ORIGINAL RESEARCH

Treatment Predicament for Pediatric Dentist: Gender-wise Comparative Correlation of Biological and Chronological Age in 8–15-year-old Children

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Abstract

Introduction: The chronological age (CA) of a patient does not always correspond to the events of growth surge; therefore treatment strategies need good knowledge of biological markers.

Aim: The aim of the present study was to investigate the relationships between the skeletal age (SA), dental age (DA), and CA along with the stages of calcification of teeth and the cervical vertebral maturity (CVM) stages in Indian subjects.

Materials and methods: A sample of 100 pairs preexisting radiographs, both orthopantomogram and lateral cephalogram, of the individuals in the age-group of 8–15 years were procured and were analyzed for the level of dental and skeletal maturity using Demirjian scale and cervical vertebral maturity index, respectively.

Results: A high correlation coefficient (r) was found to be 0.839 ($p = 0$) between chronological and dental age (DA), 0.833 ($p = 0$) between chronological and skeletal age (SA), and 0.730 ($p = 0$) between skeletal and DA.

Conclusion: The current research showed that the overall correlation between all three ages was found to be high. It was found that the SA assessed by the CVM stages had a high correlation with the CA.

Clinical significance: Within the limits of the present study, there exists a high degree of correlation between biological ages and chronological age, but still it is imperative for a correct assessment of biological age of individual patients for quality treatment outcomes.

Keywords: Age assessment, Cervical vertebral stages, Chronological age, Demirjian method, Dental age, Lateral cephalogram, Orthopantomogram, Skeletal age.

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Introduction

In children with underlying growth conditions, the planning and sequelae of orthodontic treatment can be gauged by prompt evaluation of skeletal maturity. The ideal setup for dentofacial orthopedics is linked to the identification of phases of augmented growth which can add to the modification of skeletal abnormalities, while the remaining growth posttreatment could be significant in envisaging relapse.[1–3]

Maturational indices are extremely useful for assessing the level of skeletal maturity in growing subjects prior to any orthodontic or orthopedic treatment.[4,5] The changes in the morphology of cervical vertebrae in growing individuals have emerged as a biological indicator of skeletal maturity. Various studies have supported the utilization of growth modifications in cervical vertebrae, as demonstrated on lateral cephalogram, to be an important parameter for skeletal maturity assessment, thereby eliminating the need for taking an additional radiograph.[6,7] Assessment of maturation of cervical vertebrae is done to gauge the adolescent growth spurt effectively, thereby acting as an effective diagnostic aid for enhanced treatment planning.[8–10]

The aim of the present study was to investigate the relationships between the skeletal, dental, and CA along with the stages of calcification of teeth and the cervical vertebral maturity stages in Indian subjects. The results from this study should be helpful in determining a valid clinical tool for indicators of the pubertal growth period and pubertal spurt with no need to resort (exposing) to handwrist radiographs.

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Materials and Methods

The research model was based on a retrospective cross-sectional study design. The sample was derived from archives of the Department of Oral Medicine and Radiology. The following parameters were established for sample inclusion: Indian subjects with normal growth and development, no systemic disease, no dental anomalies, no extractions of permanent teeth (third molars excluded), no history of orthodontic treatment, no history of trauma of teeth and face, and panoramic and lateral cephalometric radiographs available with high clarity and good contrast.

A total of 100 subjects (53 males and 47 females) met the inclusion criteria. The radiographic evaluation and staging of each and every record was comprehensively carried out by a single

examiner who was trained and calibrated by the chief researcher so as to limit examiner bias. A training module was prepared covering the aspects of stage assessment based on the Demirjian method for evaluating DA and cervical vertebral maturation (CVM) stages based on modified Lamparski's stages for SA.[5,11] Training sessions were organized by the chief researcher to train the examiner, and at the end of the session, the assessment was done by assigning a set of 10 samples randomly selected from the age-group of 8–15 years. The examiner was considered calibrated when all the 10 assessed samples matched with one another in subsequent assessments. The recordings were made on a self-designed pro forma.

Assessment of DA

Dental age (DA) was evaluated from a panoramic radiographs of the mandibular teeth on the left side. Tooth calcification was rated from stages A to H according to the method of Demirjian et al. for each tooth (Fig. 1).[5]

Assessment of CVM Index

The SA assessment was done using the lateral cephalogram. The morphology of the cervical vertebrae (C2–C6) was assessed, and CVM stages were assigned through stages I–VI (Fig. 2) based on modified Lamparski's stages (2000).[11]

Statistical Analysis

Statistical analysis was performed with the Statistical Package for the Social Sciences software package (version 21). Descriptive statistical analysis was done by calculating the mean and standard deviations (SD) of CA, dental maturity, and cervical vertebral maturity index. The Pearson's r was used to correlate chronological, dental, and skeletal maturity.

To assess the reliability, 25 randomly selected radiographs, both panoramic and lateral cephalometric, were reevaluated 4 weeks later by the same investigator, and Spearman–Brown formula was used to assess the results.

Result

The present retrospective study was carried out to associate and analyze skeletal, dental, and chronologic age in a sample of 100 subjects belonging to the age-group of 8–15 years.

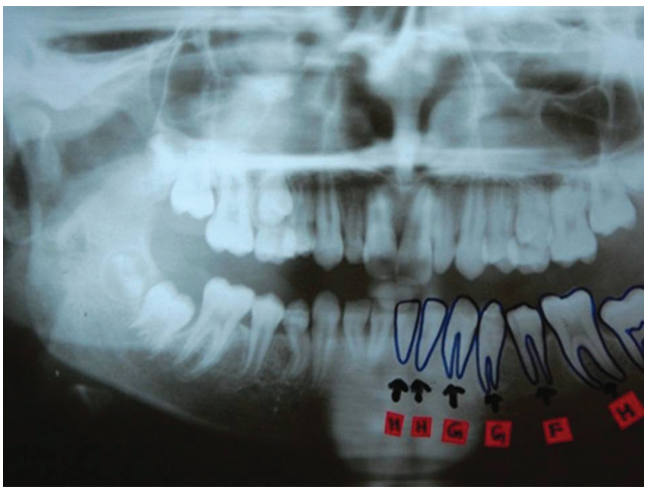

Fig. 1: OPG showing Demirjian stages [courtesy of Saranya B, Ahmed J, Shenoy N, Ongole R. Comparison of skeletal maturity and dental maturity–a radiographic assessment. Sch J App Med Sci. 2013; 1(5): 427–431]

Descriptive statistical analysis was carried out, and the mean chronological, skeletal, and DA was calculated as 139.92 ± 27.24, 135.21 ± 20.46, and 149.24 ± 33.77, respectively (Table 1).

The age distribution was done according to the cervical vertebral stage, and the mean chronological, skeletal, and DA observed were 106.1 ± 12.81, 103.7, and 107.43 in cervical vertebral stage 1 (CVS), respectively; 124.8 ± 27.62, 115.2, and 126.24 ± 28.86 in CVS 2, respectively; 127.55 ± 14.93, 128, and 143.46 ± 27.24 respectively in CVS 3. In CVS 4, the mean chronological, skeletal, and DA observed were 147 ± 15.38, 140.2, and 160.2 ± 22.11, respectively; 162 ± 15.03, 152.7, and 171.2 ± 20.33 respectively in CVS 5; and 170.18 ± 11.77, 165.1, and 178.25 ± 18.25 in CVS 6, respectively (Table 2 and Fig. 3).

Gender-wise distribution of CA corresponding to each cervical stage was done. The mean age was found to be 110.66 ± 13.59 in females and 102 ± 9.67 in males in CVS 1. In CVS 2, the mean age was 132 ± 36 and 120 ± 9.79 in females and males, respectively. CVS 3 demonstrated a mean age of 122.66 ± 10.99 in females and 130 ± 15.62 in males. In CVS 4, the mean CA was found to be 132 ± 9.79 in females and 156 ± 7.58 in males. In CVS 5, females and males were found to have a mean age of 161.25 ± 14.05 and 162.85 ± 15.52, respectively. Similarly, CVS demonstrated a mean age of 168 ±

Table 1: Distribution of study groups

		Age (years)	*Age (months)*
Group I	Prepubertal	8–10	96–120
Group II	Pubertal	10–12	120–144
Group III	Postpubertal	12–15	144–180

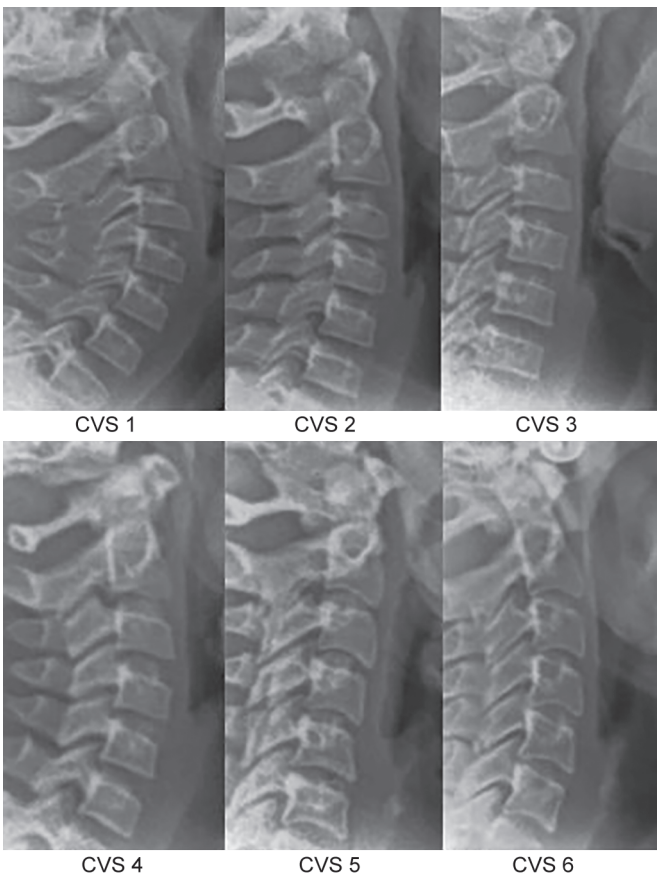

Fig. 2: Cervical vertebral stages

12 in females and 176 ± 5.65 in males (Table 3). Therefore, it can be safely concluded that the appearance of each cervical vertebral stage occurred earlier in females as compared to males, except in CVS 1 and 2, where the cervical stage appears earlier in males.

The correlation between the chronological, skeletal, and DA was compared using the Pearson's r and statistical significance was tested at a 95% level of significance ($p < 0.05$).

The overall correlations were found to be highly significant demonstrating a positive correlation. The r was found to be 0.839 ($p = 0$) between chronological and DA, 0.833 ($p = 0$) between chronological and SA, and 0.730 ($p = 0$) between skeletal and DA (Table 4).

Gender-wise correlation analysis revealed a significantly high positive correlation between chronological, skeletal, and DA in both males and females, except for the weak significant correlation between dental and SA in females (r = 0.687, $p = 0$). The r between chronological and DA was found to be 0.816 ($p = 0$) in females and 0.875 ($p = 0$) in males; the r between chronological and SA was 0.806 ($p = 0$) in females and 0.864 in males. Similarly, the coefficients were 0.687 ($p = 0$) and 0.813 ($p = 0$) in females, and males, respectively (Tables 5 to 9 and Fig. 4).

Discussion

The worth of evaluating maturational status has got recognition globally by health professionals, especially in the field of interceptive orthodontics and dentofacial orthopedics. According to Fishman, it is vital for the clinician to know about the period of growth surge and the amount of growth pending to obtain predictable and stable treatment outcomes.[12]

In the Indian subcontinent, it has been seen that the onset of puberty is a little earlier in comparison to the Caucasian population.[13] Since the age of pubertal onset is capricious and does not give a perception of the maturational status of an individual; therefore, the present study was undertaken in the circumpubertal age-group (8–15 years) to assess the age and investigate the comparisons existing between skeletal, dental, and CA within a demographic population.

Retrospective analysis of panoramic and cephalometric radiographs was executed for age assessment in the children belonging to the circumpubertal period (8–15 years). The CA of the samples was

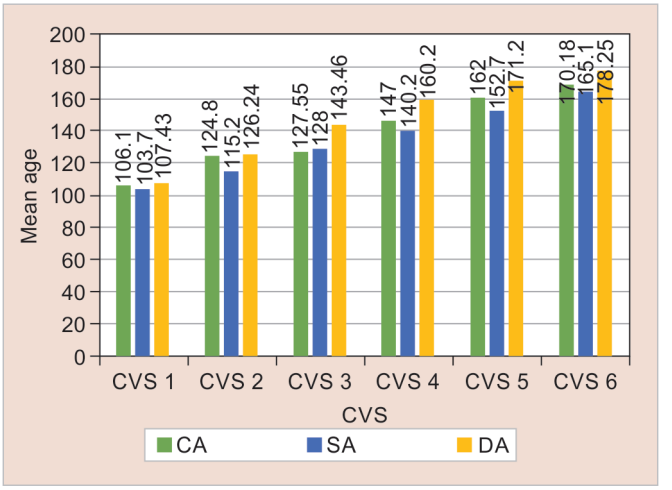

Fig. 3: Mean chronological, skeletal, and DA corresponding to cervical vertebral stage

Table 2: Frequency distribution of sample according to age-group and gender

			Age-group			
			Group I	*Group II*	*Group III*	*Total*
Sex	Female	N	15	11	21	47
		%	44.1%	42.3%	52.5%	47.0%
	Male	N	19	15	19	53
		%	55.9%	57.7%	47.5%	53.0%
Total		N	34	26	40	100
		%	100.0%	100.0%	100.0%	100.0%

Table 3: Mean chronological, skeletal, and DA

	N	*Mean (months)*	*SD*
CA	100	139.92	27.24
DA	100	149.24	33.77
SA	100	135.21	20.46

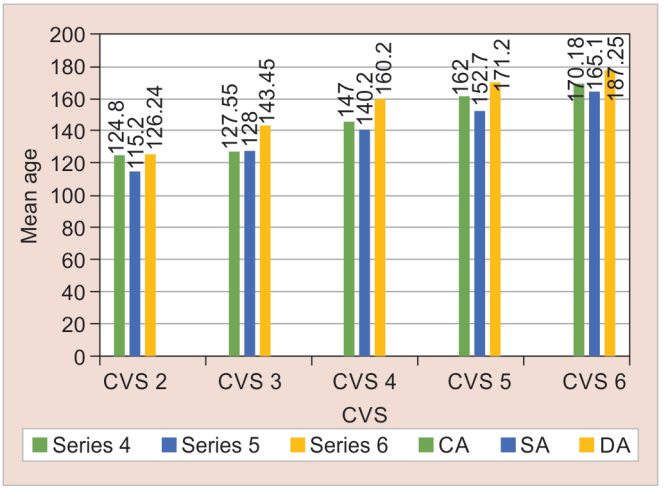

Fig. 4: Pearson's correlation between chronological, skeletal, and DA according to gender

Table 4: Mean chronological, skeletal, and DA according to the study groups

		CA	*SA*	*DA*
Group I	N	34	34	34
	Mean (months)	108.35 ± 10.01	115.07 ± 12.31	113.08 ± 22.91
Group II	N	26	26	26
	Mean (months)	138 ± 6.11	135.12 ± 15.64	155.86 ± 18.25
Group III	N	40	40	40
	Mean (months)	168 ± 9.79	152.37 ± 11.07	175.68 ± 18.74

Table 5: Mean chronological, skeletal, and DA corresponding to each CVS

		CA	*SA*	*DA*
CVS 1	N	19	19	19
	Mean (months)	106.1 ± 12.81	103.7	107.43
CVS 2	N	5	5	5
	Mean (months)	124.8 ± 27.62	115.2	126.24 ± 28.86
CVS 3	N	27	27	27
	Mean (months)	127.55 ± 14.93	128	143.46 ± 27.24
CVS 4	N	8	8	8
	Mean (months)	147 ± 15.38	140.2	160.2 ± 22.11
CVS 5	N	30	30	30
	Mean (months)	162 ± 15.03	152.7	171.2 ± 20.33
CVS 6	N	11	11	11
	Mean (months)	170.18 ± 11.77	165.1	178.25 ± 18.25

Table 6: Gender-wise mean CA corresponding to CVS

		Females	*SD*	*Males*	*SD*
CVS 1	N	9	13.59	10	9.67
	Mean (months)	110.66		102	
CVS 2	N	2	36	3	9.79
	Mean (months)	132		120	
CVS 3	N	9	10.99	18	15.62
	Mean (months)	122.66		130	
CVS 4	N	3	9.79	5	7.58
	Mean (months)	132		156	
CVS 5	N	16	14.05	14	15.52
	Mean	161.25		162.85	
CVS 6	N	8	12	3	5.65
	Mean (months)	168		176	

Table 7: Pearson's r between chronological, skeletal and DA

	CA	*DA*	*SA*	*p*
CA	1	0.839**	0.833**	$p = 0$
DA	0.839**	1	0.730**	
SA	0.833**	0.730**	1	

**Correlation is significant at 0.01 level (two-tailed)

recorded from the data available in the Oral Radiology Department. In spite of CA being an indecisive guide with wide variation in growth and development of facial areas in the prepubertal period, it may aid the practitioner in predicting the timing of growth of a subject when twinned with a reliable indicator of maturity.[1,14]

The appearance of ossification centers in certain bones at specific intervals helps to assess the level of skeletal maturity in an individual. According to Hassel and Farman, skeletal maturation has a closer association with sexual maturity as compared to other biological indicators.[15]

Various authors like, Fishman, have established that the events of ossification in the bones of handwrist region are closely related to the maturation of the craniofacial region.[12] There is enough data available in the literature supporting the usage of radiographs of the handwrist as the most consistent method of SA assessment.[16–18]

However, to prevent unwarranted radiation exposure to subjects, it is imperative to relate maturational status to events of skeletal changes in the bones other than that of handwrist.[4] Since it's a distinguished fact that the lateral aspect of the body of cervical vertebrae changes with growth which makes it befitted for the estimation of skeletal maturation and age. Therefore, the use of lateral cephalograms over handwrist radiographs has been suggested by various researchers (Lamparski, O'Really et al., Hassel and Farman, Franchi et al., Bacceti et al.). This method evaluates the morphology of second through sixth cervical vertebral bodies and thereby assigning maturational stages (Hassel and Farman, Franchi et al., Bacceti et al.). So, in recent years, authors like Bacetti et al., Wong et al., and Chen et al. have reinvigorated the evaluation of the cervical vertebrae as a biomarker for skeletal maturity.[7,19,20]

The present study also assesses the status of dental maturity in the age-group of 8–15 years and its comparison with the skeletal and CA using the Demirjian method (1973), which is based on the stages of calcification of seven left permanent teeth. Nolla stated since environmental influence is varied, the eruption of teeth is more wavering in comparison to the mineralization sequence.[21] Therefore, for dental maturity assessment, the method according to Demirjian was chosen.

Demirjian's method for DA assessment is based on the formation of the root, which is a more reliable indicator of dental maturity than the dental emergence method.[5] Merit of this method is the involvement of morphology and the proportion

Table 8: Pearson's correlation between chronological, skeletal, and DA according to study groups

		CA-DA	*CA-SA*	*DA-SA*
Group I	r	0.709**	0.576*	0.463*
	p	0	0	0.006#
Group II	r	0.116#	0.463#	0.097#
	p	0.572#	0.017#	0.634#
Group III	r	0.358**	0.387**	0.253**
	p	0.023#	0.014#	0.114#

**Correlation is significant at 0.01 level (two-tailed); #correlation is nonsignificant

Table 9: Pearson's r between chronological, skeletal, and DA according to gender

	CA-DA	*CA-SA*	*DA-SA*	*p*
Female	0.816**	0.806**	0.687**	$p = 0$
Male	0.875*	0.864*	0.813*	

**Correlation is significant at 0.01 level (two-tailed); *correlation is significant at 0.05 level (two-tailed)

of root length relative to the height of the crown rather than the complete length of the tooth; therefore, foreshortened or elongated projection of the teeth does not affect stage determination.[5]

In our study, although the chronological, skeletal, and DA were found to be highly correlated, individual inconsistencies were found. The mean SA was found to be somewhat higher than the mean chronological and DA, and the mean DA was found to be lower than the mean CA. The results of the research depicted that the mean CA for each cervical maturity level indicated that the appearance of each cervical vertebral stage is consistently earlier in females as compared to males except in the case of CVS 1 and CVS 2, strengthening the fact that females mature earlier than males.[22] Similar findings were observed by Grave et al., Bjork et al., and Krailassiri et al. supporting the current results.[22–24]

The current research showed that the overall correlation between all three ages was found to be high. It was found that the SA assessed by the CVM stages had a high correlation with the CA indicating that the CA could be suitable for assessing skeletal maturity while diagnosing and treatment planning. This is in agreement with the findings of Sierra, Uysal et al., Al-Hadlaq et al., and Baidas.[14,25] However, the result is in contrast with the conclusions of Fishman and Alkhal et al., who found a low correlation between the skeletal and CA in a sample of 400 Chinese subjects. This could be attributed to the fact that different ethnic groups have different growth patterns due to diversity in the gene pool. Also, the socioeconomic status of the individuals, along with the nutritional status and presence or absence of systemic illness, are major influential factors in growth and development.[26,27]

The correlation between chronological and DA was also found to be high. Similar findings were observed by Rożyło-Kalinowska et al., Nanda et al., and Kapoor et al.[27–29] However, not much data is available in the literature challenging this finding except for the study of Thorson and Hagg, who stated that chronological and DA are not significantly correlated.[30] Although the association between DA and CA is high, individual variations do exist, and tooth development seems to vary between populations, ethnic groups, and cities in the same country.[31–33]

As per the present literature, the relationship between dental and skeletal maturity is varied and controversial. Some authors have reported noteworthy correlations, while others have reported little or insignificant correlations between dental and skeletal maturation. This study revealed a high statistically significant correlation existing between the skeletal and DA which is in accordance with the findings of Uysal et al. and Krailassiri et al.[23,25]

Numerous investigators have determined the relationship between the maturation of the skeletal system and the maturation of permanent dentition. Demisch and Wartmann have reported a significant correlation between dental and SA; Chertkow, Coutinho et al., and Engstrom et al. also report the same. On the contrary, Lewis and Garn, and Tanner have reported insignificant correlations between the level of skeletal and dental maturity.[25,34–38] The lack of agreement between the results of previous studies with the present study may be attributed to the variation in sample size, population assessed, and difference in methods used for estimating skeletal and dental maturity.

Conclusion

Within the scope and limitations of the current study, the following conclusions can be drawn:

- The mean chronological, skeletal, and DA was calculated as 139.92 ± 27.24, 135.21 ± 20.46, and 149.24 ± 33.77, respectively, indicating a difference among the three ages, thereby emphasising the fact that the CA of an individual is not always in accordance with the skeletal and DA. An individual may be ahead or behind his/her actual CA.
- The appearance of each cervical vertebral stage occurred earlier in females as compared to males supporting the fact that females mature earlier than males.
- The overall correlations between skeletal, dental, and CA were found to be highly significant, demonstrating a positive correlation.
- Gender-wise correlation analysis revealed a significantly high positive correlation between chronological, skeletal, and DA in both males and females, except for the weak significant correlation between dental and SA in females.

However, there are certain limitations that need to be addressed before making any generalized statements. The CA obtained from the patient's record was in whole numbers (in years) and not up to the exact number of months. Also, the present study did not evaluate the variations in ethnicity, environmental factors, or gene pool of the assessed sample. So, there is a need to carry out further studies on a larger sample size involving secondary determinants also to get a more valid representation of the population.

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