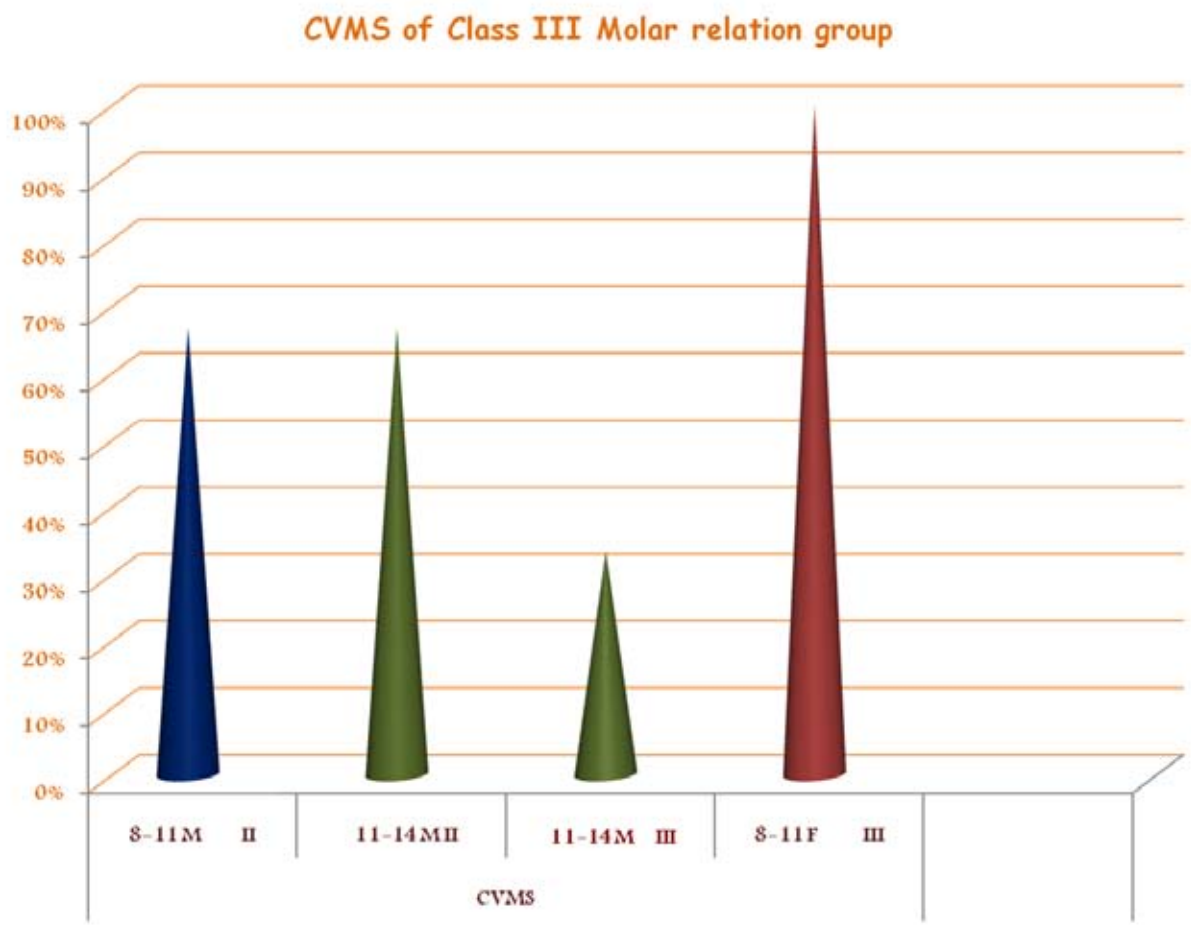
To test the reproducibility of assessment of dental developmental stage and skeletal maturation stages of cervical vertebrae, two investigators re-evaluated randomly selected panoramic and cephalometric radiographs from 10 of the same male subjects and 10 of the same female subjects 4 weeks after the first evaluation for each group. Intra- and inter examiner reproducibility were tested and the differences double interpretations were statistically tested.

Results

The highest percentage distributions of skeletal maturation stages (CVMS) for Angle's different molar relationship groups (Class I, II and III) respectively are shown in *Table 2*

Angle's Molar relation Group	Cervical Vertebrae Maturation Stages			
	8-11 Males	12-14 Males	8-11 Females	12-14 Females
Class I	I 66.7%	II 85.7%	II 57.1% / I 42.9%	IV 87.5%
Class II	II 43.8%	II 60%	II 72.7%	IV 64.3%

Table 2. *Highest percentage distribution of cervical vertebrae maturation stages for Class I and II Molar relations Group.*



Graph 1. *Highest percentage distribution of cervical vertebrae maturation stages for all subjects in Angle's Class III molar relation group*

In Class III Angle's molar relation group (Graph 1):
Out of the total sample of 10 subjects in this malocclusion group, the percentage distribution for the four groups were: *Younger male group* (6 subjects) showed *CVMS II* (66.7%). *In older male group (3* subjects) two presented with *CVMS II* and one with *CVMS III*. *In the younger female group*, only one girl was there who showed CVMS III compared to CVMS I/II for the Class I and Class II malocclusion groups.

The CVMS and calcification stages of each of the studied teeth with highest percentage distribution according to distribution of chronological age and sexual dimorphism is shown in *Table 3*

The Spearman rank-order correlation coefficients between the CVMS *and the dental calcification stage* were calculated (*Table 4*):

For females, all correlations between skeletal and dental stages were *statistically significant at P < .01 signifi-*

Age Group & Sex	CVMS		Canine	1st Premolar		2nd Premolar	2nd Molar		3rd Molar	
8-11 Males	**I** 44.1%	**II** 44.1%	**F** 61.8%	**E** 47.1%		**E** 55.9%	**E** 44.1%	**D** 38.2%	**A** 32.4%	**B** 32.4%
12-14 Males	**II** 64%		**G** 48%	**G** 60%		**F** 52%	**F** 44%	**E** 40%	**D** 44%	
8-11 Females	**II** 66.66%		**F** 61.1%	**E** 38.9%	**F** 33.3%	**E** 50%	**E** 72%		**A** 44.4%	
12-14 Females	**IV** 69.56%		**H** 56.5%	**H** 56.5%		**G** 52.2%	**G** 65.2%		**E** 52.2%	

Table 3. *Highest percentage distribution of stages (skeletal and dental) according to chronological age and sex distribution*

Tooth	Correlation Coefficients			
	Females		Males	
	r	Significance	r	Significance
Canine	.540	**	.324	*
1st Premolar	.592	**	.393	**
2nd Premolar	.634	**	.195	
2nd Molar	.659	**	.277	*
3rd Molar	.544	**	.176	

* $P < 0.05$

** $P < 0.01$

Table 4. *Correlation coefficients of subjects (males and females) between cervical vertebrae stages and dental calcification stages*

cance level.

For males, only *first premolar presented with significant correlation at P<.01significance level. Canine and second molar* were *statistically significant at P<0.05 significance level*.

The correlations ranged from .540 to .659 for females and .176 to .393 for males.

In females, the tooth sequence in order of the *highest to lowest correlation* was:

Second molar > second premolar > first premolar > third molar > canine

In males the corresponding sequence was:

First premolar > canine > second molar

From above findings it can be interpreted that for younger females (8-11years) CVMS II showed highest percentage with maximum correlation to permanent mandibular second molar Stage E; in older females (12-14years) CVMS IV was most common with highest correlation with stage G of permanent mandibular second molar.

In young males (8-11years) both CVMS I and II were common in maximum correlation with permanent mandibular first premolar stage E; in older males (12-14years) CVMS II presented with highest percentage in maximum correlation to stage G of permanent mandibular first premolar.

The reproducibility of all the assessments was found to be good, with high coefficient values. *The coefficients of reliability* were found to be between .986 and .998 for dental calcification stage assessment and between .990 and 1.000 for the skeletal maturity assessments. No significant intra- or interobserver differences ($P > .05$) were observed.

Discussion

The present study was carried out in different malocclusion groups to establish correlation between chronological age, cervical vertebrae maturation stage (CVMS) and dental calcification stage in Indian children. Clinicians and researchers have shown enough evidence that growth and development of dentofacial structures and hence their growth modifications time is different in different malocclusion groups. This study is an attempt to decide logically, the most controversial early orthodontic treatment time in Angles molars relationship: Class I,II and III.

According to Indian literature, pubertal spurt in females begins as early as 10 years or even early and mean age of menarche is 12.6years. While in males, the pubertal spurt period is from on an average 13-16 years.(10) With these viewpoints we divided our study group of 8-14 year old children with orthodontic treatment needs in two subgroups of 8-11 and 12-14 years and evaluated them separately for males and females.

The dental formation stages were evaluated using the Demirjian's method.(12) The cervical vertebral development was evaluated using the New Improved Version of the Cervical Vertebral Maturation (CVM) Method by Baccetti, Franchi and McNamara in 2002. This is a simplified method compared to the earlier proposed methods as: Interpretation of phase of patient in growth curve is easier by reducing the stages from six to five, definition of cervical vertebral morphology at each developmental stage that allows the clinician to apply the information derived from a single cephalogram and avoids definition of stages based on comparative assessment of between-stage changes as was in the previous methods.(13)

The sample for our study demonstrated distribution according to the prevalence of various malocclusions groups seen in Indian population i.e Class II cases showing maximum number while Class III showing minimum number of cases studied. The results showed that the females were consistently ahead of males in attaining skeletal maturity in all groups as observed by the advancement in CVMS which was in accordance with information published in several studies.(9,14-16) Regarding the skeletal maturation in malocclusion groups, it was

observed that in Angle's Class I group 66.7% of males had CVMS I but in Angle's Class II malocclusion group, 43.8% (highest) presented with CVMS II stage(*Table 2*). *Signifying little advancement in skeletal maturity in males with Angle's Class II compared to the Angle's Class I malocclusion group.* According to *Profitt*, to treat Class I moderate crowding, starting treatment just at the end of mixed dentition (circumpubertal period) and maintaining leeway space facilitates a non extraction treatment making it the gold standard time.(17,18) For a patient with crowding in early mixed dentition(prepubertal period) we have options of serial extraction and expansion, with expansion currently being a popular approach. (17,19) To assess prepubertal and circumpubertal period for most effective growth modification therapy in Angle's Class I malocclusion, the results of our study can be applied. For e.g. *it would be best time to treat Angle's Class I crowding indicated by expansion in a female showing Stage E of permanent mandibular second molar signifying that she has reached the circumpubertal phase corresponding with CVMS II.*

Our interpretation supports the theory of starting treatment early in patients with Angle's Class II malocclusion to achieve optimal results. Various studies provide evidence of significant increase in mandibular growth with pubertal spurt(11,20,21) *(CVMS II to CVMS III according to Improved CVM Method) in Angle's Class II and Class I subjects.* The absolute amount of mandibular lengthening at pubertal peak, however, is significantly smaller in Class II subjects than in those with normal occlusion. Clinical relevance is thus emphasized, that when we consider therapeutic modalities such as functional jaw orthopedics they have greatest effectiveness when they include the pubertal growth spurt in the active treatment period.(22,23) The bottom line: if you start growth modification too late (postpubertal);it doesn't work;if you start it too soon(prepubertal), it takes too long i.e. *circumpubertal period according to our study is shown by attainment of dental calcification stage E of permanent mandibular second molar in females and stage G of permanent mandibular first premolars in males, could be the best time to intervene for Class II malocclusion cases.*

For Angle's Class III malocclusion group, the skeletal age of younger males was CVMS II, signifying rapidly advancing skeletal maturity compared to other malocclusion groups, similar results seen in younger females, where CVMS III was observed, even in older male group CVMS III has been achieved, being ahead than younger males. For Angle's Class III malocclusion cases, treatment timing depends on distinguishing between mandibular prognathism and maxillary deficiency.(17) *Data shows that facemask treatment to modify growth in maxillary deficient children succeeds if and only if, the treatment is done quite early(24,25*) *According to this, best treatment timing for facemask therapy should be early prepubertal phase i.e. CVMS I or dental calcification stages upto the crown formation stage for different mandibular teeth considered in our study.*

Another highlighting fact on sexual dimorphism in one respect of our study was the accelerated pubertal spurt in Indian females compared to males confirming the previous reports.(26,27) As evident females have achieved CVMS IV in the older age group (12-14years) compared to CVMS II in the older males group, signifying that peak in growth has already occurred around one year back in older females while in males the spurt will occur within one year at this age. Thus, pointing *to take advantage of pubertal growth spurt, orthopedic treatment should be initiated earlier in females than males for whom the treatment period is longer as they attain skeletal maturity later*.

When dental calcification stages were considered, it was found that with increase in chronological age, females showed advanced dental maturity (i.e. 2 stages ahead) from younger females; compared to the older males who were one stage ahead from younger males. Spearman correlation coefficients for females between skeletal and dental stages were highly statistically significant at $p<0.01$. Second molar showed highest correlation ($r=.659$). In younger males (8-11years), first premolar showed the highest correlation ($r= .393$)with CVMS I to II(prepubertal) and in older males(12-14years) it has reached Stage G, along with attained CVMS II(circumpubertal). These findings for maximum correlation with second molar and premolars were in accordance with findings of *Uysal et al(27)and Krailassiri et al(6)*. When comparing the calcification stages of males and females in same age group, same level of dental maturity was observed in younger age group and advanced dental maturity of females than males in the older group, this was in accordance with studies conducted before and those of *Hagg & Taranger* who also found that dental eruption was earlier in females than in males.

Finally, main purpose of assessment i.e. to establish stage/stages of tooth formation as first level diagnostic tool to estimate the timing of pre peak, peak and post peak periods is evident. Optimal treatment timing now can be judged without resorting to the need of any other radiograph than routine dental radiographs i.e. OPGs or IOPAs without resorting to hand wrist radiographs or serial recordings of annual increase in stature or even lateral cephalograms. Also estimation of puberty and related developmental periods, now by means of dental calcification stages according to our study have a significant role even in the field of pediatric forensic odontology because of the fact that the calcified dental structures are not easily destroyed with time and prove to be beneficial in age estimation.

Conclusions and Clinical Applicability

Scanty data exists regarding treatment timing for different malocclusion groups i.e. Is treatment timing different in different malocclusions? It was felt that there was a need to carry out a study of this nature to establish a valid, simple, economical and ready to use clinical tool to assess the optimal treatment time for a growing child seeking early treatment of developing malocclusions. Following conclusions were drawn:

- In females, permanent mandibular *second molar showing Stage E* signifies *circumpubertal phase* corresponding with skeletal age of CVMS II, while *Stage G* of same tooth signifies the *postpubertal* period corresponding with skeletal age of CVMS IV.
- In males, permanent mandibular *first premolar showing stage E* signifies the *circumpubertal phase* corresponding with skeletal age of CVMS II.
- Early orthodontic interventions for *Angle's Class I and Class II malocclusions* should be performed at the *circumpubertal period represented by CVMS II in Indian* children as not much difference was observed in skeletal maturity stage for these in our population group.
- For *Angle's Class III* malocclusion, in younger females (8-11years) and older males(12-14years) *CVMS III* representing the postpubertal phase was observed signifying need for early orthodontic intervention (facemask therapy) in *prepubertal phase* for this group.
- In females the correlation between skeletal and dental calcification stage for each tooth can be represented from highest to lowest correlation as:

  Second molar > second premolar > first premolar > third molar > canine

For males the order is:

First premolar > canine > second molar

Our study will be specifically helpful in planning treatment for *early orthodontic intervention* for various *developing malocclusions* in Indian children. However, a larger sample is required to confirm the results particularly in relation to Angle's Class III malocclusion. Our results may not be applied to other population groups, so further study is required in this field.

References

1. Franchi L, Baccetti T, McNamara JA Jr. Mandibular growth as related to cervical vertebral maturation and body height. Am J Orthod Dentofacial Orthop. 2000;118:335-40.
2. Franchi L, Baccetti T, De Toffol L, Polimeni A, Cozza P. Phases of the dentition for the assessment of skeletal maturity: A diagnostic performance study. Am J Orthod Dentofacial Orthop. 2008;133:395-400.
3. Soegiharto BM, Cunningham SJ, Moles DR. Skeletal maturation in Indonesian and white children assessed with hand-wrist and cervical vertebrae methods. Am J Orthod Dentofacial Orthop. 2008;134:217-26.
4. Chertkow S. Tooth mineralization as an indicator of the pubertal growth spurt. Am J Orthod Dentofacial Orthop. 1980;77:79-91.
5. Coutinho S, Buschang PH, Miranda F. Relationships between mandibular canine calcification stages and skeletal maturity. Am J Orthod Dentofacial Orthop. 1993;104:262-8.
6. Krailassiri S, Anuwongnukroh N, Dechkunakom S. Relationships between dental calcification stages and skeletal maturity indicators in Thai individuals. Angle Orthod. 2002;72:155-66.
7. Nanda RS, Chawla TN. Growth and development of dentitions in Indian children. I. Development of permanent teeth. Am J Orthod. 1966;52: 837-53.
8. Santos EC, Bertoz FA, Arantes F de M, Reis PM, de Bertoz AP. Skeletal maturation analysis by morphological evaluation of the cervical vertebrae. J Clin Pediatr Dent. 2006; 30:265-70.
9. Bjork A, Helm S. Prediction of the age of maximum pubertal growth in body height. Angle Orthod. 1967;37:134-43.
10. Agarwal DK, Agarwal KN, Upadhyay SK, Mittal R, Prakash R, Rai S. Physical and sexual growth pattern of affluent Indian children from 5 to 18 years of age. Indian Pediatr 1992;29:1203-82.
11. Hunter WS, Baumrind S, Popovich F, Jorgensen G. Forecasting the timing of peak mandibular growth in males by using skeletal age. Am J Orthod Dentofacial Orthop. 2007;131:327-33.
12. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. Hum Biol 1973;45:211-27.
13. Baccetti T, Franchi L, McNamara JA. An improved version of the cervical vertebral maturation(CVM) method for the assessment of mandibular growth. Angle Orthod. 2002;72:316-23.
14. Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. Angle Orthod. 1982;52:88-112.
15. Hagg U, Taranger J. Maturation indicators and the pubertal growth spurt. Am J Orthod.1982;82:299-309.
16. Uysal T, Ramoglu SI, Basciftci FA, Sari Z. Chronologic age and skeletal maturation of the cervical vertebrae and hand-wrist: Is there a relationship? Am J Orthod Dentofacial Orthop. 2006;130:622-8.
17. Proffit WR. The timing of early treatment: An overview. Am J Orthod Dentofacial Orthop. 2006;129:S47-9.
18. Gianelly AA. Treatment of crowding in the mixed dentition. Am J Orthod Dentofacial Orthop. 2002;121:569-71.
19. Suda N, Ishii-Suzuki M, Hirose K, Hiyama S, Suzuki S, Kuroda T. Effective treatment plan for maxillary protraction: Is the bone age useful to determine the treatment plan? Am J Orthod Dentofacial Orthop. 2000;118:55-62.
20. Tulloch JF, Phillips C, Koch G, Proffit WR. The effect of early intervention on skeletal pattern in Class II malocclusion: A randomized clinical trial. Am J Orthod Dentofacial Orthop. 1997;111:391-400.
21. Stahl F, Baccetti T, Franchi L, McNamara JA Jr. Longitudinal growth changes in untreated subjects with Class II Division 1 malocclusion. Am J Orthod Dentofacial Orthop. 2008;134:125-37.
22. Malmgren O, Omblus J, Hagg U, Pancherz H. Treatment with an orthopedic appliance system in relation to treatment intensity and growth periods. A study of initial effects. Am J Orthod Dentofacial Orthop. 1987;91:143-51.
23. Houston WJB, Miller JC, Tanner JM. Prediction of the timing of the adolescent growth spurt from ossification events in hand wrist films. Br J Orthod. 1979;6:145-52.
24. Kapust AJ, Sinclair PM, Turley PK. Cephalometric effects of face mask/expansion therapy in Class III children: a comparison of three age groups. Am J Orthod Dentofacial Orthop. 1998;113:204-12.
25. Baccetti T, McGill JS, Franchi L, McNamara JA Jr, Tollaro I. Skeletal effects of early treatment of Class III malocclusion with maxillary expansion and face-mask therapy. Am J Orthod Dentofacial Orthop. 1998;113:333-43.
26. Kamal M, Ragini, Goyal S. Comparative evaluation of hand wrist radiographs with cervical vertebrae for skeletal maturation in 10-12 years old children. J Indian Soc Pedo Prev Dent. 2006;24:127-35.
27. Uysal T, Sari Z, Ramoglu SI, Basciftci FA. Relationships between dental and skeletal maturity in Turkish subjects. Angle Orthod. 2004;74:657-64.