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A COMPARATIVE EVALUATION OF DENTAL CALCIFICATION STAGES AND SKELETAL MATURITY INDICATORS DURING THE PUBERTAL GROWTH PERIOD

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ABSTRACT

Aim:

To compare the dental mineralization stages using Orthopantamogram (OPG) and skeletal maturation stagesusing Hand wrist radiographs during the pubertal growth period.

Material and Methods:

The present study was conducted on 60 males and 60 females in Department of Orthodontics , Jaipur Dental College,Jaipur (Rajasthan) India. A total of 120 dental panoramic radiographs and hand-wrist radiographs were obtained and analyzed.The skeletal maturation was assessed using Hand wrist radiograph using the method proposed by Grave and Brown method. Dental maturation stages were analysed from Orthopantamogram (OPG) using the method proposed by Demirjian et al.

Results:

The results showed differences between the sexes of the sample ($P < 0.05$) and between the skeletal maturation periods.In males, mandibular canine and mandibular second molar were statistically significant ($P<0.05$) with higher correlation observed in relation to Stage F for onset of pubertal growth , Stage G coincided for peak of the pubertal growth period ,Stage H coincided for end of the pubertal growth period

In females, mandibular canine and mandibular first premolar were statistically significant ($p<0.05$)and higher correlation was observed in relation to stage F for the onset of pubertal growth period, Stage G coincided with the peak of the pubertal growth period ,Stage H coincided with the end of the pubertal growth period.

Conclusion:

There is a correlation between dental maturation and Skeletal maturation stages in determining the pubertal growth period. Dental mineralization stages studied from Orthopantamogram(OPG) can be used as a routine diagnostic tool to determine the skeletal maturation of the individual. On comparison of chronological age the females preceded males

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in all three stages of skeletal maturation by approximately 1.6 years.

Keywords:
Demirjian method, Grave method, skeletal maturity indicators, tooth calcification

INTRODUCTION

Any modification in the growth of an individual to correct the underlying malocclusion should be undertaken during the period of growth spurts. Period of accelerated growth is called growth spurts, but there is difference in the age observed between females and males. Females mature earlier than males[1,2].Growth spurts occurs at various periods in life just before birth ,one year after birth, during the mixed dentition period and pre-pubertal age. Pre-pubertal growth spurt brings about multitude of changes in the human body and is ideal for correction of malocclusion using growth modification like myofunctional appliance.

Though the chronological age of an individual gives an overall status of growth, it is not a reliable indicator of maturation[3]. To understand the individual skeletal maturation, to know the ideal time for growth modification and to determine the amount of growth remaining we need methods of growth prediction.Growth prediction methods have been classified into measurement approaches and experimental approaches. Measurement approaches are Implant radiology[4] and vital staining whereas experimental approaches are Craniometry, Anthropometry, Cephalometric radiology and Three-dimensional imaging .

X-rays used in orthodontics are mostly Orthopantamogram (OPG) and Lateral Cephalogram which give an insight into the underlying dental and skeletal conditions of

malocclusion and to some extent the skeletal maturation of the individual through cervical vertebral maturation.Dental OPG one of the routine diagnostic aids in orthodontics is used to determine the position of the teeth, however it also provides details about the dental maturation of the toothand thereby facilitate the determination of the dental age.

Demirjian[5], Nolla's[6] have proposed their methods to study the dental maturation of an individual by studying the individual tooth maturation and determine the dental age. Demirjian A, et al[5] conducted a study on fifty subjects from the French-Canadian population to determine the dental maturation stages using OPG. The tooth were scored based on the developmental criteria like shape change of the pulp chamber and dentinal deposition. The teeth on the left side of the mandible from the central incisor to the second molar teeth were considered. The dental maturation was calculated by measuring the individual tooth score for each stage and the summed scores of all seven teeth gives the dental age.

Skeletal maturation is assessed from the analysis of cervical vertebral maturation using lateral cephalograms and analysis of bones in the Hand and wrist regions using hand wrist radiographs. Hand wrist radiograph is commonly used due to the ease in taking radiograph and the wide region available for assessment and reliability.

Hand wrist radiographs have been used to detect skeletal maturation stages by analysing the small bones of the hand and wrist region. Researchers like Fishmann[7], Grave and Brown[8], have proposed their methods of assessment of the bones in the hand and wrist region.In the present study Grave and Brown[8] method has been used to determine the skeletal maturation. The method was chosen due to its versatility and reliability. The changes that are studied are classified into epiphyseal changes and individual bone changes. These changes are broadly

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classified into fourteen stages and three stages of growth.

The present study used the method proposed by Demirjian[5] et al to determine thedental maturation stages and, Grave and brown[8] method for skeletal maturation assessment.For proper orthodontic diagnosis and treatment planning, accurate assessment of skeletal maturity is important. As a result, many investigators have attempted to predict the duration, magnitude, direction, and timing of the adolescent growth changes. The purpose of this study was to compare the dental mineralization stages using OPG and skeletal maturation stages using Hand wrist radiographs during the pubertal growth period.

MATERIAL AND METHODS

Study design:- Comparative study design.

Study duration:-3 months (September 2015-November 2015)

Study done-Department of Orthodontics , Jaipur Dental College,Jaipur (Rajasthan) India

Sample collection-

The samples were selected from the out patients visiting Department of Orthodontics,Jaipur dental college,Jaipur,Rajasthan,India. A total of 120 samples were selected in the age group between 7 to 17 years. OPG and Hand-wrist radiographs were taken using SIRONA Orthophos XG 5 DS/Ceph for all the samples the skeletal maturation and dental mineralization stages were analysed.

Inclusion criteria:

1.Patients within the age group of 7 years to 17 years.

2.Patients with no previous history of orthodontic therapy

3.OPG and Hand-wrist radiographs to be taken at the same time

Exclusion criteria:

1.Patients with congenitally missing teeth.

2.Patients with history of any previous orthodontic therapy.

3.Patients with cleft lip or palate,debilitating diseases,poor periodontal conditions.

Procedure-

OPG and Hand-wrist radiographs were obtained from all the samples selected and the radiographs were assessed .

Dental calcification : Dental calcification stages were studied by using Orthopantamogram (OPG) analysing the teeth present on the left side of the mandibular arch and assessed using Demirjian et al[8] method(Figure 1) .Tooth calcification stages were designated from stage A to stage H based on the development criteria like dentinal deposition, shape change of the pulp chamber; calcification of tooth from single occlusal points to root apical closure were analysed. The values for each stage were calculated separately and were summed up to give the dental maturity score of the individual which gives the dental age of the individual. The present study was performed with a slight modification on the original method proposed by Demirjian et al. The study was performed on mandibular canine, mandibular first premolar, mandibular second premolar and mandibular second molar to determine the dental mineralisation stages. The tooth with the highest correlation to skeletal maturation was identified. This method is chosen because it shows higher accuracy even when applied to north-Indian population[9] and is also reliable as it uses distinct changes in the shape and

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proportion of root length.

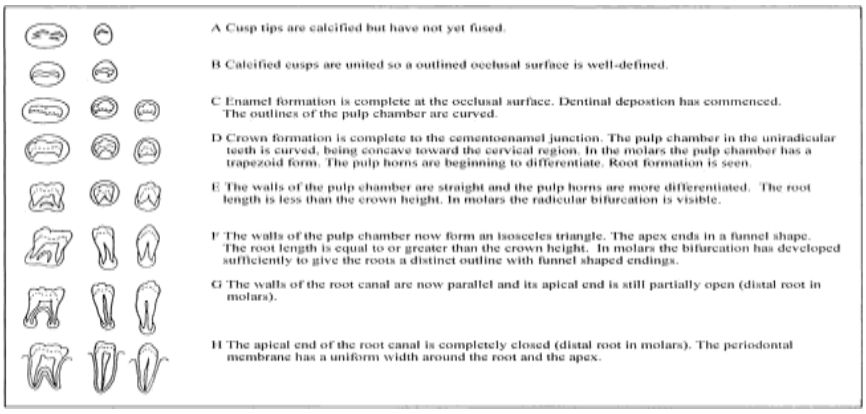

Figure 1-Dental calcification stages by Demirjian et al

Skeletal maturation:

Skeletal maturation was assessed from hand-wrist radiograph using Grave and Brown method[10]. This method studied skeletal maturation using the left hand of the individual and classified it into fourteen stages of bone ossification categorizing them into three growth periods; Onset, Peak and End of pubertal growth spurt. Stages were designated on the basis of the ossification events occurring at various points in the hand wrist. Epiphyseal events like epiphysis as wide as the diaphysis , epiphysis capping and union of the epiphysis and diaphysis are studied on the first, second, third fingers and radius. Other events studied included the hooking of the hamate and appearance of the pisiform. The onset, peak and end of the pubertal growth spurt were studied by using the indicators like appearance of the pisiform for onset of puberty, Epiphysis capping the diaphysis in radius bone for peak of the pubertal period, and fusion of the epiphysis and diaphysis of the radius bone for the completion of the pubertal growth period. This method is used because even small radiographic changes are detectable and also it provides a reliable description of the events.(Figure 2)

		Ossification event
1	*PP2=*	Epiphysis of proximal phalanx of second finger is as wide as its diaphysis
2	*MP3=*	Epiphysis of middle phalanx of third finger is as wide as its diaphysis
3	*H-1*	Hooking of hamate (stage 1)
4	*Pisi*	Appearance of pisiform
5	*R=*	Epiphysis of radius is as wide as its diaphysis
6	*S*	Appearance of ulnar sesamoid
7	*H-2*	Hooking of hamate (stage 2)
8	$MP3_{cap}$	Epiphysis of middle phalanx of third finger caps its diaphysis
9	$PP1_{cap}$	Epiphysis of proximal phalanx of first finger caps its diaphysis
10	R_{cap}	Epiphysis of radius caps its diaphysis
11	$DP3_u$	Complete epiphyseal union of distal phalanx of third finger
12	$PP3_u$	Complete epiphyseal union of proximal phalanx of third finger
13	$MP3_u$	Complete epiphyseal union of middle phalanx of third finger
14	R_u	Complete epiphyseal union of radius

Figure 2-Skeletal maturation stages by Grave and Brown Method

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STATISTICAL ANALYSIS

The measured data obtained from the analysis of the Orthopantamograms and hand wrist radiographs were measured and tabulated separately and evaluated statistically. Statistical calculations were done using SPSS software.The means of the chronologic ages for both the sexes in three periods of skeletal maturation was analysed by 2-way analysis of variance (ANOVA) and post hoc tukey test. Analysis of ordinal multinomial logistic regression was done to evaluate the which teeth had the mineralization association to skeletal maturation.

RESULTS

Table 1: Chronologic age of males and females based on skeletal maturation

The results showed differences between the sexes of the sample (P <0.05) and between the skeletal maturation periods(P <0.05).

Maturation Event	Number of subjects		Chronologic age, mean (SD)	
	Male	Female	Male	Female
Onset	23	16	11.09 (2.19)	9.57 (1.93)
Peak	19	15	13.03 (1.58)	11.31 (2.12)
End	18	29	15.10 (1.94)	13.41 (2.28)

Table 2: Results of ordinal multinomial logistic regression analysis for male

The results reveal mandibular canine and mandibular second molar were statistically significant predictors for males (P <0.05).

Variable	Estimate	SE	Wald chi-square	P value	Odds Ratio
Canine	1.5	0.5	8.2	0.004	4.1
First Premolar	0.8	0.65	1.44	0.24	2.2
Second Premolar	0.25	0.53	0.22	0.65	1.28
Second Molar	0.91	0.36	6.67	0.010	2.49

Table 3: Results of ordinal multinomial logistic regression analysis for female

Statistically significant results were found for mandibular canine and first premolar (p<0.05).

Variable	Estimate	SE	Wald chi-square	P value	Odds Ratio
Canine	0.55	0.36	2.35	0.012	1.73
First Premolar	0.54	0.46	1.4	0.024	1.72
Second Premolar	0.68	0.43	2.54	0.11	1.95
Second Molar	0.34	0.31	1.18	0.28	1.4

Table 4: Distribution of mineralization stages of teeth at the Onset of Pubertal growth period

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In males, mandibular canine(36%) and mandibular second molar (44.40 %) were statistically significant (P<0.05) with higher correlation observed in relation to stage F for onset of pubertal growth period.

In females, mandibular canine and mandibular first premolar were statistically significant (p<0.05)and higher correlation was observed in relation to stage F for the onset of pubertal growth period mandibular canine (37.5%) and mandibular first premolar (36%).

Dental Maturation Stages	Canine		First Premolar		Second Premolar		Second Molar	
	Male	Female	Male	Female	Male	Female	Male	Female
C				3.30%		2.10%	5.10%	6.20%
D	1.00%	4.60%	9.10%	10.20%	11.40%	14.50%	21.50%	27.00%
E	10.20%	15.80%	20.50%	24.50%	25.90%	21.40%	9.20%	9.10%
F	36.00%	37.50%	22.60%	36.00%	26.70%	23.80%	44.40%	34.20%
G	33.00%	23.50%	36.10%	16.70%	28.90%	30.20%	18.70%	18.10%
H	20.90%	19.80%	12.50%	10.40%	8.10%	7.90%	1.00%	5.50%

Table 5: Distribution of mineralization stages of teeth at the Peak of Pubertal growth period

In males, mandibular canine and mandibular second molar were statistically significant (P<0.05) with higher correlation observed in relation to stage G coincided for peak of the pubertal growth period {mandibular canine(33 %) stage G and first premolar (36.10%) .

In females, mandibular canine and mandibular first premolar were statistically significant (p<0.05)and higher correlation was observed in relation stage G coincided with the peak of the pubertal growth period {mandibular canine (36%) and first premolar (44.30%) }

Dental Maturation Stages	Canine		First Premolar		Second Premolar		Second Molar	
	Male	Female	Male	Female	Male	Female	Male	Female
D						2.80%	1.10%	5.00%
E	1.20%	1.30%	4.90%	5.20%	4.80%	7.20%	5.20%	9.50%
F	8.00%	9.70%	12.40%	13.20%	17.20%	20.00%	21.80%	26.60%
G	60.00%	56.80%	33.20%	44.20%	35.20%	33.80%	54.40%	45.30%
H	30.80%	32.40%	49.30%	37.20%	42.80%	36.20%	17.40%	13.40%

Table 6 : Distribution of mineralization stages of teeth at theEnd of Pubertal growth period

In males, mandibular canine and mandibular second molar were statistically significant (P<0.05) with higher correlation observed in relation to stage H coincided for end of the pubertal growth period. {mandibular canine(85.10%) and mandibular first premolar(78.40%)}. In females, mandibular canine and mandibular first premolar were statistically significant (p<0.05)and higher correlation was observed in relation stage H coincided with the end of the pubertal growth period{mandibular canine (85.20%) and mandibular first premolar (78.30%)}.

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Dental Maturation Stages	Canine		First Premolar		Second Premolar		Second Molar	
	Male	Female	Male	Female	Male	Female	Male	Female
F		1.60%		4.30%	3.40%	8.30%	13.20%	18.70%
G	8.20%	13.50%	16.50%	17.30%	18.80%	17.80%	28.80%	29.80%
H	91.90%	85.20%	83.50%	78.30%	77.90%	73.80%	58.30%	51.40%

DISCUSSION

A consistent early occurrence of each skeletal maturation stages were observed in girls when compared to boys. It indicates that in each stage of development females preceded males.

Table 1 shows the mean chronologic age for girls was approximately 1.6 years (range 1.5-1.7 years) younger than the boys. These results are consistent with the study done by A.Bjork[10] who reported that the maximum pubertal growth in girls preceded males by approximately eighteen months, the appearance of the ulnar sesamoid also was seen advanced in females by twenty one months. Chapman[11] also reported that ossification of the adductor sesamoid appeared in females approximately one year earlier than males. S.Mittal et al[12] reported that females maturation was consistently earlier than males in all stages of maturation.

The analysis of ordinal multinomial logistic regression shows that the Odds ratio of the tooth predicts the pubertal growth period by the mineralization stages.

Table 2 shows Statistically significant results in relation to mandibular canine and first molar in males. . It shows that mandibular canine mineralization can predict the skeletal maturation four times more than any other tooth. The second molar is 2.5 times more reliable for prediction of skeletal maturation than other teeth.

Table 3 shows that statistically significant correlation was observed in relation to mandibular canine and mandibular first premolar for females. These results were in accordance with the works done by B.Rai et al[13], Uysal et al[14], Seymour Chertkow[15], Chertkow and Paul Fatti[16].

Table 4 shows that during the Onset of Pubertal growth period stage F of the mandibular canine and mandibular second molar was seen as reliable predictor for maturation in boys.For girls stage F of the mandibular canine and first premolar was seen as a reliable predictor of maturation.The results are in accordance with Reshma nayak et al[17] and Sandra Coutinho et al[18] whose results show that stage F of the canine had higher correlation to onset of the pubertal growth period.

Table 5 shows the peak of the maturation period teeth were identified in the stages G of the dental maturation.For boys the stages were seen in mandibular canine stages G and second molars .For girls the stage G were seen in mandibular canine and first premolar, other teeth with higher percentage of distribution was seen in mandibular second molar but as the tooth was not statistically significant it was neglected.These findings were in accordance with the study done by Sushil kumar et al[19] and who suggested stage G of the canine coincided with the pubertal peak period.These findings are also consistent with Vijayta Yadav et al[20] who suggested Stage G of the first premolar concides with the peak of the pubertal growth.

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Table 6 shows end of the Pubertal growth was significant with stages H of the mandibular canine and mandibular first premolar .For boys stages H of the mandibular canine and the second molar had higher percentage of distribution.For girls higher distribution was observed in stage H of mandibular canine and first premolar.(Table 6) Similar results were obtained from the studies done by Vijayashree et al[21] who found that stage H of the second molar coincided with end of the pubertal growth period. Reshma nayak et al[22] found that stage H of the canine coincided with end of the pubertal growth period.

These findings are inconsistent with the study done by Arthur B.Lewis et al[23] who had found a positive but less significant correlation between the tooth formation and general growth and development between tooth formation timings and maturational status.

CONCLUSION

The study results suggest that dental maturation stages can be used as a reliable tool for identification of pubertal growth period with the following findings:

1.There is a correlation between dental maturation and skeletal maturation stages in determining the pubertal growth period. On comparison of chronological age the females preceded males in all three stages of skeletal maturation by approximately 1.6 years .These results also suggest that any growth modification therapy like myofunctional appliances, orthopaedic appliances must be initiated for females at a younger age when compared with males.

2.In males, mandibular canine and mandibular second molar were statistically significant with higher correlation observed in relation to stage F for onset of pubertal growth period, stage G coincided for peak of the pubertal growth period and stage H coincided for end of the pubertal growth period.

3.In females, mandibular canine and mandibular first premolar were statistically significant and higher correlation was observed in relation to stage F for the onset of pubertal growth period, stage G coincided with the peak of the pubertal growth period and stage H coincided with the end of the pubertal growth period.

4.From the study it was concluded that dental mineralization stages studied from Orthopantamogram(OPG) can be used to determine the skeletal maturation of the individual thereby reducing the additional radiation exposure to the patient caused by hand wrist radiograph.

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CONFLICTS OF INTEREST

There were no conflicts of interest.

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