Correlation of Dental Calcification and Skeletal Maturaty Indicators

Rana Modassir Shamsher Khan,[1] **Abida Ijaz**[2]

Abstract

Assessing maturational status and pubertal growth spurt of patient have a considerable influence on diagnosis, treatment planning, and the outcome of orthodontic treatment. The hand – wrist radiograph is commonly used for the assessment skeletal development. There is association between skeletal maturity and different stages of dental calcification, thus stages of dental calcification might be used as a first – level diagnostic tool to estimate the timing of the pubertal growth spurt. The study analyzed the effectiveness of using tooth calcification stage instead of hand – wrist radiograph to assess skeletal maturity. A total of 200 subjects (100 males 100 females) with mean age 12.23 ± 2.33 years visiting the Children's Hospital and the Institute Of Child Health Lahore, were included in the study. The skeletal maturity indicators and dental calcification stages were evaluated. Result showed that the canine stage F coincided with the MP3 stage and indicates the onset of a period of accelerating growth. The canine stage G was related to S stage and MP_3C-AP stage, and was indicative of rapid growth velocity.

Key Words: Hand – wrist radiograph, skeletal maturity indicator, dental calcification stage.

Introduction

An understanding of growth events was of primary importance in the practice of clinical orthodontics. Clinical decisions regarding use of extraoral traction forces, functional appliances, extraction versus non-extraction treatment and orthognathic surgery were based on growth considerations. Prediction of timing and amounts of active growth, especially in the craniofacial complex, was useful to the orthodontist.[1]

During growth, every bone went through a series of changes that could be seen radiographically. The timing of the changes varies because each person had his or her own biologic clock. There were some exceptions, but generally speaking, the events were reproducible enough to provide a basis for comparison between different persons.[2-3]

Basically three common approaches had been used in the past to assess the hand – wrist radiographs. First was the atlas system involved the matching of a hand – wrist radiograph with a standard series of chronologically oriented radiographic images.[4] A second assessment variation involved matching features of many individual bones and then assigning point scores to the stages revealed.[3] Third method emphasized alteration in bony shapes and establishes ratios between linear measurements of the long bones of the hand and wrist; the grading of the indicators and ratios was then calculated to determine the skeletal age.[5]

Currently skeletal maturation system of Fishman is commonly used. This technique offers an organized and relatively simple approach to determine the level of maturation.[6]

Todd[7] stated that in an evenly maturing skeleton any area would show the same maturation developmental status. Garn and Rohman[8] found a high correlation among assessments from the hand – wrist, the elbow, the shoulder, the hip, the knee, and the foot.

Hunter 64 found that the mandible exhibited the

Khan R.M.S.[1]
Assistant Professor Orthodontics, Lahore Medical and Dental College, Lahore

Ijaz A.[2]
Department of Orthodontics, Lahore Medical and Dental College, Lahore

most consistent relationship with growth in height throughout adolescence. This was probably because the mandible grows in a manner similar to a long bone.

The implant study of sutural growth of the upper face by Björk[9] clearly illustrated that the maximum pubertal growth spurt of the upper face was in concurrence with mandibular growth and that growth terminated earlier in the maxilla.

Dental maturation was considered as a good index for estimating chronological age.[10]

Engström and coworkers[11] reported stronger relationships between the stages of tooth mineralization of the mandibular canine appear to correlate better with ossification stages than the other teeth.[12-13]

Coutinho S[14] and Lu Y[15] studied the relationship between mandibular canine calcification and skeletal maturity and concluded that mandibular canine calcification can give an initial assessment for estimating the timing of puberty.

Material and Methods

This research was designed as a descriptive study. Study material consisted of 200 children, 100 males and 100 females visiting orthodontic departments of children's hospital and institute of child's health Lahore. The age range of the children was 8 – 16 years. According to age range the patients were divided in to three age groups:

Group 1: Age range was 8 – 1 years. It included 30 male and 30 female.

Group 2: Age range was 11 – 13 years. It included 40 male and 40 female.

Group 3: Age range was 14 – 16 years. It included 30 male and 30 female.

Children's selection was performed after clinical examination of the face, dental arches and by taking medical and dental history. All subjects were Pakistani, well nourished, and free of any serious illness. The subjects had undergone neither previous orthodontic treatment nor extraction of any permanent teeth. The subjects had no previous history of orthodontic treatment, trauma or injury to the face and hand and wrist region.

Radiographs were taken following parental consent.

Assessment of Skeletal Maturity Stages

The skeletal maturation was based on the system of Fishman.[16] To facilitate clear discrimination between the stages and to provide a good description relative to growth status, only 5 out of 11 skeletal maturity indicators used in the system were selected in the present study.

MP_3: The middle phalanx of the third finger, the epiphysis equals its diaphysis.

S stage: The first mineralization of the ulnar sesamoid bone.

MP_{3cap}: The middle phalanx of the third finger, the epiphysis caps its diaphysis.

DP_{3u}: The distal phalanx of the third finger, complete epiphysis union.

MP_{3u}: The middle phalanx of the third finger, complete epiphysis union.

Assessment of Dental Calcification Stage

The method described by Demirjian[17] was chosen in the study. In Demirjian method there were 8 stages of calcification, A to H for each tooth. But we are using only 4 stages "E to H" of calcification.

The stages were;

E. The walls of the pulp chamber were straight and the pulp horns were more differentiated. The root length was less than the crown height. In the molars the radicular bifurcation was visible.

F. The walls of the pulp chamber now form an isosceles triangle. The apex ends in a funnel shape. The root length was equal or greater than the crown height. In the molars the bifurcation had developed sufficiently to give the roots a distinct outline with funnel shaped ending.

G. The wall of the root canal were now parallel and its apical end was still partially open (distal root in molars).

H. The apical end of the root canal is completely closed (distal root in molar). The periodontal membrane has a uniform width around the apex.

All the assessments were made simultaneously on an illuminated viewing box in a dark room. Data was analyzed by SPSS 11, programme for windows XP. The arithmetic percentage distribution, mean and standard deviation for all the concerned variables were determined using the above – mentioned software with the help of SPSS processor. The data for radiograph assessment was ordinal and association assessed by calculating coefficient of correlation (spearman correlation).

Results

The present study was carried out on total number of 200 children, comprising 100 males and 100 females with mean age 12.23 years with S.D of 2.33 years (Table 1).

Distribution of Children According to Skeletal Maturity Indicators

Out of the 200 children 104 (52%) were in MP_3 stage. 38 (19%) children were in S stage. MP_{3CAP} comprised 12 (6%) children. DP_{3u} stage comprised 12 (6%) children and lastly MP_{3u} had total of 34 (17%) children (Table 2).

Distribution of Children According to Dental Calcification Stages

According to calcification stages of canine, 18 (9%) of children were in stage E. 74 (37%) in stage F, 62 (31%) in stage G and in stage H there were 46 (23%) children (Table 4).

There was strong correlation between SMI and DCS with coefficient of correlation n = 0.858, p = 0.00 (srearman correlation) (Table 2).

Percentage Distribution of Dental Calcification Stages in the Skeletal Maturity Stages

In the MP_3 stage of skeletal maturity the tooth calcification stage F was 65.4% present. In the stage S only 15.8% children were in calcification stage F, where as tooth calcification stage G dominated in this group by 84.2%.

On the other hand stage G also present in skeletal stage MP_{3CAP} by 83.3%.

In the DP_{3u} stage calcification stage H was dominated by 83.3%, while in MP_{3u} stage all children were in stage H showed completion of calcification.

This showed that there is high correlation between MP_3 stage and the F stage of tooth calcification. The stage G of tooth calcification showed high relation with the stages S and MP_{3CAP} of skeletal maturity (Table 3).

Table 1: Percent Distribution of Gender with mean age and Std. Deviation.

Gender	Frequency	Percentage
Male	100	50.0
Female	100	50.0
Total	200	100.0

Mean Age, Std. Deviation. 12.23 ± 2.33 years.

Discussion

Relationships between the calcification stages of individual teeth and skeletal maturity have been previously reported. Racial variation in the relationship has also been suggested. Unfortunately, little is known of this relationship in Pakistani children and adolescent. The findings from this study may be used to establish a valid clinical tool for indicators of the pubertal growth period in Pakistani children, adolescent, and young adults without the necessity of resorting to hand – wrist radiograph.

Table 2: Distribution of skeletal maturity indicators and calcification stages of canine.

Skeletal Maturity Indicators		Tooth Calcification Stages				Total
		E	F	G	H	
	MP_3	18	68	18		104
	S		6	32		38
	MP_{3CAP}			10	2	12
	DP_{3u}			2	10	12
	MP_{3u}				34	34
Total		18	74	62	46	200

Coefficient of correlation = 0.858, p = 0.00 (spearman correlation)

Table 3: Percent distribution of calcification stages of tooth in skeletal maturity stages.

Stage	MP_3	S	MP_{3CAP}	DP_{3u}	MP_{3u}
E (%)	17.3	0	0	0	0
F (%)	65.3	15.8	0	0	0
G (%)	17.3	84.2	83.3	16.7	0
H (%)	0		16.7	83.3	100
Total (%)	99.9	100	100	100	100

Because of rounding, values may not total 100.

Key Abbreviation
F, G, H. Tooth calcification stages
MP_3, S, MP_{3cap}, DP_{3u}, MP_{3u}. Skeletal maturity indicators

The role of the adductor sesamoid of the thumb and the epiphysis of the middle phalanx of the third finger as indicators of the pubertal growth spurt has been described by numerous workers.[18,219] However, little correlation has been shown to exist between the appearance of these indicators and the over – all maturational state of the dentition.[20] But the result of our study shows that there is a significant correlation (coefficient correlation n = 0.858, p value is 0.00, spearman correlation) between skeletal maturity indicators and calcification stages of canine. In all these studies the pattern of mineralization of various teeth was analyzed which varied from tooth to tooth.

Coutino S[14] studied that the relationship between calcification of the mandibular canine and skeletal maturity indicators was quite high, ranging from 0.53 to 0.85. Canine calcification stage G is related to capping the third middle phalanx and appearance of the adductor sesamoid. The present study revealed that at G stage 73.3% males and 87.5% females were in stages S and MP_{3CAP}. So a strong association was found between skeletal and dental maturity. The associations were similar to those reported by Sierra[13] who used the ossification center method of staging.

According to Kopecky and Fishman[21] MP_3 stage was accelerated stage, S and MP_{3CAP} stages were peak growth stages, while DP_{3u} and MP_{3u} stages were decelerative stages. When we apply these growth stages in our study, the result shows that the mean age of accelerative growth stage in males and females is 10.97 ± 1.33 years and 10.75 ± 0.95 years respectively. The Peak growth stage in males is 13.96 ± 1.33 years and in females 12.78 ± 1.73 years. Females are advanced than males in attaining SMIs by a period of 1.18 years.

Lastly the decelerative stages in males come at mean chronological age of 15.56 ± 0.39 years and in females 14.12 ± 1.28 years. So again females attain these SMIs earlier than males about duration of 1.44 years.

Björk[22] found that capping of the epiphyses of the third middle phalanx was very closely related to the age of pubertal maximum growth velocity. Other investigators have shown that capping of the third middle phalanx coincides closely with PHV.[19,23] The present study revealed that 83.3% children with capping of third middle phalanx showed 'G' stage of calcification. This indicates that canine root calcification stage G is closely related to the age of pubertal growth velocity.

According to Chertkow[12] the completion of root formation prior to apical closure (Stage G) of mandibular canine coincided with the appearance adductor sesamoid and capping of third middle phalanx, with 77 percent of the white girls and 78 percent of the white boys of Caucasoid origin. While in our study 90.9% of the boys and 78.5% of girls were in DCS 'G' had SMI stages 'S' and 'MP_{3CAP}. This shows that Pakistani subjects are advance in attaining skeletal maturity stages as previously documented by Shaikh A, Rikhasor R, Qureshi A.[24]

The close relationship between calcification Stage 'G' of the mandibular canine and other maturational indicators of the pubertal growth spurt among Pakistani children therefore raises the possibility of the use of this tooth as an indicator of approaching adolescence.

Demirjian A[25] derived data from the work of the Montreal Human Growth Research Centre which had 50 French – Canadian girls between 6 and 15 years of age In conclusion the results substantiate that skeletal, somatic, and sexual maturity are interrelated presumably by a common controlling mechanism. Dental development is unrelated to the other developmental systems. On contrary our study shows that there is a strong correlation between skeletal and dental maturity. This is also supported by genetic study of three genes Osteoprotegerin (OPG), receptor activator of

nuclear factor – kappaB (RANK), and RANK ligand (RANKL) by Ohazama A.[26]

Ease of recognition of this stage of development of the tooth, together with the free availability of intraoral or panoramic radiographs in an orthodontic or pedodontic practice, can make the assessment of onset of puberty possible in children of Pakistani origin without the necessity of resorting to the use of hand – wrist radiographs or serial recordings of annual increases in stature.

Conclusions

The conclusion of the study are;

1. There is strong correlation between canine calcification and skeletal maturity.
2. The canine stage F coincided with the MP_3 stage and it indicates the onset of a period of accelerating growth.
3. The canine stage G is related to S stage and MP_{3CAP} stage and is indicative of rapid growth velocity.

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