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The relationship between the stages of calcification of mandibular 2nd molar and skeletal maturity among 8-13 year old children: A study

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ABSTRACT:
Malocclusion may be defined as a mal-relationship of the dental arches beyond the range of what is accepted as normal. The adolescent growth spurt is a period of sudden increase in skeletal growth of the body and the face and thus any Dentofacial intervention during that period helps achieve more skeletal effects and stable treatment results. This study was aimed at determining the growth potential of the patient by investigating the relationship between the stages of calcification of mandibular 2nd molar and skeletal maturity stages among 8-13 years old children. 2. To correlate chronological and dental ages with skeletal maturity. A retrospective and cross-sectional in vitro study was carried out using the traditional films of pre-treatment OPGs and lateral cephalograms of 150 subjects (75 males and 75 females) visiting the department of Pediatric & preventive dentistry. Skeletal maturity was assessed on the lateral cephalograms using CVMI method described by Hassel & Farman. The permanent second molar calcification stages were assessed according to Demirijan index (DI) proposed by Demirjian et al. Females were found to be more advanced than males in both dental and skeletal maturation, being in accordance with previous reports. Each DI stage of mandibular second molar appeared at an earlier age in the females than males, which shows that dental maturation occurrs earlier in girls than boys by almost a year and completes earlier too, concluding thereby that interceptive orthodontic treatment should be initiated earlier in girls in order to harness the adolescent growth spurt to maximize the potential for effective interceptive orthodontic treatment.
Key words: Dentofacial intervention, Skeletal maturity, Dental maturity, Demirijan index, CVMI method.

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INTRODUCTION:-

Malocclusion may be defined as an irregularity of the teeth or a mal-relationship of the dental arches beyond the range of what is accepted as normal[1]. With evolution the jaws of the modern man have become smaller, primarily because of the change in dietary habits. This discrepancy in the tooth bone ratio does not permit the teeth to erupt in a regular arch form thus leading to malocclusion. With advent of time this problem has indeed assumed alarming proportions. Another factor that is responsible for bringing this particular problem into the limelight is the increased awareness amongst the general public who aspire to have a perfect set of teeth. In fact after tooth decay and periodontal disease today malocclusion ranks 3rd among world-wide dental public health priorities[2].

The adolescent growth spurt is a period of sudden increase in skeletal growth of the body and the face and, thus any dentofacial intervention during that period helps achieve more skeletal effects and stable treatment results [3]. Therefore knowledge of the status of skeletal maturation and cranio-facial growth of an individual holds great importance [4]. Skeletal age assessment is essential and helpful in formulating viable treatment plans for malocclusion [5]. Skeletal maturation staging from radiographic assessment is a widely used approach to predict the timing of pubertal growth, to estimate growth velocity and to estimate proportion of growth remaining [6].

There have been many attempts to correlate dental development with skeletal growth. Hand wrist examination is the gold standard for evaluating remaining growth, yet it clearly can be augmented with additional information such as dental development. Cervical vertebrae morphology can also be evaluated for remaining growth as it correlates strongly with skeletal maturity indicators [7]. In addition this method has the added advantage of eliminating the need for an additional radiographic exposure since the vertebrae are already recorded in the lateral cephalogram taken as a pre-treatment record [5].

Then again, dental maturity can be determined by the stage of tooth eruption or by the stage of tooth formation. Tooth formation is proposed as a more

reliable criterion for determining dental maturation [8]. 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 again avoid additional radiation exposure to obtain hand wrist radiograph[9]

As the Pedodontist is practically the first dental specialist to whom a child is brought for his dental treatment, the onus is on him not only to assess but also to prevent and intercept this particular problem, thus necessitating need for research in this particular speciality.

1. This study was aimed at determining the growth potential of the patient by investigating the relationship between the stages of calcification of mandibular 2nd molar and skeletal maturity stages among 8-13 years old children.
2. To correlate chronological and dental ages with skeletal maturity.

METHOD:-

A retrospective and cross-sectional in vitro study was carried out using the traditional films of pre-treatment OPGs and lateral cephalograms of 150 subjects (75 males and 75 females) visiting the department of Pediatric & preventive dentistry between the age group 8-13 years.

The selection criteria aimed at the subjects being between 8 -13 years of age, well nourished, and free of any known serious illness that could affect skeletal growth and general development.

Whereas subjects who had undergone orthodontic treatment and extraction of any permanent teeth or having impaction/transposition of teeth or any congenital anomalies of teeth or jaw or even a history of trauma or injury to the face and neck were excluded.

Equipments and materials used were:

1.Orthopantomogram

2. Lateral Cephalogram

- Locally made illuminated tracing table
- Acetate tracing paper
- 3H pencils
- Eraser
- Paper clips
- Metal scale
- Protractor

3.OPG machine

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) [4].

Stages	**Amount of growth expected**	**Characteristics**
Stage 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.
Stage 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.
Stage 3Transition	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.
Stage 4 Deceleration	10% - 25%	eceleration 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.
Stage 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.
Stage 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.

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.

Evaluation of dental maturity on panoramic radiograph: The permanent second molar calcification stages were assessed according to Demirijan index (DI) proposed by Demirjian et al. If the left side tooth was not clear, then its counterpart on the right side was evaluated.
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 deviations of the mean ages for the CVMI stages and the DI stages of 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 ($\chi 2$) 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 50% (n=75) males and 50% (n=75) females. The age range of the study sample was from 8 years to 13 years . The mean age of males was 10.14 years (SD = 1.43 years), of females was 10.81 years (SD = 1.58 years), and of the total sample was 10.48 years (SD = 1.54 years).

The females were found to be more advanced than males in both dental and skeletal maturation, being in accordance with previous studies[20, 21, 22,11]. Each DI stage of mandibular second molar appeared at an earlier age in the females than males, which shows that dental maturation occurs earlier in girls than boys by almost a year and completed earlier in girls.

In this study, the DI was evaluated relative to CVMI for both genders which revealed significant association between the DI and CVMI. This association was stronger in the females. However, the dental calcification in relation to CVMI skeletal maturity was more advanced in males. It is therefore suggested that tooth calcification stages relative to skeletal maturation stages should be considered separately for different genders.

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.

Sample distribution and mean age

	Total	Males	Females
Sample size	150	75	75
% Sample size	100%	50%	50%
Mean age	10.48±1.54	10.14±1.43	10.81±1.58
Age range	8-13	8-13	8-13

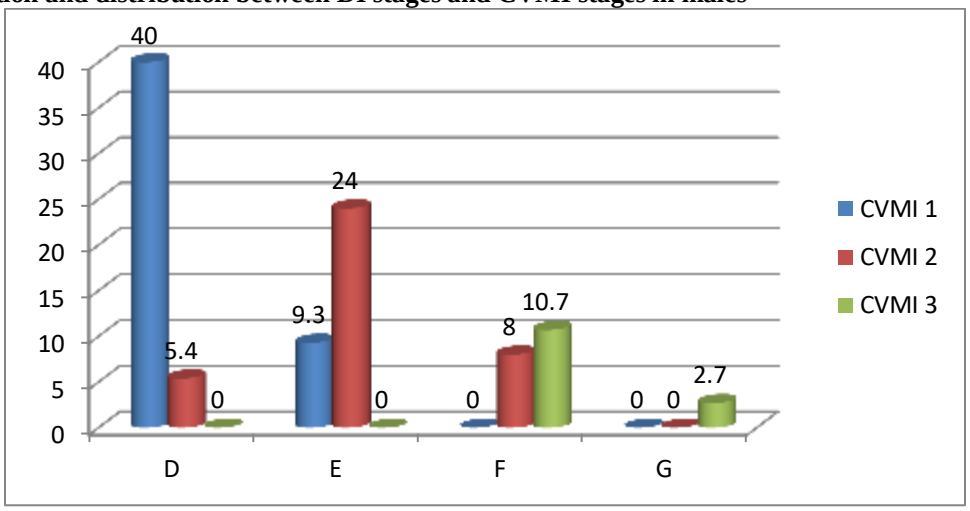
Percentage distribution and the mean age at different CVMI stages

CVMI stages	Females n(%)	Males n(%)	Total n(%)	Mean Age Males	Mean Age Females	Gender Difference	p-Value
1	9(12)	37(49.3)	46(30.7)	9.15±0.68	8.38±0.48	0.77	0.003*
2	29(38.7)	28(37.4)	57(38)	10.51±0.94	9.96±0.76	0.55	0.019*
3	22(29.3)	10(13.3)	32(21.3)	12.8±0.25	11.43±0.82	1.37	0.001**
4	15(20)	0	15(10)	-	13±0	-	-
5	0	0	0	-	-	-	-
6	0	0	0	-	-	-	-

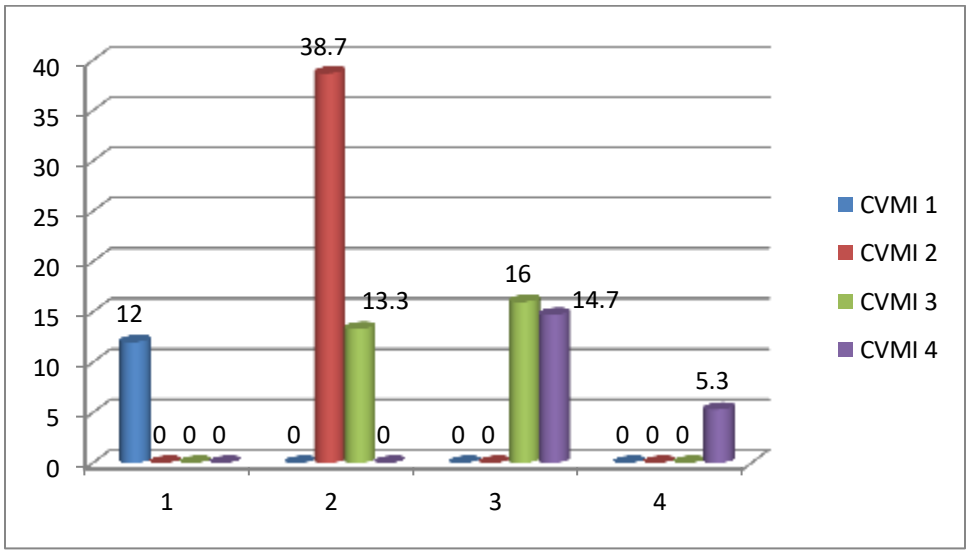
Mean age of different DI stages of males and females

DI stages	Males n(%)	Females n(%)	p-value
D	34(45.3)	9(12)	0.001**
E	25(33.3)	41(54.7)	
F	4(5.4)	24(32)	
G	12(16)	1(1.3)	

The association and distribution between DI stages and CVMI stages in males



The association and distribution between DI stages and CVMI stages in females



DISCUSSION:

Skeletal maturity was assessed on the lateral cephalograms using CVMI method described by Hassel & Farman [10]. 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 [10, 11,12].

According to Hassel and Farman [10], 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 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 [13]. The observations of the present study are in accordance with earlier studies, as each CVMI stage consistently appeared earlier in girls than boys. When the mean age of CVMI stages of the present study was compared to other populations [10,14,15].

Dental eruption is much more variable in its timing than dental maturation [16,17] and is influenced by local and environmental factors [18]. 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 [18] 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.

Studies [13,19] have reported that the radiographic assessment of tooth calcification stages might be clinically useful for skeletal maturity assessment.. The mandibular second molar calcification stages have shown strong correlation with skeletal maturity [13].

The females were advanced than males in both dental and skeletal maturation, being in accordance to the previous reports [20,21,22,11]. Each DI stage of mandibular second molar 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.

In this study, the DI was evaluated relative to CVMI for both genders which revealed significant association between the DI and CVMI. This association was stronger in the females. However, the dental calcification in relation to CVMI skeletal maturity was more advanced in males. Previous studies [13,23] 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.

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.

The Pearson correlation coefficients between skeletal maturity for second molar stages, was 0.713 and 0.863 respectively [4,24,20,21,13]. It suggests that a significant association exists between skeletal and dental maturation stages. In view of above findings second molar calcification stages can be used as initial tool to predict the skeletal maturity level of the individuals.

Knowledge of active facial growth is important as there is more skeletal response with myofunctional appliances if treatment is given during the peak height velocity period than during the pre-peak period [4] Therefore 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. 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:

In simpler words it can be concluded that a significant relation exists between the dental calcification stages to the skeletal maturity, which is stronger in females than males. Although more research is recommended with larger sample size and a uniform number of study subjects selected in different age categories to authenticate the findings of this study further.

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