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Evaluation of Pubertal Growth Spurt in Orthodontic Patients Using Demirjian Index: An Orthopantomography Based Study

Moazzam Jawaid[1*] Puneet Kumar[2] Vikash Kumar[3] Kumar Shresth Gami[4] Ruchi Jaiswal[5] Zakia Tabassum[6]

[1]Assistant Professor, Department of Oral Medicine and Radiology, Sarjug Dental College and Hospital, Darbhanga, India.
[2]Assistant Professor, Department of Pedodontics and Preventive Dentistry, Sarjug Dental College and Hospital, Darbhanga, India.
[3]MDS, Department of Orthodontics and Dentofacial Orthopaedics, Bihar, India.
[4]Assistant Professor, Department of Conservative Dentistry and Endodontics, Sarjug Dental College and Hospital, Darbhanga, India.
[5]General Dental Practioner, Darbhanga, Bihar, India.
[6]General Dental Practioner, Gaya, Bihar, India.

ABSTRACT

Background: Assessment of pubertal growth spurt is a common clinical practice in many health professions, especially for growth assessment in orthodontics and dentofacial orthopedics and for age estimation in forensic sciences.

Aim: The present study was conducted to establish Orthopantomogram (OPG) as a reliable method for the assessment of pubertal status of subjects using Demirjian Index

Material and Methods: OPGs of the 250 subjects of study group were assessed for dental maturity by Demirjian Index (DI). The Spearman rank-order correlation coefficient was used to measure the association between pubertal growth spurt and dental calcification stage of individual teeth.

Results: The mean chronologic age of girls was significantly lower than that of boys in each pubertal stage. The mandibular second molar had the highest and the canine the lowest correlation with the pubertal stage.

Conclusion: Mandibular second molar DI calcification stages can be used as an indicator for pubertal growth spurts and orthopantomogram can be used as an effective tool for estimation of pubertal growth spurt.

Keywords: Demirjian Index, Orthopantomograph, Pubertal Growth Spurt.

INTRODUCTION

Assessment of pubertal growth spurt is a common clinical practice in many health professions, especially for growth pattern assessment in orthodontics and dentofacial orthopedics and for age estimation in forensic sciences. Due to considerable variations in development among children, chronological age may have little role in the determination of the maturation stage of a subject and has given rise to the concept of biologic or physiologic age. Physiologic age is the rate of progress toward maturity and is evaluated by somatic, sexual, skeletal, and/or dental maturity.[1]

Dental development has been widely investigated as a potential predictor of age estimation and indicator for pubertal growth spurt. Generally, dental development can be assessed by either evaluation of the phase of tooth eruption or of the stage of tooth calcification, with the latter method being more reliable. According to previous reports, the stages of mandibular second molar calcification

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*Correspondence **Dr. Moazzam Jawaid.**
Department of Oral Medicine and Radiology, Sarjug Dental College and Hospital, Darbhanga, India.
Email: moazzamjawaid1988@gmail.com

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showed the highest correlation with maturity indicator of the pubertal growth spurt as compared to other teeth.[2] It has been suggested that racial variations also play a role in the correlation of dental and skeletal maturation. It has been indicated that ethnic origin of the population, climate, nutrition and socioeconomic levels are causative factors for these racial variations.[3]

The completion of root formation in the mandibular second molar as observed in OPG may be used clinically as a maturity indicator of the pubertal growth spurt with a degree of reliability similar to that of some of the other indicators described for hand-wrist radiographs among children. Tooth calcification stages assessed from panoramic radiographs can be used clinically as a maturity indicator of pubertal growth. The mandibular second molar calcification showed the highest correlation with skeletal maturity compared to other teeth.[4]

The ability to assess pubertal status by the stages of mandibular second molar calcification through the examination of an OPG which is a routine diagnostic radiograph for dental treatment will have added advantage over the conventional hand-wrist radiographic method. No extra exposure to radiation would be there if assessment of skeletal maturity will be performed using routine radiographs, keeping in mind the ALARA (As Low as Reasonably Achievable) principle.[5] Hence the present study was conducted to establish OPG as a reliable method for the assessment of pubertal status of subjects.

MATERIALS AND METHODS

A total of 250 subjects of either gender between the age group of 8-16 years reporting to the outpatient Department of Oral Medicine, Diagnosis & Radiology, Sarjug Dental College and Hospital, Darbhanga, were included in the study. The number of subjects were selected according to the evaluation carried out with the help of computer software. The Informed consent was obtained from the subjects and the concerned parents. The study was approved by the Ethical committee, Suryug dental college, Darbhanga, Bihar.

Subjects between age group of 8-16 with normal mandibular teeth were included in the study. The subjects who had history of systemic disease that could affect the presence and development of mandibular permanent teeth and subjects who had previous history of trauma or injury to the face were excluded from the study.

Orthopantomogram was taken with the film size of 10 × 12 cm. The film was exposed at 64 kV and 8 mA for an average of 12 seconds. The radiograph was done as per the standard protocols. Standardized lateral cephalometric radiograph of each individual was taken with the cephalostat. The film was exposed at 66 kV and 10 mA for an average of 0.8 seconds with a tube to film distance of 6 feet on a 8 x 10 cm X-ray film size. All the usual protective measures for radiographic exposure were followed in each patient.

Radiographs of high clarity and good contrast were selected. Interpretation of all radiographs were undertaken without referring to the clinical data record of age of the patient by a committee of teachers of the Department Of Oral Medicine, Diagnosis And Radiology. All the radiographs were taken using a Alldent HF Digital Machine, Allengers Medical Systems, India.

Demirjian Index (DI)

The dental maturity staging was done in the orthopantomogram according to the calcification stage of the lower left mandibular teeth using the Demirjian's method (Demirjian et al. 1985).[6] The left mandibular central and lateral incisor, canine, first and second premolar, first and second molar were rated on an 8 stage scale from A to H (Fig 1) .

A. Calcification of single occlusal point without fusion of different calcifications.

B. Fusion of mineralization points; the contour of the occlusal surface is recognizable.

C. Enamel formation is being complete at the occlusal surface, and dentin formation being started. Besides,the pulp chamber is curved, and no pulp horn is visible.

D. Crown formation is complete to the mark of the cemento-enamel junction(CEJ). Root formation has started. Besides, the pulp horns are beginning to differentiate, but the walls of the pulp chamber remain curved.

E. The root length remains shorter as observed than the crown height. Besides the walls of the pulp chamber are being straight, and the pulp horns are more differentiated than in the stage D. In molars, the radicular bifurcation being observed started to calcify.

F. Here, the walls of the pulp chamber observed to form an 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 clear cut form.

G. The walls of the root canal are being parallel, however the apical end is partially open. In molars, it is considered that only the distal root is evaluated.

H. The root apex is completely closed (distal root in molars). The periodontal membrane surrounding the root and apex is uniform in width throughout.[6]

The pubertal growth spurt were assessed using cervical vertebral maturity assessment was done using the 6 stage method (Baccetti et al. 2005). The morphological features of the cervical vertebrae 2, 3 and 4 (mainly shape of the body and concavity of the inferior border) were analyzed and categorized in one of the six stages CS1 to CS6.

- CS1: Here,the lower borders of all three vertebrae (C2-C4) being flat. Besides,the bodies of both C3 and C4 being trapezoid in shape. Very significant amount of adolescent growth expected (80% to 100%).

- CS2: A concavity is present at the inferior border of C2.Besides the bodies of both C3 and C4 are trapezoid in shape. Significant amount of adolescent growth expected (65% to 85%).

- CS3: Concavities at the inferior borders of both C2 and C3 being present. Besides the bodies of C3 and C4 can be found to be either trapezoid or rectangular-horizontal in shape. Moderate amount of adolescent growth expected (25% to 65%).

- CS4: Concavities at the inferior borders of C2, C3, and C4 are being observed. Besides the bodies of both C3 and C4 are rectangular-horizontal. Deceleration of adolescent growth spurt.

- CS5: At least one of the bodies of C3 and C4 should be square in shape. However, if not square, the body of the other cervical vertebra is rectangular-horizontal. Final maturation of the vertebrae takes place during this stage.

- CS6: At least one of the bodies of C3 and C4 is rectangular-vertical in shape. Adolescent growth is completed (little or no growth expected).

- CS1- CS2 represent pre-pubertal status while CS3- CS4 represent pubertal status and CS5-CS6 signify post pubertal status.[7]

Stastical analysis

The obtained data was feed in the word excel sheet. The results were then statiscally analyzed using the spearman coefficient relation and the data was set statiscally significant at p value≤ 0.05. The software used was Statistical Package for Social Sciences (SPSS) version 17.

RESULTS

All digital panoramic radiographs of the 250 subjects of study group were assessed out of which 50% subjects were males while 50% subjects were females (Graph 1) . The committee of teachers of Department of Oral Medicine, Diagnosis and Radiology conducted the analysis. The OPGs were assessed for dental maturity by Demirjian Index (DI). The lateral cephalograms were assessed by CVMI. Spearman rank-order correlation coefficient was used to measure the association between pubertal growth spurt and dental calcification stage of individual teeth.

Calcification stage D & E of second molar was most common (67% & 67.1% respectively), while the calcification stage G of central incisor was lowest (33%) corresponding to the pre-pubertal stage. (Table 1). The calcification stage F & G of the second molar had the highest percentage (73.6% and 76%) corresponding to pubertal growth spurt.(Graph 2)

Calcification stage H of second molar was most common (84%), while the Calcification stage G of

central incisor was lowest (33%) corresponding to the post-pubertal stage. (Table 2).

Table 1: Percentage distribution of calcification stages of individual teeth at pre-pubertal stage.

Calcification stages	Teeth						
	CI	LI	CN	PM1	PM2	M1	M2
D	0	0	0	33	33	0	67
E	0	0	0	67	67	0	33
F	0	0	0	0	0	0	0
G	33	33	33	0	0	33	0
H	67	67	67	0	0	67	0

Table 2: Percentage distribution of calcification stages of individual teeth at post pubertal stage.

Calcification stages	Teeth						
	CI	LI	CN	PM1	PM2	M1	M2
G	16	16	23	21	19	16	16
H	84	84	77	79	81	84	84

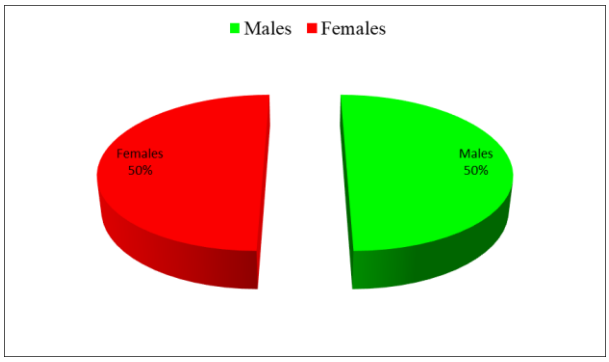
Table 3: Spearman correlation coefficients between pubertal growth spurts and dental maturity stages.

TOOTH	r	P value
CI	0.391	0.04 (≤0.05)
LI	0.381	0.04(≤0.05)
CN	0.391	0.02(≤0.05)
PM1	0.482	0.02(≤0.05)
PM2	0.454	0.04(≤0.05)
M1	0.345	0.03(≤0.05)
M2	0.548	0.01(≤0.05)

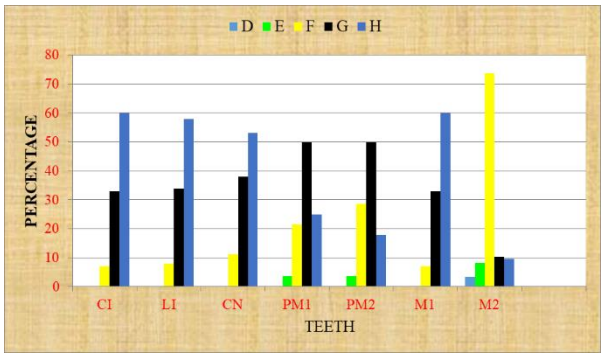
r- correlation coefficient

CI-Central Incisor, LI- Lateral Incisor, CN-Canine, PM1- First Premolar

PM2- Second Premolar, M1- First Molar, M2- Second Molar



Graph 1: Gender wise distribution of subjects.



Graph 2: Percentage distribution of calcification stages of individual teeth at pubertal growth spurt.

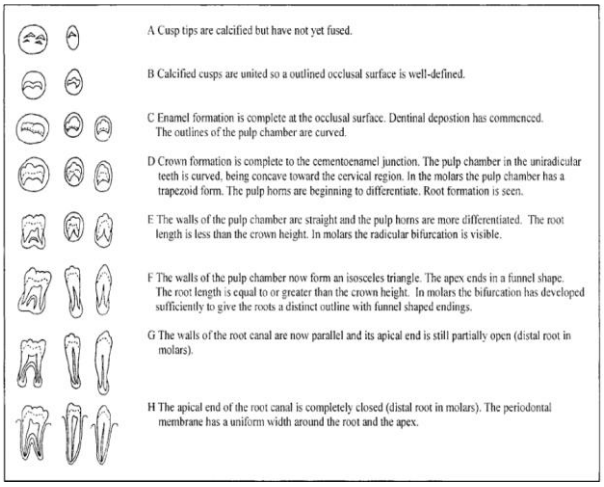


Fig 1: Developmental stages of the permanent dentition (Adapted from Demirjian et al 1985, Krailassiri et al 2002).

Spearman rank-order correlation coefficients between the pubertal growth spurt and developmental stages (Demirjian Index) for the seven teeth are given in Table 3. All correlations calculated between cervical vertebral and dental maturity stages were found to be statistically significant ($P \leq 0.05$). The correlation coefficients ranged from 0.381 to 0.548. The tooth sequence in order from the lowest to the highest correlation was first molar (0.391), lateral incisor (0.454), canine (0.391), central incisor (0.391), second premolar (0.454), first premolar (0.482) and second molar (0.548). Second molar was found to be most significantly correlated with the pubertal gowth spurts.

From these results it can be summarized that the second molar DI calcification stages are most significantly correlated with pubertal growth spurts. It can be observed that the DI stage D& E of

second molar correspond to pre-pubertal stage. While DI stage F&G of second molar represent pubertal stage. Similarly DI stage H of second molar correspond to post pubertal stage.

DISCUSSION

Assessment of pubertal growth spurts is a common clinical practice in many health professions, especially for growth evaluation and age estimation in forensic sciences. Because of variations in factors such as gender, race, and environment, chronologic age is unreliable in the prediction of human growth and development.[8] Besides hand-wrist radiograph evaluation, the assessment of calcification stages using orthopantomogram has been intensely investigated in recent years as another method of assessment of pubertal growth status.[9]

In our study significant correlation ($p \leq 0.5$) was found between the calcification stages of teeth and the pubertal growth spurt. In the present study, dental calcification stages which are believed to simple and practical method, were used to assess dental maturity, whereas pubertal status was assessed by the widely used CVM method. According to CVMI the CVS1-CVS2 stage represent pre pubertal stage, CVS3-CVS4 represent pubertal growth spurt and CVS5- CVS6 represent post pubertal condition. Kumar S et al[4] ,Chen J et al[2] and Chertkow have reported high correlations between tooth calcification stages and pubertal growth status which would probably allow clinicians to more easily identify pubertal growth stages from panoramic radiographs.[2,4,10,11,12] On the other hand, Lewis and Garn, and Tanner reported low or insignificant correlations between pubertal growth spurts and dental maturation.[13,14]

This difference among previous studies is a result of the different methods used for assessing pubertal status and dental maturity. The mean chronologic age corresponding to beginning of pubertal growth spurt was found to be 10.3± 1.2 years in girls and 13.8±1.12 years in boys. This is similar with earlier reports about the age of the beginning of the pubertal growth spurt in Chinese adolescents.[15] Mean chronologic age in girls was significantly lower than in boys in each stage. This indicates that the maturation of the girls was earlier than that of boys.

These findings agree with earlier studies that found differences in skeletal ages based on gender. This is applied to other parameters of growth and development, such as height and sexual maturation.

The present study unlike other previous studies included all the mandibular teeth except third molars. Most studies of the dentition have used either mandibular canines or third molars for dental age assessment, but these two parameters have shown some drawbacks. Root formation and apex closure of mandibular canines is completed by the age of 13 years, but most children exhibit pubertal growth up to the age of 16 to 17 years. On the other hand third molars, are the most commonly missing teeth in the human dentition, making them unreliable for pubertal status assessment.[16] The present study was therefore carried out to establish the reliability of using the developmental stages of mandibular teeth except third molars as indicators of maturity. This offers an advantage because their overall development tend to continue over a longer period. Apex closure generally extends up to the age of 16 years in normal children.[17]

In the present study, the calcification stages of the mandibular second molar were found to have the highest correlation coefficient with pubertal growth spurts as reported previously by Chen J et al, Kumar S.[2,4,18] Some of previous studies have found mandibular canine to have highest correlation with the pubertal growth spurts as stated by the Chertkow S. Some investigators have suggested that the development of the second premolar has the highest correlation with pubertal status.[19]

This discrepancy can be attributed to the racial variation. It has been suggested that racial variations also play a role in the relationship between dental and skeletal maturation. Among Africans the root apex of canine observed to be completely closed (stage H), while in Europeans the apical end is partially open (stage G) at the pubertal stage. Geographic variation in tooth and skeletal maturation has been observed between midwestern and mid southern American adolescents.[20]

The present radiographic study was taken up to assess the reliability of using the developmental stages of all mandibular teeth except third molars as indicators of pubertal growth spurts. But in previous studies this feature was not observed

because they included only 3-4 teeth for study. However, it could be proposed that the study should be conducted in a larger population, comparing with different ethnic groups to establish the actual validity and reliability.

CONCLUSION

As chronological age and dental emergence have been shown to be poorly related to pubertal growth spurt, at least during circum-pubertal growth phases, these parameters are not reliable indicators for clinical application. Therefore, over the last five decades, efforts have been carried out to find reliable and reproducible indicators of pubertal maturity in different populations. A new method is seen with dental maturity, which can be easily accessed through the evaluation of tooth formation. It can be carried out on panoramic radiographs that are routinely used for different purposes with minimal irradiation to the patient.

From the results of the present study, it can be concluded that mandibular second molar DI calcification stages can be used as an indicator for pubertal growth spurts. and orthopantomogram can be used as an effective tool for estimation of growth. Hence, it is proposed that more studies on this subject should be conducted in a larger population, comparing with different ethnic groups.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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