COMPARATIVE EVALUATION OF PERMANENT MANDIBULAR CANINE AND SECOND MOLAR CALCIFICATION STAGES FOR ASSESSMENT OF THE SKELETAL MATURITY

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ABSTRACT

Introduction: Knowledge of the skeletal maturation status and pubertal growth spurt of an individual influences the diagnosis, treatment planning and the treatment outcome. The dental calcification stages can be used to assess the status of skeletal maturation.
Objectives: To 1. Evaluate the reliability of the calcification stages of the mandibular permanent canines and the second molars to assess the skeletal maturity level; 2. Compare the mandibular permanent canines and the second molars for assessment of skeletal maturity.
Study design: A retrospective and cross-sectional study was done using the pre-treatment lateral cephalograms and panoramic radiographs of 99 males and 110 females in the age range of 7 to 18 years 7 months. These radiographs were evaluated with Demirjian Index (DI) and cervical vertebrae maturation indicators (CVMI) of Hassel and Farman.
Results: A significant association was found to exist between the dental calcification stages of permanent mandibular canines and second molars with the cervical vertebrae maturation status, which was stronger in females. Mandibular second molars showed better association compared to mandibular canines with the skeletal maturity levels.
Conclusion: Mandibular second molar and canine calcification stages can be used as indicators for assessment of skeletal maturity. Mandibular second molar should be preferred over mandibular canine to assess the level of skeletal maturity.

Keywords: Skeletal maturation - Cervical vertebrae maturation indicators - Demirjian Index - Mandibular second molar - Mandibular canines

RESUME

Introduction : La connaissance de la maturation squelettique, le statut pubertaire et le regain de croissance d'un individu influe sur le diagnostic, le plan et les résultats du traitement. Les étapes de la calcification dentaire peuvent être utilisées pour évaluer l'état de la maturation squelettique.
Objectifs : 1. Évaluer la fiabilité de la calcification stades de l'articulation mandibulaire permanent canines et le deuxième molaires d'évaluer le squelette du degré de maturité; 2. Comparer l'articulation mandibulaire permanent canines et le deuxième molaires pour évaluation de maturité squelettique.
Conception de l'étude : une étude retrospective transversale a été effectuée à l'aide du pré-traitement cephalograms et des radiographies panoramiques de 99 garçons et 110 filles tous agés de 7 à 18 ans et7 mois. Ces radiographies ont été évalués avec Demirjian Index (DI) et avec les indicateurs de maturation vertèbres cervicales (CVMI) de Hassel et Farman.
Résultats: une association significative a été constatée entre les stades de dentaire calcification des canines maxillaires permanentes et les deuxièmes molaires avec la maturation des vertèbres cervicales; et le constat était plus amplifié chez les femmes. Les deuxièmes molaires maxillaires ont montré une meilleure association de niveaux de maturation du squelette comparé aux canines maxillaires.
Conclusion : Les secondes molaires mandibulaires et les etapes de calcification des canines peuvent etre utilisées comme des indicateurs d'évaluation de la maturité du squelette ; cependant, les seconds molaires maxillaires offrent une meilleure précision dans cette évaluation.

Mots clés : maturation squelettique - vertèbres cervicales maturation - indicateurs Demirjian - deuxième molaire mandibulaire, Canines mandibulaires

INTRODUCTION

Knowledge of the status of skeletal maturation and the cranio-facial growth of an individual holds a great importance for an orthodontist. These factors influence the treatment plan and eventual outcome of the dentofacial orthopaedic and orthognathic surgical treatment [1]. Timely analysis of the patient's growth potential helps the clinicians take advantage of active growth and achieve more skeletal changes in dentofacial structures. The adolescent growth spurt is a period of sudden increase in skeletal growth of the body and the face and, thus, any dentofacial orthopaedic intervention during that period helps to achieve more skeletal effects and stable treatment results[2, 3].

Determination of biologic age is the most reliable method

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Traditionally the hand-wrist x-rays have been used to study ossification-related events to indicate the level of the skeletal maturity [5-8].

Hassel and Farman had proposed cervical vertebrae maturation indicators (CVMI) observed on the lateral cephalograms to assess the skeletal maturity levels and correlated it with Fishman's skeletal maturity indicators (SMI) assessed on hand-wrist x-rays [4]. Further studies confirmed that the CVMI stages are consistently correlated with SMIs in the hand-wrist region. CVMI is, thus, considered a reliable indicator for assessment of skeletal maturity [9-12].

Dental calcification stages have also been suggested to assess the skeletal maturity level of an individual. Morris and Park in a review concluded that a strong relation exists between dental maturity and skeletal maturity assessed from the radiographs. They proposed that dental maturation can be used as an initial estimator and an adjunct in evaluating the skeletal growth status of the individuals [13]. Examination of the dental calcification stages is the quickest method to assess the skeletal maturity, and can be done using the routine radiographs e.g. intra-oral periapical view (IOPA) and orthopantamogram (OPG), which will avoid additional radiation exposure to obtain hand - wrist radiograph.2 The lateral cephalograms and OPGs are essential pre-treatment diagnostic radiographs taken for orthodontic treatment which can be used to assess the skeletal maturation levels without resorting to hand wrist x-rays [4). Relationships between the calcification stages of various mandibular teeth and the skeletal maturity have also been reported with variable significance [1]. Mandibular canine calcification has been found to be a reliable indicator in some studies (14-16), while others have refuted the claim [17-19]. Studies have found that the permanent mandibular second molars calcification stages can also be used as predictors of skeletal maturation [1,16,20]. However, no study has been done to compare the mandibular canine and second molars for skeletal maturity assessment.

AIMS AND OBJECTIVES

This study was carried out to:

1. Evaluate the reliability of the calcification stages of the mandibular permanent canines and the second molars to assess the skeletal maturity level
2. Compare the mandibular permanent canines and the second molars for assessment of skeletal maturity.

Significance of the study:
If a significant correlation exists between the dental calcification stages and skeletal maturation, it can assist the clinicians to evaluate skeletal maturation status of an individual by using IOPA or OPG radiographs. It will thus avoid extra radiation exposure and economic burden on the individual especially in resource constraint settings.

MATERIALS AND METHODS

A retrospective and cross-sectional study was carried out using the traditional films of pre-treatment OPGs and lateral cephalograms of 209 subjects (99 male and 110 female) of Rwanda origin selected from the records of orthodontic patients at King Faisal Hospital, Rwanda.

Selection criteria

Subjects in the age range of 7 to 19 years were selected in this study because most of the patients seeking orthodontic treatment belong to this age group and are at different stages of skeletal maturity. Subjects with normal overall physical growth and absence of previous orthodontic treatment were considered for the study. Subjects with any gross skeletal deformities e.g. clefts, hemiatrophy, hypertrophy and gross facial asymmetry were not included in the study.

Radiographic assessment

Radiographic assessments were performed on a back-illuminated radiographic view box in a darkened room by a single examiner.

Evaluation of cervical vertebrae maturity on lateral cephalogram: Cervical vertebrae maturity was evaluated by using the cervical vertebrae maturity index (CVMI) proposed by Hassel and Farman (Table 1) [1].

Evaluation of dental maturity on panoramic radiograph: The permanent mandibular left canines and the second molar calcification stages were assessed according to Demirijan index (DI) proposed by Demirjian et al (Table 2) [21]. If the left side tooth was not clear, then its counterpart on the right side was evaluated.

Randomly selected records of 15 patients were re-evaluated after 2 weeks of first evaluation to test the reproducibility of assessments of DI and CVMI, and data was evaluated in terms of the weighted kappa statistics. The kappa statistics for intra-observer agreement were 0.82 for DI assessments and 0.89 for CVMI assessments, showing acceptable intra-observer agreement.

Statistical analysis

Statistical analyses were done using SPSS 13.0, SPSS Inc, Chicago, Ill., and Epi Info 3.4.3 (CDC, Illinois). Descriptive statistics were calculated for both genders to determine the sample distribution, the means and the standard

Table 1: Cervical vertebra maturation indicators (CVMI, Hassel and Farman) (4)

Stage	Stage	Amount of growth expected	Characteristics
1	Initiation	80% - 100%	C2, C3, and C4 inferior vertebral body borders are flat. Vertebrae are wedge-shaped. Superior vertebral borders are tapered posterior to anterior.
2	Acceleration	65% - 85%	Concavities are developing in the inferior borders of C2 and C3. The inferior border of C4 is flat. The bodies of C3 and C4 are nearly rectangular in shape.
3	Transition	25% - 65%	Distinct concavities are seen in the inferior borders of C2 and C3. A concavity is beginning to develop in the inferior border of C4. The bodies of C3 and C4 are rectangular in shape.
4	Deceleration	10% - 25%	Deceleration of adolescent growth spurt. Small amount of adolescent growth expected. Distinct concavities in the inferior borders of C2, C3, and C4. C3 and C4 are nearly square in shape.
5	Maturation	5% - 10%	Final maturation of the vertebrae takes place during this stage. Insignificant amount of adolescent growth expected. Accentuated concavities of inferior vertebral body borders of C2, C3, and C4. C3 and C4 are square in shape.
6	Completion	Little or no growth	Adolescent growth is completed. Deep concavities are seen in inferior border of C2, C3, and C4. C3 and C4 heights are greater than widths.

Table 2: Dental Calcification Stages Using Demirjian Index (DI) (21)

Stage	Characteristics
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 has been completed at the occlusal surface, and dentin formation has commenced. The pulp chamber is curved, and no pulp horns are visible.
D	Crown formation has been completed to the level of the cement-enamel 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 have become more differentiated than in the previous stage. In molars, the radicular bifurcation has commenced to calcify.
F	The walls of the pulp chamber now 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 now 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.

deviations of the mean ages for the CVMI stages and the DI stages of mandibular canines and the second molars. Cross-tabulation was done to find distribution of DI stages among CVMI stages stratified by the gender. Mann Whitney / Wilcoxon Two-sample test (Kruskal Wallis test for 2 groups), the Pearson chi-square test values (χ2) and Pearson contingency coefficient were also estimated to determine the relationships between DI and CVMI among the genders. A p-value of < 0.01 was considered as statistically significant.

RESULTS

The study involved 47.4% (n=99) males and 52.6% (n=110) females. The age range of the study sample was from 7 years to 18 years 7 months. The mean age of males was 13.27 years (SD = 2.1 years), of females was 12.89 years (SD = 2.26 years), and of the total sample was 13.08 years (SD = 2.18 years) (Table 3).

Table 3. Sample distribution and mean age

	Total	Males	Females
Sample size	209	99	110
% Sample size	100 %	47.4%	52.6%
Mean age	13.08±2.18	13.27±2.1	12.89±2.26
Age range	7 – 18.58	8.83 – 18.58	7 – 18.42

Table 4 shows the percentage distribution and mean age at different CVMI stages. Each stage appeared consistently earlier in females than in males (Figure 1). Mann Whitney / Wilcoxon Two-sample test (Kruskal Wallis test for 2 groups) showed highly significant differences among various CVMI stages in both the genders (Females, Chi square χ2(5)=81.57, p <0.001; & Males, χ2(4) = 59.08, p <0.001).

Table 4: Percentage distribution and the mean age at different CVMI stages

CVMI stages	Females n (%)	Males n (%)	Mean age males Years ± SD	Mean age females Years ± SD	Gender difference Yrs
1	2(1.8)	0(0)		7.33±0.47	-
2	8(7.3)	10(10.1)	11.05±1.7	9.9±1.17	1.1
3	13(11.8)	38(38.4)	12.13±1.28	10.8±1.05	1.33
4	23(20.9)	19(19.2)	13.4±1.37	11.9±1.75	1.5
5	25(22.7)	15(15.2)	14.1±1.06	12.8±0.9	1.3
6	39(35.5)	17(17.2)	16.2±1.45	15.15±1.45	1.05

Mann Whitney / Wilcoxon Two-sample test (Kruskal Wallis test for 2 groups): (Females, χ2(5) = 81.57, p <0.001; Males, χ2(4) = 59.08, p <0.001)

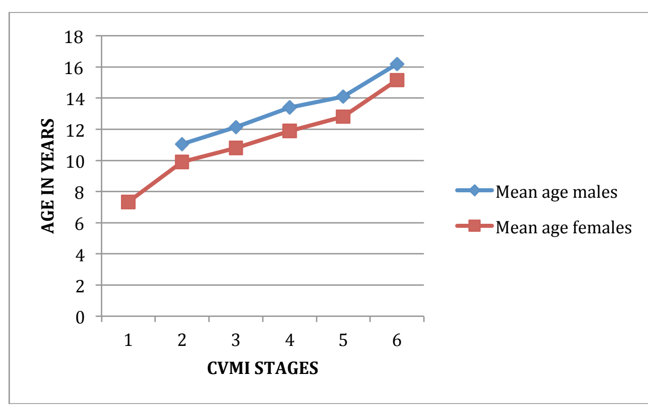

Figure 1: Mean age at each CVMI stage

Table 5 shows the mean ages of different DI stages of mandibular canine and second molar teeth. Females achieved subsequent maturation of teeth earlier than males (Figure 2, 3). Mann Whitney / Wilcoxon Two-sample test (Kruskal Wallis test for 2 groups) showed significant differences among various DI stages of teeth in both the gender (Canines: Females, χ2(3) = 50.74, p <0.001; Males, χ2(2) = 40.67, p <0.001; Second molars: χ2(5) = 77.23, p <0.001, and χ2(4) = 56.68, p <0.001 for the females and the males respectively).

Table 5: Mean age of different DI stages of mandibular canines and the second molar

DI stages	Mandibular canines Males, (years)	Mandibular canines Females, (years)	Mandibular 2nd molars Males, (years)	Mandibular 2nd molars Females, (years)
C				7
D			9.6 ±1	9.0 ±0.95
E	-	8.2 ±0.83	11.28 ±1.3	10.78 ±1.2
F	10.98 ±1.4	10.25 ±1.2	12.66 ±1.1	11.71 ±1
G	12.67 ±1.36	11.29 ±0.93	14.05 ±1.6	13.4 ±1.25
H	14.22 ±1.83	13.79 ±1.83	15.46 ±1.64	15.64 ±1.44

Mann Whitney / Wilcoxon Two-sample test (Kruskal Wallis test for 2 groups: {For canines: Females, $\chi2(3) = 50.74$, $p < 0.001$; Males, $\chi2(2) = 40.67$, $p < 0.001$; For second molars: Females, $\chi2(5) = 77.23$, $p < 0.001$; Males, $\chi2(4) = 56.68$, $p < 0.001$}

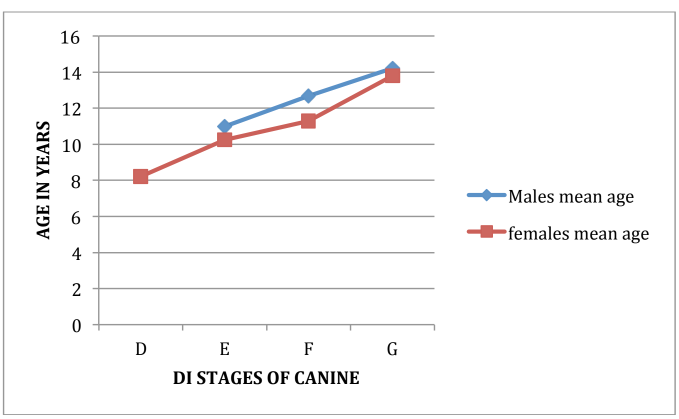

Figure 2: Mean age at each DI stage of canines

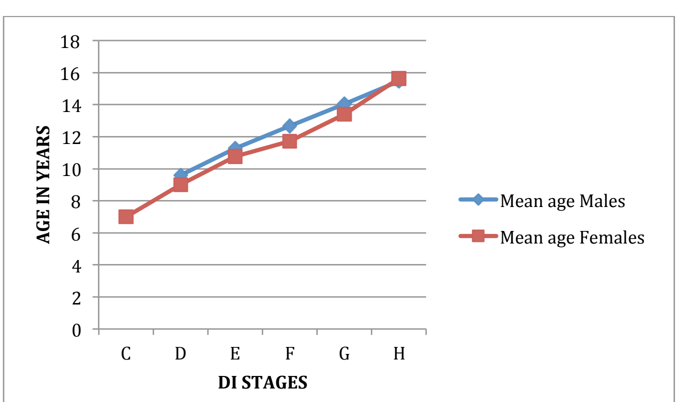

Figure 3: Mean age at each DI stage of second molars

Tables 6 show the association and distribution of DI stages of mandibular canine and CVMI stages. In males, the $\chi2(8)$ was 55.54 ($P < 0.001$) and Pearson contingency coefficient was 0.599 which shows a significant association between DI and CVMI. The DI Stage F corresponded CVMI stage 2 (pre–peak of pubertal growth spurt); DI stage G to CVMI stage 3 (peak of pubertal growth spurt), and DI stage H was associated with CVMI stages 4, 5 and 6 (end of pubertal growth spurt).

Table 6: Contingency table showing association and distribution between DI stages of mandibular canines and CVMI stages in males

CVMI stages	DI stages of mandibular canines: males			DI stages for mandibular canines: females			
	F	G	H	E	F	G	H
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
1				2(100)			
2	**8 (72.7)**		3 (27.3)	**3(43)**	2(28.5)		2(28.5)
3	8 (21.6)	**17 (46)**	**12 (32.4)**		4(28.6)	**5(35.7)**	**5(35.7)**
4	3 (15.8)	3(15.8)	**13(68.4)**		1(4.3)	9(38.7)	**13(56)**
5		1 (6.7)	**14(93.3)**			4(16)	**21(84)**
6			**17(100)**				**39(100)**

(Males: $\chi2(8) = 55.54$, $p<0.001$, Pearson's contingency coefficient between CVMI & DI for canines is 0.599, $p<0.001$); {Females: ($\chi2(15) = 117.48$, $p<0.001$, Pearson's contingency coefficient between CVMI & DI for canines is 0.719, $p<0.001$}

In females, the $\chi2(15)$ was 117.48 ($p < 0.001$), and Pearson contingency coefficient was 0.719 which also shows a highly significant association between DI and CVMI. The DI stage E corresponded to CVMI stages 1, 2; DI stage G with CVMI stage 3, and DI stage H with CVMI stages 4, 5, and 6. The statistical values for female subjects were higher than males, showing a stronger association in females.

Tables 7 and 8 show the association and distribution between CVMI stages and the DI stages of mandibular second molar. In males, the $\chi2(16)$ was 72.8 ($p < 0.001$), and Pearson contingency coefficient was 0.713, while in females, the $\chi2(25)$ was 179.64 ($p < 0.001$), and Pearson contingency coefficient was 0.863 showing a significant association between DI and CVMI in both genders. In males, the DI Stage E was associated with CVMI stage 2 (pre–peak of pubertal growth spurt) and DI stages F and G were associated with CVMI stages 3 and 4 (peak of pubertal growth spurt). Stages F and G were almost equally distributed in CVMI stage 4. DI stage H was associated with stages 5 and 6 of CVMI (end of pubertal growth spurt).

Table 7: Contingency table showing association and distribution between DI stages for mandibular second molar and CVMI stages in males

	DI for mandibular second molar						
CVMI stages	C	D n(%)	E n(%)	F n(%)	G n(%)	H n(%)	Total n(%)
1							
2		2(20)	**5(50)**	2(20)	1(10)		10(100)
3		2(5.3)	9(23.7)	**18(47.4)**	9(23.7)		38(100)
4			2(10.5)	7(36.8)	**9(47.4)**	1(5.3)	19(100)
5				4(26.7)	3(20)	**8(53.3)**	15(100)
6					6(35.3)	**11(64.7)**	17(100)
Total	0(0)	4(4)	16(16)	31(31)	28(28)	20(20)	99(100)

($\chi 2(16) = 72.8$, $p<0.001$, Pearson's contingency coefficient between CVMI & DI second molars is 0.713 at $p<0.001$).

In females, the DI stages C, D corresponded to CVMI stages 1, 2; DI stages E, F with CVMI stages 3, 4; DI stage G with CVMI stage 5, and DI stages G, H with CVMI stage 6. The statistical values for the females were higher than males showing stronger association in females. Comparison in tables 6, and in 8 - 9 also shows that the DI stages in males were more advanced than females with respect to CVMI stages. Comparison of Pearson contingency coefficients shows that the mandibular second molar had stronger association to skeletal maturity as compared to canines in both the genders, and it was stronger in females than males.

DISCUSSION

Skeletal maturity

It was assessed on the lateral cephalograms using CVMI method described by Hassel & Farman [4]. It is quick and relatively easy to perform. It omits the hand – wrist x-ray avoiding excessive radiation exposure. It is a reliable method for skeletal maturity assessment equivalent to hand – wrist x-rays and shows greater reproducibility between observers [4, 22, 23].

According to Hassel and Farman [4], the CVMI stage 2 indicates the onset of accelerating growth, CVMI stage 3 shows a period of peak of pubertal growth spurt and rapid growth velocity, while CVMI stage 4 denotes the period of decelerating growth. The mean age for each CVMI skeletal maturity level presented in Table 4 indicated that females mature earlier than the males by an average of 1.5 years. Previous studies have concluded that the girls mature faster than boys [1,16,20]. The observations of the present study are in accordance with earlier studies, as each CVMI stage consistently appeared earlier in girls than boys (Table 4). When the mean age of CVMI stages of the present study was compared to other populations [4,26,27], it was observed that Rwandese children achieved each CVMI stage at an earlier age than the other populations. It can be inferred that Rwandese children seem to be more advanced in skeletal maturation as compared to other population groups.

Dental maturity

Dental eruption is much more variable in its timing than dental maturation [24,25] and is influenced by local and environmental factors [21]. Therefore, the assessment of the maturation stages of teeth was the method of choice for this study. Dental maturity was assessed with the method proposed by Demirjian et al [21] as it records the distinct details based on crown – to – root ratio of the tooth, rather than absolute length, thus, avoiding the errors of faulty projections of images [1].

Studies [1,16,20,28] have reported that the radiographic assessment of tooth calcification stages might be clinically useful for skeletal maturity assessment. Many studies evaluated mandibular canine [29,30] calcification stages using OPGs and the hand-wrist x-rays to assess the skeletal maturity. The mandibular second molar calcification stages have also shown strong correlation with skeletal maturity [1,16,20]. But there was no study comparing the mandibular canine to the mandibular second molar calcifications stages for skeletal maturity assessed by CVMI, the present study was conducted to compare and assess the reliability of mandibular canine and second molars calcification stages as an indicator of skeletal maturity.

The females were advanced than males in both dental and skeletal maturation, being in accordance to the previous reports [7,8,17,22]. Each DI stage of mandibular second molar and canines appeared at an earlier age in the females than males, which shows that dental maturation occurred earlier in girls than boys by almost a year and completed earlier in girls (Table 5).

In this study, the DI was evaluated relative to CVMI for both genders which revealed significant association between the DI and CVMI (Tables 6-8). This association was stronger in the females. However, the dental calcification in relation to CVMI skeletal maturity was more advanced in males (Tables 6-8). At the same skeletal maturity stage, male subjects had a higher distribution of the later dental calcification stages. Previous studies [1,16,20,31,31] indicated that the maturation level of tooth development is more advanced in males as compared to the females in relation to skeletal maturity stages. It is therefore suggested that tooth calcification stages relative to skeletal maturation stages should be considered separately for different genders.

Canine maturity

DI stage F was associated with CVMI stage 2, and DI stage G with CVMI stage 3. At CVMI stages 4, 5 in both genders, most of the canines were in stage G & H i.e. towards the root completion, while 100 % canines were in stage H at CVMI stage 6. It shows that canine stages can be considered as indicative of growth status in the beginning stages (stages E & F) of canine development.

Table 8: Contingency table showing association and distribution between DI stages for mandibular second molar and CVMI stages in females

	DI for mandibular second molar						
CVMI stages	C n(%)	D n(%)	E n(%)	F n(%)	G n(%)	H n(%)	Total n(%)
1	1(50)	1(50)					2(100)
2		**4(50)**	2(25)		2(25)		8(100)
3			6(46.2)	**7(53.8)**			13(100)
4		1(4.3)	2(8.7)	**12(52.2)**	6(26.1)	2(8.7)	23(100)
5			1(4)	8(32)	**15(60)**	1(4)	25(100)
6				1(2.6)	**17(43.6)**	**21(53.8)**	39(100)
Total	1(0.9)	6(5.5)	11(10)	28(25.5)	40(36.4)	24(21.8)	110(100)

($\chi2(25)$ = 179.64, DF = 25, p<0.001, Pearson's contingency coefficient between CVMI & DI second molars is 0.863 at p<0.001);

Second molar maturity

DI stage E of mandibular second molars in males and stage D in females showed highest distribution in CVMI stage 2, which signifies the accelerating phase of growth.. DI stages F, G in males and E, F in females corresponded to the CVMI stages 3 and 4, indicating that these stages represent the peak of the pubertal growth spurt.
Hassel and Farman showed that CVMI stages 5 and 6 are the periods of negligible or no remaining growth.5 In our study, the second molar DI stage H in males and DI stages G and H in females corresponded to the CVMI stages 5 and 6, showing the end of pubertal growth spurt. It indicates that the DI stage H implies an insignificant/no remaining adolescent growth.

The Pearson correlation coefficients between skeletal maturity and canine calcification stages in the present study were 0.599 in males and 0.719 in females (p < 0.001), while for second molar stages, it was 0.713 and 0.863 respectively [1,6-8,20]. It suggests that a significant association exists between skeletal and dental maturation stages, which is better for second molars as compared to canines. In view of above findings, the mandibular canines and second molar calcification stages can be used as initial tool to predict the skeletal maturity level of the individuals, but second molars provides stronger prediction as compared to canines.
It is recommended that the results of this study should not be applied to all racial/ethnic groups at global level. It was observed that there was no uniform distribution of sample in different stages of DI and CVMI, which can be due to small sample size and a larger age range of study subjects. Future studies are recommended with larger sample and reducing the age range. Also, a uniform number of study subjects should be selected in different age categories.

Clinical implications

Knowledge of active facial growth is important for dento-facial orthopedic and surgical treatment planning. There is more skeletal response with myofunctional appliances if treatment is given during the peak height velocity period than during the pre-peak period [1]. Thus for more orthopedic effects, the treatment should be started during the intervening period of CVMI 2 – 3 stages. Treatment started after these stages may result in more dental than the skeletal effects [1]. Calcification stages of teeth can allow the clinician to easily identify the skeletal maturity status. This method can be easily incorporated into clinical practice by using IOPA view for initial growth assessment of an individual. It can be advantageous in clinical settings when only IOPA of second molar region can be used for this purpose, rather than resorting to OPG, especially in resource – constraint settings.

CONCLUSION

A significant relation exists between the dental calcification stages to the skeletal maturity, which is stronger in females than males. Second molar calcification stages have better association with skeletal maturity levels, and should be preferred for maturity assessment as compared to canines.

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