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Original Research Article

Correlation of demirjian dental maturation stages with mandibular growth with help of cervical vertebrae maturation index in north Indian population

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ABSTRACT

Introduction: In the field of orthodontics, loss of precious time during rapid growth of an individual may lead to failure of addressing the laid-back growth issues which may lead to persistent dentofacial deformity in the individual. Hence, accurate and timely diagnosis aids the clinician to treat the individual appropriately for the said deformity.

Aim: To investigate the correlation of chronological age, Demirjian Dental Maturation stage with mandibular growth using CVMI method in North Indian population.

Materials and Methods: The study was performed on pre-treatment lateral cephalograms and OPGs of 270 subjects aged between 8-17 years. To establish the relationship, chronological age was established from the date of birth to the date on which radiographs were taken, Dental age was calculated via Demirjian's method and Cervical Vertebrae maturation was established on the basis of Bacetti's method. Mean tables and Spearman Rank Correlation Coefficient was used to establish the relationship among these variables.

Results: The results showed that the dental age was accelerated as compared to chronological age. Females have a higher grade of cervical vertebrae maturation as compared to males for the same chronological age. The dental calcification of 2^{nd} molar showed the greatest correlation with CVMI with R value of 0.734 in females and 0. 768 in males.

Conclusion: The chronological age in females were lesser as compared to males in all the groups except in CVMI V. Central & Lateral incisor showed least, whereas 2^{nd} molar was found to correlate the highest with the cervical vertebrae maturation.

1. Introduction

The developmental status of an individual can be determined by different growth maturity indicators which play an important role in diagnosis and treatment planning. The chronological age gives very less information about maturational status of an individual as it gets affected by various factors like genetic, epigenetic, environmental, hormonal, etc.

Analysis of cervical vertebrae maturation method consisting of six maturational stages determined on the morphology of cervical vertebrae (C2, C3 and C4).[1]

Improved staging systemconsidered only 3 cervical vertebrae (C2 — C4).[2] It was established that combining Cvs1 & Cvs2, generated a five- stage system from CVMS I-V.[3] The mandibular growth peaks between the stage CVMS II and CVMS III, and CVMS V depicts 2 years after the

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peak mandibular growth.[3]

Dental age estimation is most commonly done via Demirjian method which makes use of Panoramic radiographs.[4]The dental maturation stages of all mandibular left seven teeth used for estimating the dental age of an individual.

In the past, only a few studies have been done who correlated the above mentioned factors namely Chronological age, Improved Cervical Vertebrae Maturation Index and Demrijian dental maturation. Correlation studies done in the past by Mappes et al., Uysal et al.[5,6] etc.have compared other variables, but not all three in one single study. Therefore, our study aimed at correlating Demirjian dental maturation stages with mandibular growth using Cervical Vertebrae Maturation Index so as to facilitate orthodontists in diagnosis and treatment planning.

2. Aim and Objectives

The aim of the study was to investigate the correlation of Chronological age, Demirjian dental maturation stages with mandibular growth with help of Cervical Vertebrae Maturation Index in North Indian sample.

3. Materials and Methods

The study was performed on pre-treatment lateral cephalograms and orthopantomograms (OPGs) records of Orthodontics and Dentofacial Orthopaedics, Guru Nanak Dev Dental College and Research Institute, Sunam for Orthodontic treatment.

3.1. Inclusion criteria

Subjects in the age group of 8-17 years were included. The subjects must have all the teeth radiographically which may or may not include 3rd molars. The subjects should have no history of previous orthodontic treatment, no developmental defects involving dentition and jaws and no serious deformity.

3.2. Exclusion criteria

The subjects having history of bone deformities and diseases were excluded. Subjects who had facial asymmetry, muscular dystrophy, congenital deformities, abnormalities affecting growth and development and traumatic lesions of cervical vertebrae and dentition were also excluded from the sample.

3.3. Method

3.3.1. Estimation of chronological age

The chronological age/calendar age of the patients were established based on the time passed from the child's birth upto the day radiographs were taken.

3.3.2. Dental maturation stage and dental age estimation

Estimation of dental age was done on Orthopantomogram (OPG) using Demirjian's methodthat includes the development of the seven left permanent mandibular teeth. The evaluated teeth included both incisors, canine, first and second premolars, and first and second molar teeth. An eight-grade scale was brought into use and each tooth was given an appropriate value depicting the developmental stage. Using standard tables, separate for boys and girls and the evaluated stage was then assigned an appropriate numeric value. The values were then added up, and the obtained total score indicated the dental age which was derived from standard tables.[4]

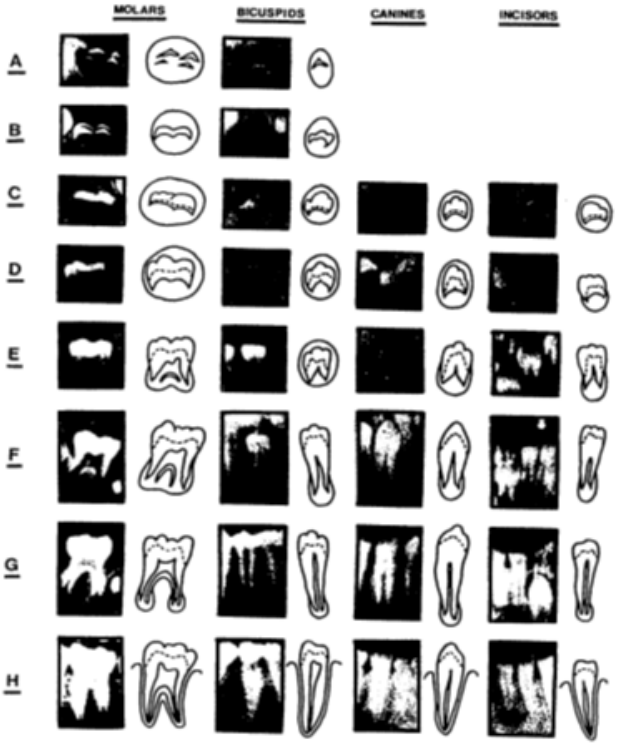


Figure 1: Spermanent dentition accordinto Demirjian's method[4]

3.4. Estimation of mandibular growth using

For estimation of Mandibular growth, cervical vertebrae (C2, C3 and C4) outlines traced from the lateral cephalogram were visually analyzed using the improved version of cervical vertebrae maturation indicators as provided by Baccetti et al. in 2002 in order to determine the skeletal maturation stage. The presence or absence of concavity at the lower border of C2–C4 as well as the shape of the vertebral bodies of C3 and C4 (trapezoidal, horizontal, square, and vertical) were analyzed.

Five developmental stages were described—from cervical stage CVMS I to CVMS V.

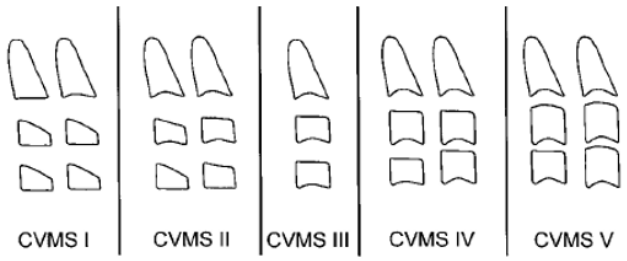


Figure 2: Improvedcervical vertebrae maturation stages

Table 1: Measurement error for males and females

	Males	Females
ICC reliability cofficient	0.997	0.989
Intraobserver Error	0.003	0.011

value= > 0.8= good reliability

Table 2: Sample distribution according to CVMS

CVMS	Males	Males (%)	Females	Females (%)	Total
I	11	68.75%	5	31.25%	16
II	38	74.51%	13	25.49%	51
III	33	58.93%	23	41.07%	56
IV	28	34.15%	54	65.85%	82
V	25	37.88%	41	62.12%	66

Table 3: Mean chronological age (CA) of males & females in different cervical vertebrae maturation stages

CVMS	Chronological age (males)		Chronological age (females)		p- value
	Mean (years)	SD	Mean (years)	SD	
I	11.091	1.083	8.60	0.80	**
II	12.474	0.678	11.31	1.07	*
III	13.818	0.796	12.26	0.90	*
IV	14.929	0.593	12.93	0.86	**
V	15.520	0.500	15.32	0.84	NS

p≥0.05 non-significant (NS), p≤0.05 significant(*), p≤0.001 highly significant (**)

Table 4: Mean dental age (DA) of males & females indifferent cervical vertebrae maturation stages

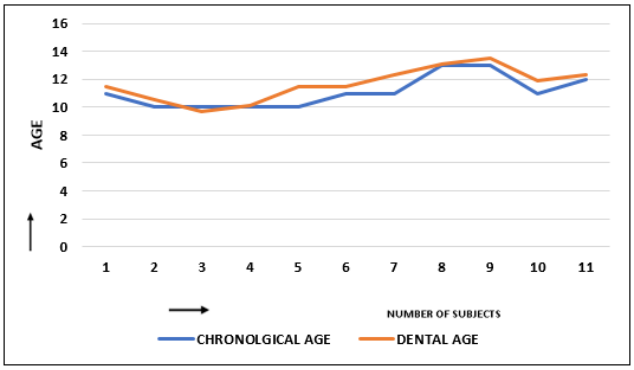
CVMS	Dental age (males)		Dental age (females)		p-value
	Mean (years)	SD	Mean (years)	SD	
I	11.627	1.129	9.10	1.14	**
II	13.145	0.800	11.78	1.23	**
III	14.185	0.858	12.54	0.87	*
IV	14.989	0.774	13.34	0.87	*
V	15.992	0.039	15.64	0.68	NS

p≥0.05 non-significant (NS), p≤0.05 significant(*), p≤0.001 highly significant (**)

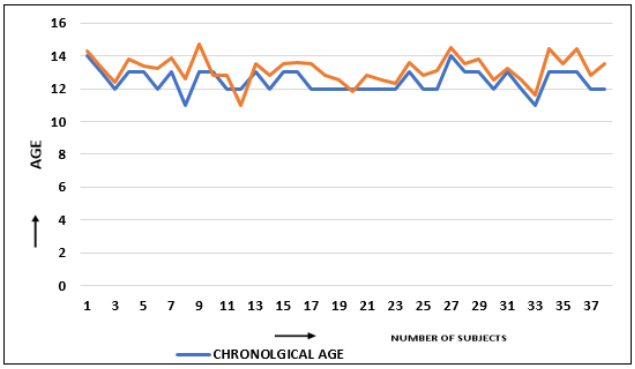
Table 5: Comparison between chronological and dental age in both genders

CVMS	Difference (males)			Difference (females)		
	Mean (years)	SD	p value	Mean (years)	SD	p value
I	0.536	0.503	*	0.50	0.74	*
II	0.671	0.523	*	0.47	0.56	*
III	0.667	0.637	*	0.28	0.69	*
IV	0.612	0.657	*	0.41	0.40	*
V	0.070	0.490	NS	0.32	0.43	*

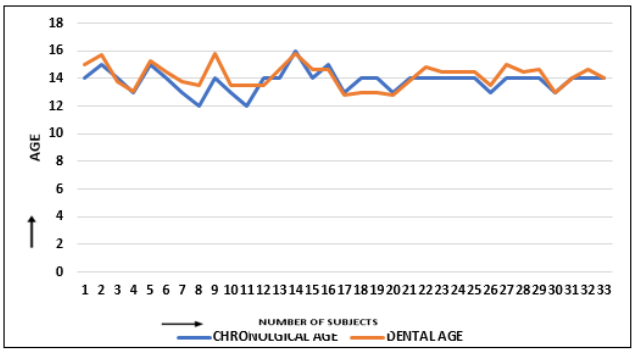
p≥0.05 non-significant (NS), p≤0.05 significant(*), p≤0.001 highly significant (**)



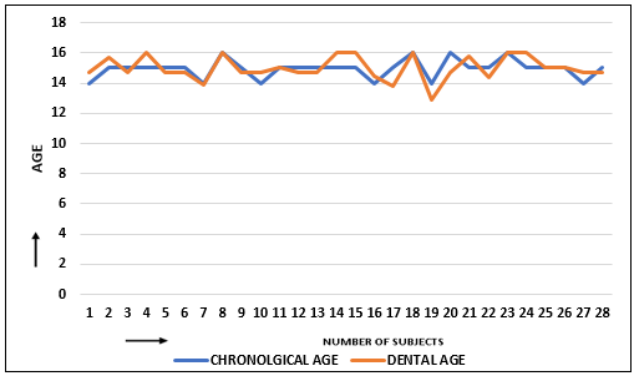
Graph 1: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage I (CVMS) in males



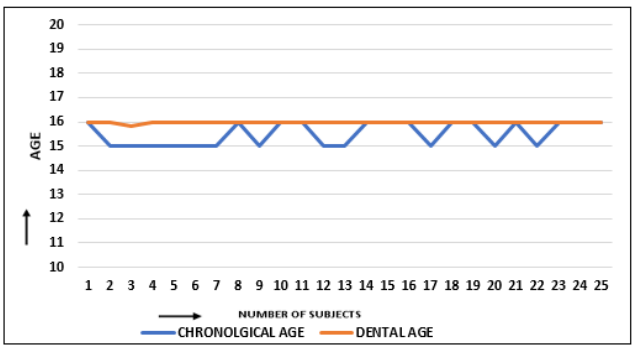
Graph 2: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage II (CVMS) in males



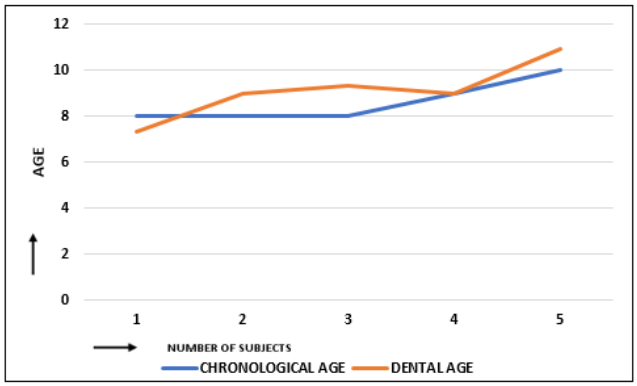
Graph 3: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage III (CVMS) in males



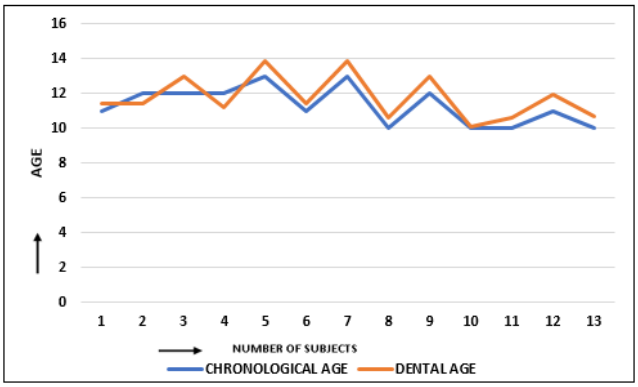
Graph 4: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage IV (CVMS) in males



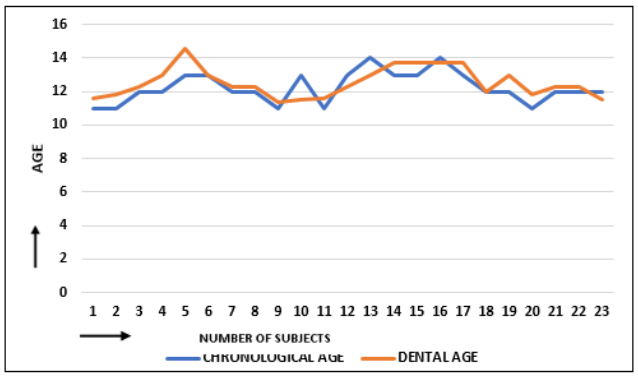
Graph 5: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage V (CVMS) in males



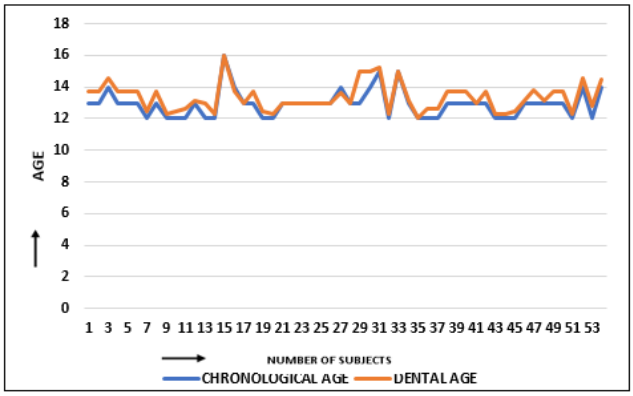
Graph 6: Comparison between chronological age (CA) and dental age (DA) for cervical vetebrae maturation stage I (CVMS) in females



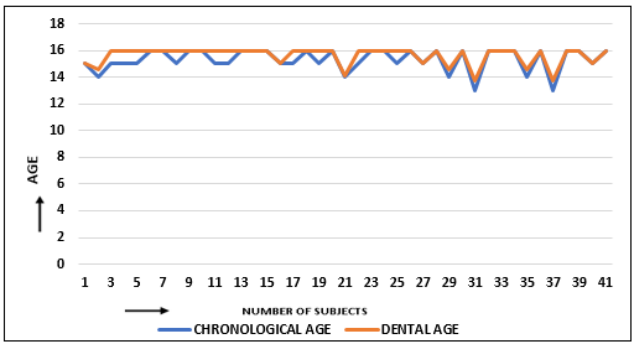
Graph 7: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage II (CVMS) in females



Graph 8: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage III (CVMS) in females



Graph 9: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage IV (CVMS) in females



Graph 10: Comparison between chronological age (CA) and dental age (DA) for cervical vertebrae maturation stage V (CVMS) in females

Table 6: Correlation between chronological age and dental age in males

CVMS	Mean Chronological Age (years)	Mean Dental Age (years)	r- Value	Status
I	11.09	11.63	0.90	**
II	12.47	13.14	0.76	*
III	13.82	14.18	0.71	*
IV	14.93	14.99	0.57	*
V	15.52	15.99	0.21	NS

r ≤0.39 Non-Significant(NS)r≥ 0.70-0.89 significant (*), r≥0.90 highly significant(**)
r= Pearson Correlation Coefficient

Table 7: Correlation between chronological age and dental age in females

CVMS	Chronological Age (Mean years)	Dental Age (Mean years)	r- Value	Status
I	8.60	9.10	0.77	*
II	11.31	11.78	0.89	**
III	12.26	12.54	0.70	*
IV	12.93	13.34	0.89	**
V	15.32	15.64	0.86	**

r≥0.70-0.89 significant (*), r≥0.90 highly significant(**)
r = Pearson Correlation Coefficient

Table 8: Correlation between dental development stages and cervical stage (CS) in males and females

	Correlation Coffecient			
	Male		Female	
	R value	Status	R value	Status
Central incisor	0.063	NS	0.151	NS
Lateral incisor	0.125	NS	0.109	NS
Canine	0.695	*	0.696	*
1^{st} Premolar	0.611	*	0.552	*
2^{nd} Premolar	0.727	*	0.602	*
1^{st} Molar	0.318	*	0.417	*
2^{nd} Molar	0.734	*	0.768	*

R≤0.19 Non-Significant (NS), R≥0.20 significant(*)
R= Spearman Rank Correlation Coefficient

4. Results

Dental maturation stages were evaluated and summed up to depict dental age with the help of Demirijian's method. The results obtained were presented as mean ± SD. The Pearson coffecient (r) was calculated to compare the association between cervical stages and dental maturation and chronological age.

4.1. Sample distribution

Grouping was done on the basis of cervical vertebrae maturation stages i.e CVMS I – V (five groups;Table 1& Graph 1).

4.2. Mean chronological and dental age of sample according to CVMS

The results confirmed that chronological age & dental age increased together with increasing CVMS and that males in the all the cervical stage tend to have more mean age as compared to females. (Tables 2 and 3 & Graphs 2 and 3) Comparisonn between chronological and dental age depicted as mean ± SD for both males & females. The results depicted statistically significant difference in all the CVMS groups in both genders except in CVMS V in males. (Table 4). Correlation between chronological age & dental age revealed that chronological age and dental age

showed an overall high correlation, r value varied from 0.21 to 0.90 in males and 0.70- 0.89 in females. The results are statistically significant except in the CVMS V group in males as the r value was 0.21 which is statistically nonsignificant. (Tables 5 and 6). Correlation between dental developmental stages & cervical stages revealed relationships with Spearman rank correlation coefficient (R) between the dental development stages of all examined teeth and cervical stages R = 0.063–0.734 in males and R = 0.109–0.768 in female subjects. The teeth showing the strongest relationship with CVM were the second molar in females (R = 0.734) and males (R= 0.768). The lowest correlation was noted for the Lateral incisor (R = 0.109 in females) and Central incisor (R = 0.063 in males) (Table 7). Percentage distribution of dental developmental stages was calculated for the central incisor, lateral incisor, canine, 1st premolar, 2nd premolar, 1st molar and 2nd molar for each stage as depicted in Table 8.

5. Discussion

Growth modification in orthodontics require accurate age estimation and assessment of mandibular skeletal maturity & dental development. Biologic age, skeletal age and bone age are nearly synonymous terms, but they don't describe the stages of maturation of an individual. Mandibular skeletal maturity can be assessed by means of a series of biologic indicators: increase in body height, skeletal maturation of the hand and wrist, dental development, cervical vertebral maturation, etc.[7,8]

Considerable variation may be present in various types of age, thereby making it essential to associate the important types of maturity indicators such as chronological, dental and mandibular skeletal maturity for a thorough diagnosis. Hence, a correlation between the three types of maturity using chronological age, Demirjian dental maturation and mandibular growth using cervical vertebrae maturation was done. Demirjian dental maturation stages of the teeth also play an important role in diagnosis, so that in absence of supplementary diagnostic records, most benefits could be drawn out of the minimum means. Therefore, in our study an attempt to find out the most reliable tooth for skeletal maturity was also done.

Lateral cephalogram and orthopantomograms of 270 subjects were evaluated (135 males and 135 females) in the age group of 8-17 years which represented a very variable period in growth & development thus allowing for subjects to be distributed in all the five stages of cervical vertebrae maturation stages. Grouping was done according to the improved cervical vertebrae maturation stages through I to V in both males and females.[2–4]

5.1. Correlation between chronological and dental age

The results of our study revealed correlation between chronological & dental age. The value in our study ranged from 0.21- 0.90 in males and 0.52- 0.89 in females. The correlation was statistically significant in all cervical stages except in Cervical Stage V in males. The significant results suggest that the chronological age and dental age increase linearly and therefore have a positive linear relationship with each other.

As the chronological age increased, the dental age also advanced as also found by Kalinowska et al.[7] The non-significant result in Stage V can be attributed to the fact that uptil stage V, dental maturation has ceased, hence dental age cannot increase whereas chronological age can. The results for other cervical stages in our study were in concordance with study done by Mini et al.[9]

5.2. Correlation between dental maturity and CVMS

The central incisor & lateral incisor in males and females showed no correlation as root completion of central & lateral incisor occurs quite early (8-9 years). The results of our study were in agreement with study by Kalinowska.[7]

The canine in males and females showed moderate correlation with cervical vertebrae maturation, the results obtained in our study were comparable to the study done Mini et al.[9] in females and males. Canine takes longer to completely mature as its mineralization of crown starts at an early age of 5-6 years and till 12-13 years its root formation is completed. (Wheelers[10])

The 1^{st} & 2^{nd} premolar in males and females also showed high correlation with cervical vertebrae maturation. The results of our study were comparable with the study by Mini et al.[9] They can serve as an appropriate indicator of skeletal maturity evaluation in growing individual.

The 1st molar in our study showed low correlation in both males and females. These results were comparable with study done by Kalinowska.[7] This would suggest that 1st molar maturation stages cannot be relied upon as an indicator of skeletal maturity because the maturation of 1st molar ceases at around 8-9 years of age (Wheelers[10]).

The 2nd molar in our study, showed highest correlation in males (0.734) and females (0.768) with cervical vertebrae maturation. The results of our study, were comparable with that of Mini et al.,[9] Kumar et al.[11] & Mittal et al.[12]

The differences in the correlation coefficients in comparison with the results of other authors may result from discrepancies in the number, age, and racial background of the studied subjects and also the methods of selection of the teeth. Mappes et al.[5] indicated that predominant ethnic origin of the population, climate, nutrition, socioeconomic levels and urbanization are the cause of the above mentioned racial variations.

Table 9: Percentage distribution of dental development stages for each CVMS

	Central Incisor		Lateral Incisor		Canine		1^{st} Premolar		2^{nd} Premolar		1^{st} Molar		2^{nd} Molar	
	Female	Male	Female	Male	Female %	Male%	Female %	Male%	Female %	Male%	Female %	Male%	Female %	Male%
CS I														
C	-	-	-	-	-	-	-	-	-	-	-	-	20.00%	19.20%
D	-	-	-	-	1.40%	3.00%	1.63 %	2.14%	20.00%	17.66%	-	-	-	2.70%
E	-	-	-	-	39.00%	37.50%	18.37%	20.00%	3.78%	2.34%	2.21%	-	40.00%	40.53%
F	-	-	-	-	58.00%	59.00%	60.00%	57.86%	40.00%	40.00%	20.00%	20.00%	40.00%	38.10%
G	-	-	-	-	1.60%	0.50%	20.00%	18.66%	36.22%	40.00%	57.80%	60.00%	-	-
H	100%	100%	100%	100%	-	-	-	1.34%	-		20.00%	20.00%	-	-
Total	100%	100%	100%	100%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%
CS II														
C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	-	-	-	-	-	-	-	-	3.58%	-	-	-	-	-
E	-	-	-	-	5.68%	1.34%	-	-	-	2.63%	2.65%	-	2.46	5.26%
F	-	-	-	-	14.27%	9.19%	30.77%	10.53%	33.33%	21.05%	-	-	33.9%	21.05%
G	-	-	-	-	78.33%	86.84%	15.38%	47.37%	41.67%	68.42%	30.68%	7.89%	63.64%	73.68%
H	100%	100%	100%	100%	1.72%	2.63%	53.85%	42.11%	21.42%	7.89%	66.67%	92.11%	-	-
Total	100%	100%	100%	100%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%
CS III														
C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	-	-	-	-	-	-	-	-	-	-	-	-	5.26%	-
E	-	-	-	-	-	-	-	-	-	3.03%	-	-	-	-
F	-	-	-	-	6.83%	2.37%	5.64%	2.45%	21.05%	-	-	-	10.53%	3.03%
G	-	-	-	-	89.47%	91.57%	32.25%	36.94%	42.11%	60.61%	5.56%	-	84.21%	96.97%
H	100%	100%	100%	100%	3.70%	6.06%	62.11%	60.61%	36.84%	36.36%	94.44%	100.00%	-	-
Total	100%	100%	100%	100%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%
CS IV														
C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	-	-	-	-	-	-	-	-	3.70%	-	-	-	1.85%	-
G	-	-	-	-	87.04%	82.14%	35.19%	3.57%	51.85%	32.14%	-	-	92.59%	75.00%
H	100%	100%	100%	100%	12.96%	17.86%	64.81%	96.43%	44.44%	67.86%	100.00%	100.00%	5.56%	25.00%
Total	100%	100%	100%	100%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%
CSV	-													
C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D	-	-	-	-	-	-	-	-	-	-	-	-	-	-
E	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G	-	-	-	-	19.51%	12.00%	8.56%	-	2.44%	-	-	-	21.95%	16.00%
H	100%	100%	100%	100%	80.49%	88.00%	91.44%	100.00%	97.56%	100.00%	100.00%	100.00%	78.05%	84.00%
Total	100%	100%	100%	100%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%	100%	100.00%

5.3. Percentage distribution of dental development stages for each cervical stage

The percentage distribution of Demirjian stages of all the seven teeth in each Cervical stage was done in the present study. The more the positive linear association of a tooth with CVMS, the more chances of the percentage distribution of that particular tooth to fall in higher Demirjian stage as the cervical vertebrae maturation stage advanced or in other words higher the Demirjian stage, higher is the cervical vertebrae maturation stage. The main drawback of the study was the fact that sample size was less and hence, does not accurately depict the results, further studies are required for the same.

6. Conclusions

1. The chronological and dental age increased, as the cervical stage advanced in both the genders.
2. The chronological age in females were lesser as compared to males in all the groups except in CVMI V, suggesting that females attain skeletal maturity before males. At CVMI V, no difference exists between both the genders.
3. The difference between chronological age and dental age varied from 5- 6 months in males, whereas in females the range varies from 2- 6 months.
4. Significant association between chronological and dental age was seen in all groups in both genders except in CVMI V in males.
5. Central incisor and Lateral incisor showed least correlation with the cervical vertebrae maturation index in both genders, whereas 2nd molar followed by 2nd premolar showed the highest correlation with the cervical vertebrae maturation in males. In females, 2nd molar followed by canine showed the highest correlation with cervical vertebrae maturation.
6. Stage G of 2nd molar, canine and 2nd premolar suggest active growth phase in both males and females as during CVMS II or III, majority percentage of the 2nd molar, canine and 2nd premolar were in Stage G.

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8. Conflict of Interest

None.

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