

# Comparative Evaluation of Development of Mandibular Second and Third Molars for the Assessment of Skeletal Maturity

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## ABSTRACT

**Objective:** Objective of the study was to compare the developmental stages of mandibular second and third molars for assessing the level of skeletal maturation.

**Study design:** A retrospective and cross-sectional study was conducted. Pre-treatment lateral cephalograms and panoramic radiographs (OPG) of 130 males and 161 females aged 9–18 years were evaluated. Demirjian Index (DI) for mandibular second and third molars developmental stages and the cervical vertebrae maturation indicators (CVMI) suggested by Hassel and Farman for skeletal maturation were used.

**Results:** Significant association was observed between mandibular molars maturation levels and the cervical vertebrae maturation (Pearson's contingency coefficient = 0.735 in females and 0.757 in males for third molars; and 0.726 in females, and 0.672 in males for second molars). Correlations were higher for third molars. CVMI stage 2 (acceleration phase of pubertal growth spurt (PGS)) corresponded to third molar DI stage B in females and stage C in males, while in second molar DI stage E in females and stage F in males was associated with CVMI-2. On the other hand, the third molar DI stages C and D corresponded to CVMI stages 3 and 4 in both genders. The second molar DI stage F in females and stage G in males corresponded to CVMI stage 3 (active PGS).

**Conclusion:** Mandibular third molars development showed stronger association with skeletal maturity assessment as compared to second molars. Mandibular second and third molars can be reliably used for skeletal maturity assessment. Second molar DI stages E and F in females; and F and G in males indicate the active growth period. Third molar DI stage B in females and C in males can indicate the acceleration phase of PGS. Completion of the crown of third molar indicates deceleration of PGS.

**Key words:** Cervical vertebrae maturation, Growth maturity, Demirjian Index, Mandibular molar.

## INTRODUCTION

Adolescent or pubertal growth spurt (PGS) of craniofacial complex is the most important phase for dentofacial orthopedic treatment. Appropriate timing of growth modification therapy to intercept a skeletal jaw disharmony is the key to success for a positive favorable outcome. It is related to the amount

of residual growth and accurate prediction of growth spurt timing.<sup>1</sup> Methods for assessing the growth status include physical stature, secondary sexual features, peak height velocity, growth charts and radiographic methods. Various methods have been proposed to assess skeletal development using the hand and wrist (HW) radiographs but these require an additional

radiograph.<sup>1-5</sup> Studies have confirmed the validity of cervical vertebrae maturation (CVM) method to assess the adolescent growth status, and it does not need an additional radiograph because CVM can be visualized on a lateral cephalogram.<sup>6-13</sup>

Level of calcification and development of teeth is a reliable criterion to evaluate the dental maturity.<sup>14</sup> Significant correlations have been reported between skeletal and dental maturity with varying results.<sup>15-22</sup> Mandibular third molar has been found to be least reliable tooth for skeletal maturity assessment.<sup>18-22</sup> Engstrom et al. (1983)<sup>23</sup> had reported significant correlation between lower third molar development and skeletal maturation. Racial variations in the relationship between the tooth calcification stages and skeletal maturity have been reported.<sup>24</sup>

Mandibular incisors, canine, premolars and first molars finish most of their development before PGS but second and third molars develop for a longer period and can be seen developing during and beyond PGS. Assessment of calcification of these teeth can be of clinical importance to assess the skeletal maturity status.<sup>25</sup>

## Aim and Objective

To evaluate and compare the developmental stages of mandibular second and third molars for assessing the level of skeletal maturation.

## MATERIALS AND METHODS

A descriptive, retrospective and cross sectional study design was approved by Ethical Committee of King Faisal Hospital Kigali, Rwanda. 291 sets of pre-treatment lateral cephalograms and panoramic (OPG) X-rays images were selected from orthodontic records of 130 males and 161 females of Rwanda origin aged 9–18 years with a mean age of 13.5 years. Congenitally missing teeth, skeletal deformity, history of previous orthodontic treatment and abnormal pathology were exclusion criteria for the study. A null hypothesis was established that there is no association between skeletal and dental maturity.

## SAMPLE SIZE DETERMINATION

$$\text{Formula} = n_0 = \frac{Z^2 pq}{e^2}$$

Where  $Z$  = critical value (It helps to obtain confidence interval);  $\alpha = 0.05$ , therefore  $\alpha/2 = 0.025$ , the  $Z$  value (0.025) = 1.96 (at pre-considered  $\alpha$ -value which is 1.96 at 95% confidence interval.)

$p$  = proportion (variability) = 0.5 ( $p = 0.5$  which is considered at maximum value because the population variability is not known)

$$q = 1 - p$$

$e$  = level of precision (sampling error or power) = 0.05

$\alpha$ -value = 0.05 = level of significance

$\beta$ -error =  $1 - \alpha = 0.95 = 95\%$  (power of the study)

So, sample size ( $n_0$ ) =  $(1.96)^2 \cdot (0.5) \cdot (0.5)/(0.05)^2 = 384$

But since population size was small, because it was a retrospective study using the radiographic records from the department ( $N = 400$ ), a factor of correction was applied to calculate the appropriate sample size.

$$n = \frac{n_0}{1 + (n_0 - 1)/N}$$

Therefore,  $n = 384/1 + (383/400) = 196$

So, a minimum of 196 subjects had to be studied. However, 291 sets of radiographs could be identified based on selection criteria which were included in the study.

The exact age up to the completed months was calculated from the date of birth of each subject. However, for the purpose of statistical analysis with SPSS and Epi Info software for easing the data entry, the subjects within 1–3 months were assigned value of 0.2 years, 4–6 months were assigned 0.5 years, and 7–9 months were given 0.8 years value, while subjects with 10–11 months were given 1 year value.

Cervical vertebrae maturity (CVM) evaluation was done by Hassel and Farman method (Table 1).<sup>6</sup> Dental maturity (DI) of mandibular second and third molars was assessed on OPG by Demirjian Index, (DI) (Table 2).<sup>14</sup> 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, which showed acceptable intra-observer agreement.

## STATISTICAL ANALYSIS

Statistical analyses were performed 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, means and standard deviations (SD) of the mean ages for CVMI stages. Cross-tabulation was performed to assess distribution of DI stages among CVMI stages stratified by gender. Mann Whitney/Wilcoxon Two-sample test (Kruskal Wallis test for 2 groups), Pearson chi-square test values ( $\chi^2$ ), ANOVA and Pearson contingency coefficient were estimated to determine the relationships between DI and CVMI among the genders.  $p < 0.05$  was considered as statistically significant.

**Table 1**Cervical vertebra maturation indicators (CVMI, Hassel and Farman, 1995)<sup>6</sup>

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, 1973)<sup>14</sup>

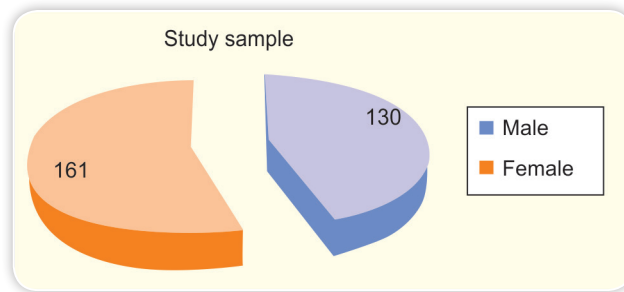
Stage	Characteristics
A	Calcification of single occlusal points without fusion of different calcifications
B	Fusion of mineralization points; the contour of the occlusal surface is recognizable
C	Enamel formation has been completed at the occlusal surface, and dentin formation has commenced. The pulp chamber is curved, and no pulp horns are visible.
D	Crown formation has been completed to the level of the cemento-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

## RESULTS

Study involved radiographic records of 44.7% ( $n = 130$ ) males and 55.3% ( $n = 161$ ) females aged 9 to 18 years (**Figure 1**). Mean age of males was 13.562 years ( $SD = 1.99$  years), of females was 13.563 years ( $SD = 1.93$  years), and of the total

sample was 13.563 years ( $SD = 1.96$  years). There was no statistical difference in mean age between the genders.

**Table 3** shows distribution and mean age of different CVMI stages among the genders (**Figure 2**). Significant differences were observed in both genders among the mean age of different



**Figure 1** Study sample

CVMI stages evaluated by ANOVA and Chi-square test. Mann Whitney/Wilcoxon Two-sample test (Kruskal Wallis test for 2 groups) showed highly significant intra-group differences among various CVMI stages in both genders ( $\chi^2(5) = 103.73$ ,  $p < 0.001$ , and  $\chi^2(5) = 87.8$ ,  $p < 0.001$  for females and males

respectively). Significant statistical inter-group difference between genders was found by Pearson's Chi-square test ( $N = 291$ ,  $\chi^2(5) = 64.4$ ;  $p$ -value = 0.00). ANOVA showed significant (intragroup and intergroup) differences between mean ages of CVMI stages in both genders (F-statistics: Females = 59.79, Males = 55.6).

**Table 4** show the distribution of DI stages of second molars among CVMI stages. Significant association was observed among DI stages of second molar and CVMI stages (Females:  $\chi^2(20) = 179.7$ , contingency coefficient  $C^* = 0.726$ ; males:  $\chi^2(20) = 107$ ,  $C^* = 0.672$ ;  $p$ -value = 0.00).

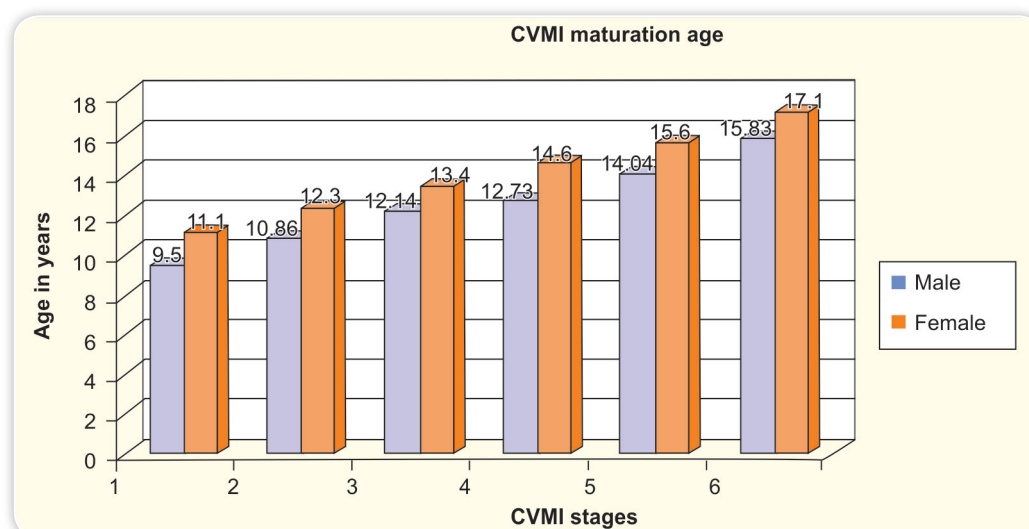
**Table 5** shows association and distribution between CVMI stages and DI stages of mandibular third molar (Females,  $\chi^2(35) = 189.5$ ;  $C^* = 0.735$ , ( $p < 0.001$ ); males,  $\chi^2(35) = 174$ ;  $C^* = 0.757$  ( $p < 0.001$ ), showing significant association between DI and CVMI.

**Table 3**

Distribution and mean age according to CVMI stages

CVMI	Total		Females		Males		Females		Males	
	N	%	N	%	N	%	Mean age, yrs	SD, yrs	Mean age, yrs	SD, yrs
1	19	6.5	3	1.9	16	12.3	9.5	0.5	11.1	1.34
2	45	15.5	12	7.5	33	25.4	10.86	1.16	12.3	0.92
3	51	17.5	16	9.9	35	26.9	12.14	0.74	13.4	1.23
4	62	21.3	43	26.7	19	14.6	12.73	1.16	14.6	1.13
5	70	24.1	52	32.3	18	13.8	14.04	1.15	15.6	1.15
6	44	15.1	35	21.7	9	6.9	15.83	1.27	17.1	0.92

(Females,  $\chi^2 = 103.73$ ,  $df = 5$ ; Males  $\chi^2 = 87.8$ ,  $df = 5$ , F-statistics: females 59.79, males = 55.6,  $p$ -value = 0.0000).



**Figure 2** Mean age of CVMI stages

**Table 4**

Percentage distribution of calcification stages of second molar in different CVMI stages in both genders

CVMI	1	2	3	4	5	6	1	2	3	4	5	6
DI %	Females						Males					
D	67	17					12.5					
E	33	25	6				44	12	3			
F		42	32	16	4		31	36	20	5		
G		17	62	72	54	11	12.5	52	60	42	45	
H				12	42	89			17	53	55	100

(Females:  $\chi^2$  (20) = 179.7, contingency correlation coefficient (C\*) = 0.726; males:  $\chi^2$  (20) = 107, C\* = 0.672; p-value = 0.00)**Table 5**

Percentage distribution of calcification stages of third molar in different CVMI stages

CVMI	1	2	3	4	5	6	1	2	3	4	5	6
DI %	Females						Males					
A		8					19		3			
B	100	58		9	2		44	6			5.6	
C		34	94	51	25	6	37	73	43	10	5.6	
D				35	31	11		21	37	37	17	
E			6	5	29	20			14	32	50	22.3
F					11	40			3	16	17	11.2
G					2	20				5	5.6	55.3
H						3						11.2

(Females:  $\chi^2$  (35) = 189.5, C\* = 0.735; Males:  $\chi^2$  (35) = 174, C\* = 0.757, p = 0.00)

## DISCUSSION

Lateral cephalogram and OPG views are the essential X-rays needed for orthodontic treatment planning and show clear views of cervical vertebrae and mandibular dental development. Therefore, these views can be used to assess skeletal maturity by studying the cervical vertebrae maturation and the dental calcification events.<sup>15-25</sup> Maxillary dental buds cannot be seen clearly due to overlapping by other anatomical structures. HW radiographs lead to unnecessary radiation exposure to the patients which are not used now for maturity assessment. Lopes et al. concluded that OPGs can be used as the first diagnostic tool to estimate pubertal growth period by assessing the dental mineralization stages.<sup>26</sup> Since the dental eruption is variable in its timing and is influenced by multiple factors,<sup>19,21,27</sup> therefore, the assessment of dental calcification stages was the method of choice for this study. Dental maturity was assessed by Demirjian et al. method.<sup>14,15,21</sup>

Significant correlation of mandibular teeth calcification stages with skeletal maturity has been reported.<sup>15-22</sup> Most of the studies have reported high reliability of canines and second molars but insignificant reliability of third molars.<sup>18-22</sup> Only some studies reported significant relationship of mandibular third molars for skeletal maturity assessment.<sup>23,28,29</sup> Since most of the teeth finish their development by 12 years of age, therefore, beyond this age, the maturation stages of second and third molars only can be of value for assessing the skeletal maturation level.<sup>25</sup> In the present study, a comparison of mandibular second and third molars calcification stages was assessed to determine the level of skeletal maturity. Since the development of these teeth continues over a longer duration and many developmental stages can be seen during the active growth phase, therefore, these teeth can be of benefit for skeletal maturity assessment.<sup>25</sup>

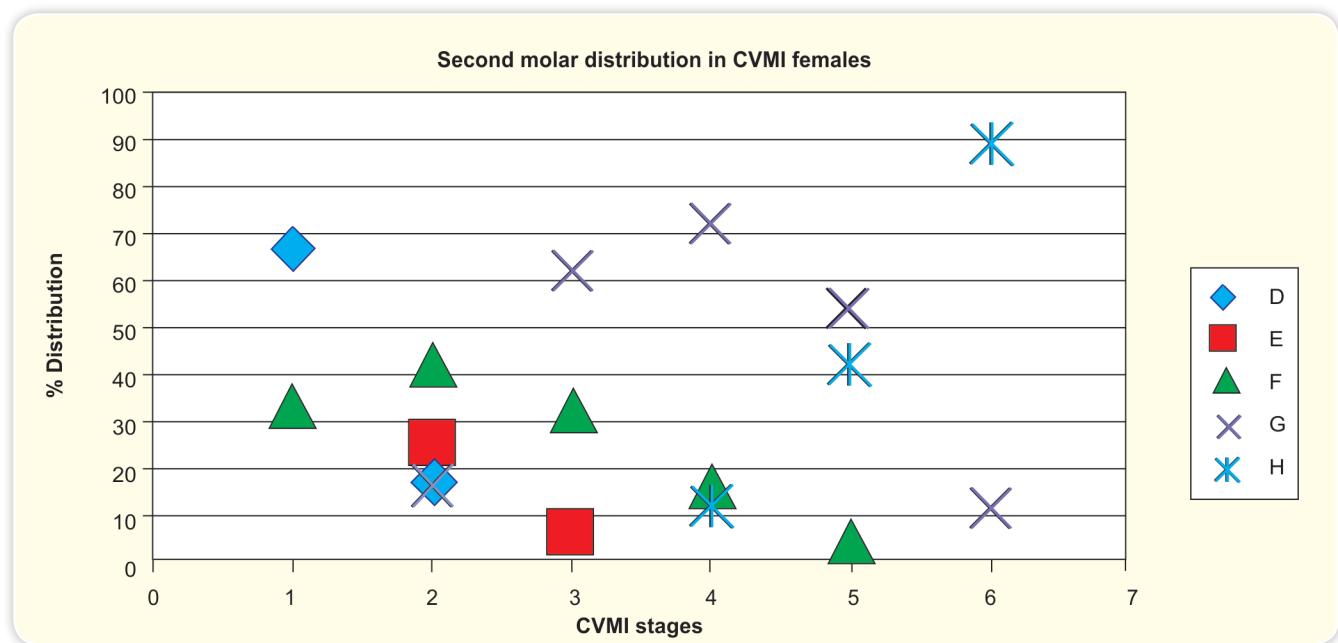
### Cervical Vertebrae Maturation (Figure 2)

Each CVMI stage in females appeared at an earlier age as compared to males showing that females mature earlier than males. The gender difference ranged between 1.26 years to 1.87 years among different stages. Duration of the pubertal peak interval (CVMI 3–CVMI 4) is found to be 1.2 years in males and 0.59 years in females. It shows that the time for starting dentofacial orthopedic intervention is more crucial

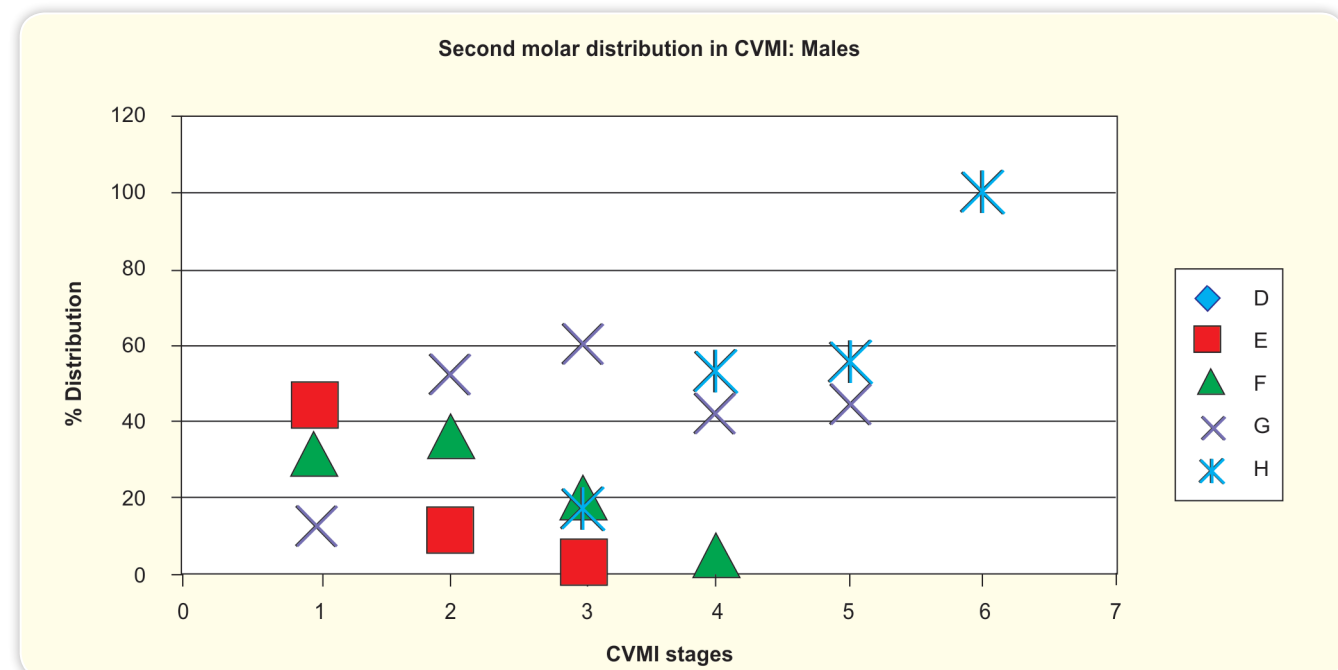
in females as compared to males. The pubertal growth period duration (CVMI 2–CVMI 4) in males (2.2 years) was longer than females (1.9 years), with a gender difference of 5 months.

### Mandibular Second Molars and Skeletal Maturity Correlations (Figures 3 and 4)

For an orthodontist, acceleration phase of growth and beyond are of more clinical significance for myofunctional treatment



**Figure 3** Distribution of DI stages of second molar among CVMI stages in females



**Figure 4** Distribution of DI stages of second molar among CVMI stages in males



planning. Therefore, we observed the dental maturation stages associated with CVMI-2 onwards.

DI stage E was found to be mostly present in CVMI stages 1 and 2. DI stage F (42%) was prominent during CVMI-2 stage showing the acceleration phase of PGS, and to some extent (32%) in CVMI-3 stage. Later on, the DI stage G was predominant at CVMI stage 3 and 4 which is indicative of an active PGS and individual may be at the peak of the growth curve or may have started deceleration of growth. At CVMI 5, 6, the Stage H was present in high percentage indicating little or no residual growth. Overlapping DI stages in different CVMI stages may be due to second molars having a long period of development. It was interpreted that in females, DI stages E & F are of clinical significance for growth assessment and may indicate the acceleration in the growth rate of active growth spurt.

In males, DI stage G was prominent (52%) in CVMI-2 stage, while the DI stages F (36%) was also present. DI stage F may indicate the acceleration phase of PGS. But as the skeletal and dental growths progress with time, the DI stage G may indicate ongoing PGS. DI stage G was also predominant in CVMI stage 3 indicating the ongoing PGS. DI stage H started appearing prominently from CVMI stage 4 onwards, indicating that stage H represents the descending phase of growth spurt which later on indicates little or no residual growth. It was interpreted that in males, DI stages F&G may be used as clinically significant for growth assessment. Stage F may indicate the approaching PGS (CVMI-2) and stage G indicates the ongoing active PGS (CVMI-3).

Authors further observed that it is beneficial to err on the lower DI stage for indication of growth status rather than the higher DI stage for maturity assessment and timing the treatment. Lower DI stage may give enough time to plan the treatment based on the ensuing growth stage. Since in this study, the higher DI stages were found distributed over multiple skeletal stages, it is worth mentioning that it may give a false-positive assessment of growth status. Perinetti et al. had concluded that DI stages are more reliable to indicate only the pre-pubertal growth stage.<sup>30</sup> Presence of stage H is indicative of little growth, so it should not be used as a criterion for evaluation of skeletal status, as it may indicate false growth staging.

Kraillasi et al. in Thai sample found that second molar stage E in females corresponds to S-stage in hand-wrist bones (CVMI 2), and stage G in males corresponds to MP3cap stage (CVMI 3).<sup>18</sup> Kumar et al. in Indian subjects also noted the second molars DI stage E corresponded to stage 2 of CVMI (pre-peak of pubertal growth spurt) and DI stages F and G

corresponded to stages 3 and 4 of CVMI (peak of pubertal growth spurt), while the DI stage H was associated with stages 5 and 6 of CVMI (end of pubertal growth spurt).<sup>21</sup> Similarly, Cossellu et al. in Italian subjects found second molar stage E corresponded to CVM 1 and 2 (the phase prior to PGS); stage F to the phase of PGS, and stage G indicated that the growth spurt is underway.<sup>22</sup> These studies corroborate the results of the present study.

### Mandibular Third Molars and Skeletal Maturity Correlations (Figures 5 and 6)

In females, the DI stage B (58%) was predominant in CVMI stage 2, indicating acceleration phase of PGS. DI stage C (94%) was predominant in CVMI-3 indicating active PGS. But during CVMI-4 stage the DI Stage D (35%) also started appearing along with stage C (51%) which is the stage of slowing down of the growth rate. Some overlapping of dental stages of third molars in different CVMI stages might be due to very long period of its development. Predominance of stages D and E in CVMI stage 5 and DI stage F appeared in CVMI stage 6. Therefore, third molar DI stage C may indicate the active growth phase while the presence of stage D may indicate that the pace of PGS is slowing down, and the stage E may indicate minimal residual growth.

In males, DI Stage C (73%) showed the highest distribution at CVMI stage 2 (pre-peak of pubertal growth spurt), indicating the acceleration of the growth spurt. DI stages C (43%) was present in CVMI stage 3, while stage D (37%) also started showing during CVMI stage 3 (peak of pubertal growth spurt). During CVMI stage 4 (deceleration phase of growth spurt), mostly DI stages D and E were observed. It might indicate that the presence of stage D heralds the slowing of the growth rate. DI stage E was associated with CVMI 5 and DI stage G was predominant in CVMI 6 (end of pubertal growth spurt) indicating minimal residual growth.

Therefore, third molars stage B in females and stage C in males indicated CVMI-2 (the acceleration phase of PGS expected within 1 year time). Also DI stage C in both the genders might be indicative of CVMI stage 3 (peak of PGS). Third molar Stage D was found to be equally present in both CVMI stages 3 and 4 in males. Therefore, authors concluded that stage D, i.e. completed crown formation and the initiation of root formation of third molar should be used to indicate the deceleration of growth. During CVMI 5 and 6 stages, scattered E, F & G stages were observed. Stage E of third molars in both genders may indicate the minimal residual growth. Authors again stress that it is beneficial to err towards lower DI stage

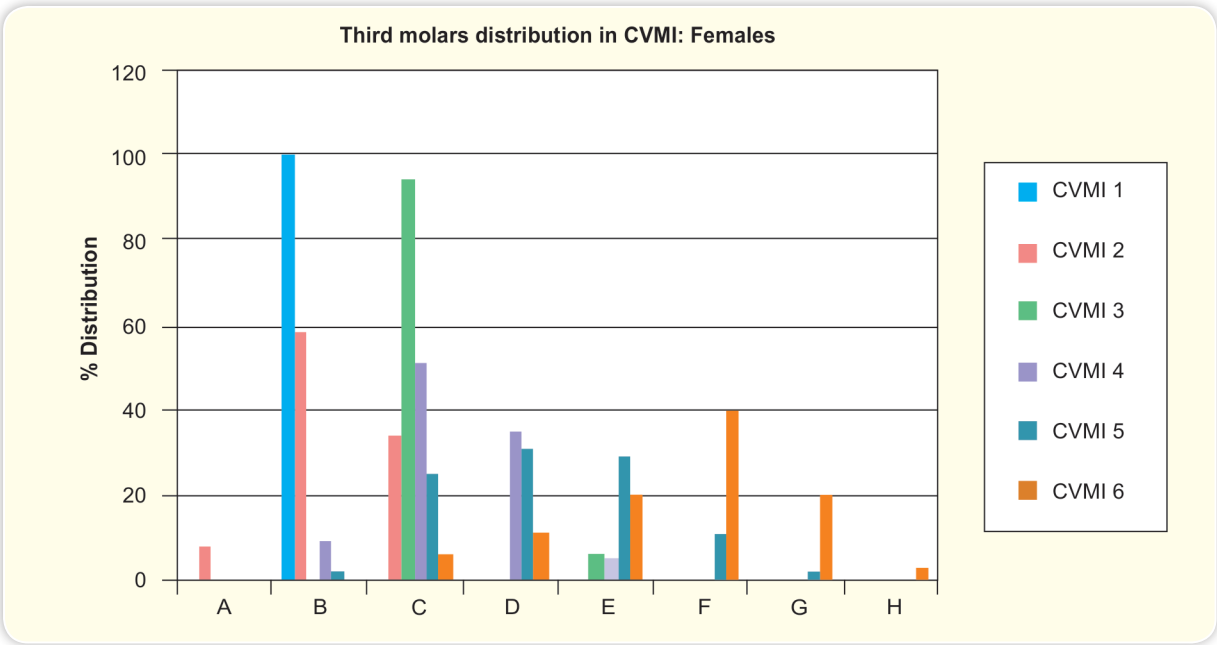


Figure 5 Distribution of DI stages of third molar among CVMI stages in females

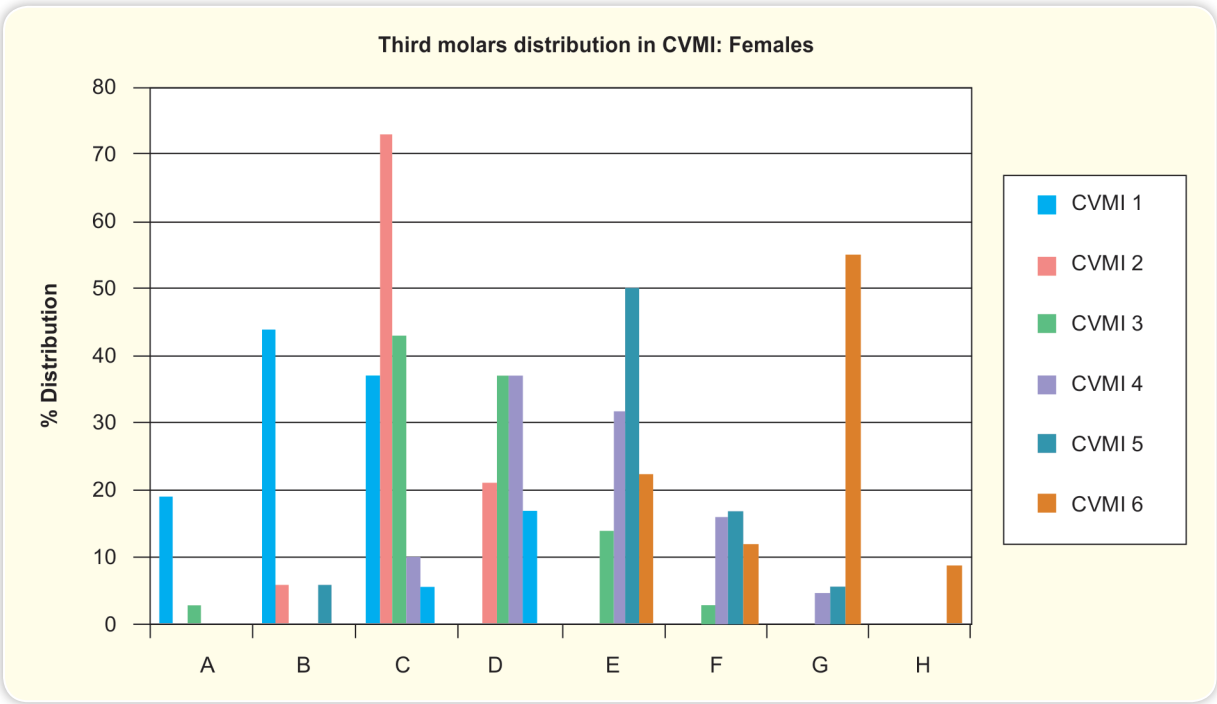


Figure 6 Distribution of DI stages of third molar among CVMI stages in males

for better indication of growth status, because taking decision of treatment timing based on the higher DI stage may give a false-positive assessment of growth status and the subsequent loss of precious treatment timing.

Past studies have reported that the appearance of adductor sesamoid of thumb indicates the beginning of pubertal growth spurt, and this stage corresponds to CVMI 2 stage (acceleration phase of PGS).<sup>6,31-33</sup> In the present study, the second molar DI



stage E in females and F in males; and third molar DI stage B in females and stage C in males showed highest distribution in CVMI-2 stage.

MP3cap stage (epiphyseal capping of diaphysis of the middle phalanx of third finger) heralds the peak of pubertal growth spurt which corresponds to CVMI-3 stage.<sup>6,33</sup> In the present study, the second molar DI stage G in females and stages G, H in males; and third molar DI stage C in both genders corresponded to CVMI stage 3. In CVMI stage 4, the DI stage D started appearing in high percentages in both genders. Thus DI stage C may represent the peak of PGS, while stage D may indicate deceleration of the growth spurt.

Fishman's SMI-10 corresponds to CVMI-5 stage, and SMI-11 signifying the end of growth corresponds to CVMI-6 stage.<sup>6,31</sup> In the present study, the second molar DI stages G & H were found in CVMI-5, and DI Stage H in CVMI-6 in both the genders. Also, the third molar DI Stages E, & F in both genders corresponded to the CVMI-5 and 6 stages, showing the end of pubertal growth spurt. Thus third molar DI stage E may indicate minimal growth in both genders.

Previously, Cho and Hwang 2009<sup>28</sup> had concluded that beginning of the root formation of third molars (Stage D) indicated growth completion in Korean females. Also, DIs above Stage E was correlated with CVMI-5, and 6; and DI Stages G, & H were correlated with CVMI-6.<sup>28</sup> Suma et al 2014<sup>29</sup> reported the completion of crown formation of third molars correlated with MP3cap stage in Indian subjects. Engstrom et al. 1983<sup>23</sup> had also reported that at stage MP3cap (equivalent to CVMI 3, SMI 6), the third molar crown formation was completed in majority of Swedish subjects and root formation (stage D of DI) had started in some. Findings of present study are consistent with these earlier studies.

Correlation values (C\* values) for third molars were 0.735 in females and 0.757 in males showing strong correlation between dental and skeletal maturation status which correspond to the results of previous studies.<sup>23,28,34</sup> In contrast, few studies reported insignificant correlations.<sup>35,36</sup> C\* values for second molar were also highly significant but less than the findings of Kumar et al. and Goyal et al.<sup>21,37</sup> These differences can be attributed to factors like differences in study design and racial differences among others.<sup>23</sup>

In the present study, each CVMI stage appeared earlier in females which shows that the skeletal maturation of girls is faster than boys. On the other hand, the DI in males was more advanced than females with respect to CVMI stages. These findings are consistent with earlier studies.<sup>9,18-21</sup>

Present study highlights that mandibular third molar can be a useful tool for skeletal maturity assessment. It can be assessed

on an IOPA view rather than resorting to OPG or Hand wrist view, thus avoiding higher radiation exposure. C\* values of third molars were higher than second molars. Therefore, third molars can be a better predictor of skeletal maturation status than the second molars. Third molars are also advantageous due to their long development period beyond PGS and can be followed for a longer period growth assessment.

Review of similar previous studies for evaluation of skeletal and dental maturation showed that the uniform sampling, age range, study design, and growth assessment methods are lacking. Thus it limits the direct comparison among the studies. It is suggested that uniform criteria should be applied in future studies. Future studies are recommended with uniform distribution of sample to involve equal number of subjects in each CVMI stage, and using the uniform methods of assessment of skeletal and dental maturation.

## CONCLUSIONS

Mandibular second and third molars calcification can be used to assess the skeletal maturity. Third molars showed better correlation than the second molars with skeletal maturation. Third molar stage B in females and stage C in males indicated acceleration phase of PGS, while stage D indicated deceleration phase of PGS. Any evidence of third molar crown completion and start of root formation (DI stage D) indicated deceleration of growth spurt. Second molar stage E in females and Stage F in males indicated acceleration phase of PGS. Second molars can be helpful for assessment if third molars are congenitally absent.

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