

DENTAL CALCIFICATION STAGES AND SKELETAL MATURITY INDICATORS IN MAHARASHTRIAN POPULATION

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ABSTRACT

Aim of the study was to search the co-relationship between the stages of calcification of various teeth and various skeletal maturity stages among maharashtrian individuals. The study of research consisted of 140 male & 225 female patients in age group of 8 years to 20 years. A total of 365 hand wrist & panoramic radiographs were obtained & assessed. The teeth development stages of the mandibular canines, first & second premolars, second and third molars were measured according to the Demirjian system. Skeletal age and skeletal maturity stages were determined from hand wrist radiographs by using the method outline in the atlas of Greulich and Pyle and the Fishman's system, respectively. The Spearman rank order correlation coefficient revealed significant relationships ($r=0.30-0.68$, $p<.01$) between dental calcification stages and skeletal maturity stages. The second premolar demonstrated the high correlation ($r=0.67$ in male patients, $r=0.68$ in female patients). The third molar demonstrated the poorest correlation ($r=0.48$ in male patients, $r=0.32$ in female patients.) The canine stage F for both sexes (63.1% for female patients 54.2% for male patients) coincided with the MP_3 stage. The second molar stage E for female subjects (51.5%) and stage G for male subjects (66.8%) were related to the S stage and the MP_{3cap} stage, respectively. This suggests that tooth clarification stages from panoramic radiographs might be clinically useful as a maturity indicator of the pubertal growth spurt period.

KEYWORDS: Hand and Wrist Radiograph, Tooth Calcification, Skeletal Maturation, Pubertal Growth Period

INTRODUCTION

Skeletal maturity of a person is determined by various methods but simple easily available and co-related with the dentition as well as skeletal maturation is must. So that even a single factor of dentition means intraoral periapical X-Ray is sufficient to assess the skeletal stages without the presence of the other X Rays like cervical verterbre, hand wrist X-Ray, facial bones, other bones of the body.¹

The hand wrist radiograph is commonly used for skeletal developmental assessment.

If a strong association exists between skeletal, maturity and dental calcification stages. The stages of dental calcification might be used as a first level diagnostic tool to estimate the timing of pubertal growth spurts.

The aim and objective of this study was to investigate the relationships between the stages of calcification of various teeth & skeletal maturity stages among maharashtrian patients.²

This study will establish, a simple & reliable method for indicators of pubertal growth spurt in Nagpurian means maharashtrian patients which slowly reduce the necessity of taking hand wrist radiographs.

MATERIALS AND METHODS

The growth research was chosen as a cross sectional descriptive study. All the study samples were derived from dental panoramic and hand –wrist radiographs of 140 male and 225 female patients registered at the orthodontic section, faculty of dentistry VSPM DENTAL COLLEGE and RESEARCH CENTER NAGPUR. Either a left or right hand wrist radiograph was used for the study design. The selection criteria included the patients were all MAHARASHTRIAN from NAGPUR. They wanted to have orthodontic treatments. No previous extractions were done and never had any orthodontic treatment with permanent teeth. All the patients were very sound and smart. ³

ASSESSMENT OF DENTAL CALCIFICATION STAGE

All panoramic radiographs were examined, left mandibular canine teeth taken, the first and second premolars, the second and third molars taken. Maxillary posterior teeth were omitted from the study. Tooth calcification was rated according to the method described by Demirjian et al²¹ in which one of 8 stages of calcification, A to H, was assigned for each tooth (Figure 1).

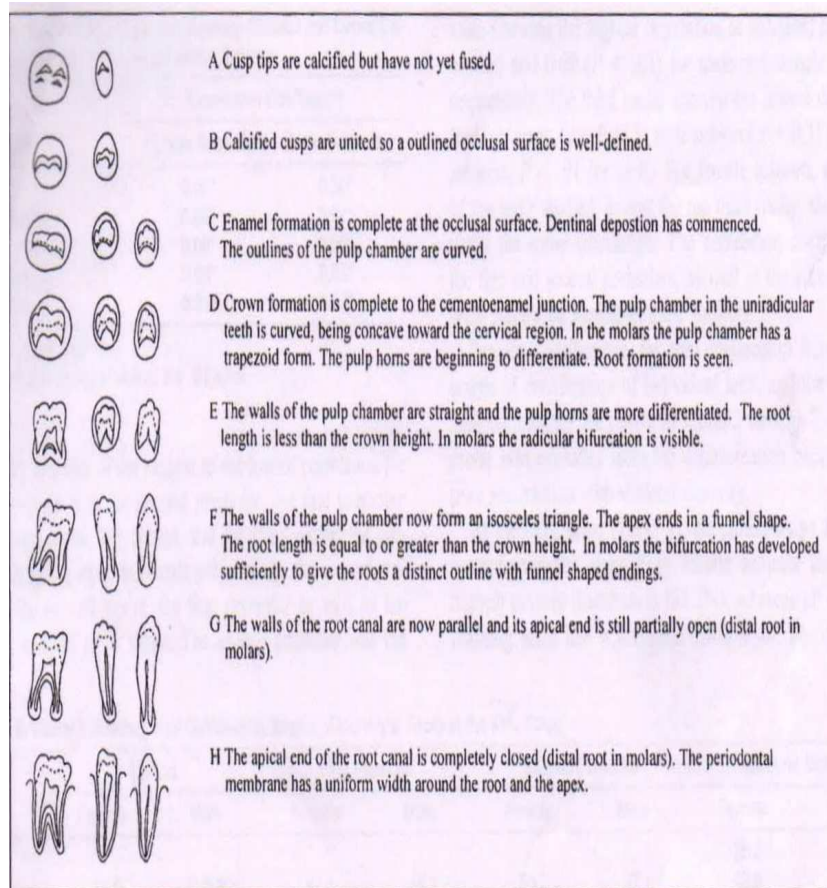


Figure 1: Dental Calcification Stages by Demirjian

ASSESSMENT OF SKELETAL MATURITY STAGE BY USING HAND WRIST RADIOGRAPH

For that refer atlas of skeletal development of hand and wrist radiographic. Atlas of Skeletal Development of the hand and wrist (Greulich and Pyle, 1959). Each hand wrist radiograph was assigned a skeletal age by comparing it with the standard radiograph of hand wrist X Ray. ⁴

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 epiphyseal union
MP _{3u}	The middle phalanx of the third finger, complete epiphyseal union

Ossification Patterns of Phalanges and Anatomy of Hand Wrist X-Ray

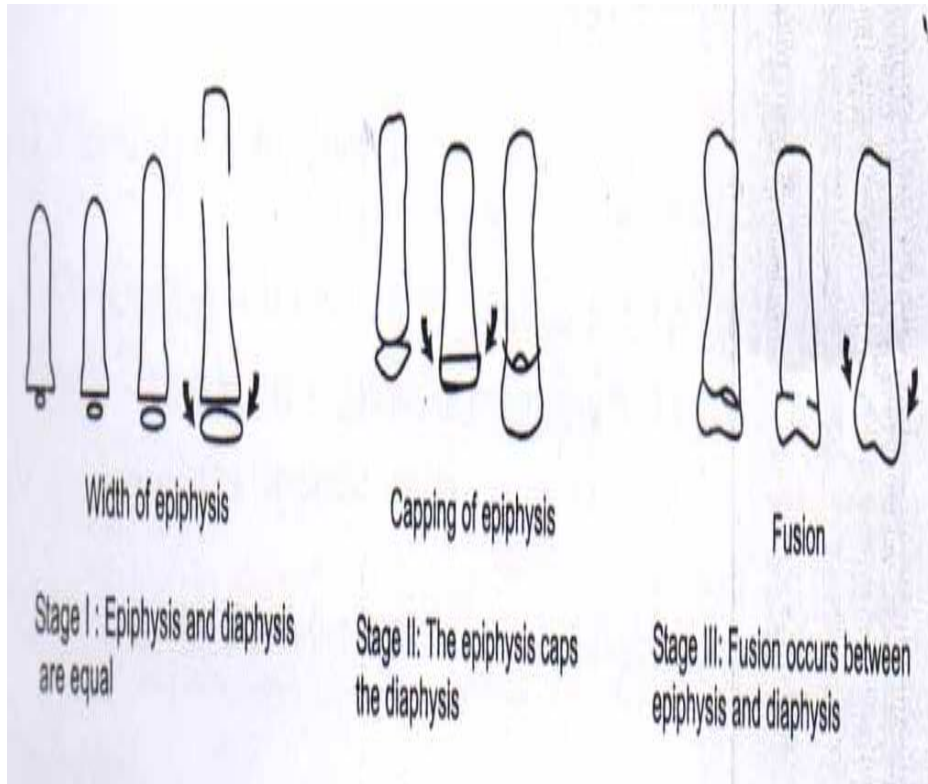


Figure 2: Ossification Patterns of Phalanges

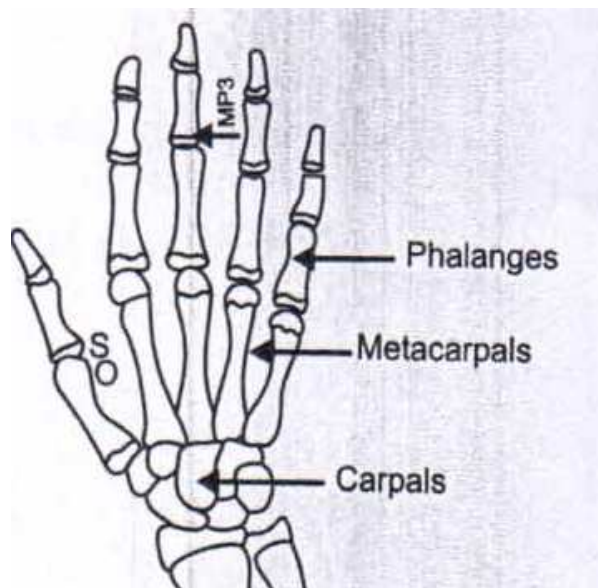


Figure 3: Anatomy of Hand Wrist X-Ray

REPRODUCIBILITY TEST

The differences between double interpretations were statistically tested.

To the test reproducibility of the assessments of skeletal maturity, dental development stage, and skeletal age, the same investigators reevaluated randomly selected hand wrist and panoramic radiographs from 10 of the same male subjects and 10 of the same female subjects 4 weeks after the first evaluation.

STATISTICAL ANALYSIS

The SPSS for windows release 7.5.1 (SPSS Inc. Chicago, Illinois) was used in calculation of all statistics.

- To assess the relationship between the stages of skeletal maturation and stages of mineralization, similarly the calcification of each tooth for was calculated in percentage.
- Statistics in descriptive study were obtained by calculating the means and standard deviations of the chronological ages & skeletal ages for the 5 stages of skeletal maturity indicators.
- The specimen rank order correlation coefficient was applied to measure the association between skeletal maturational indicators & dental calcification stages of individual teeth, and the statistical significance of the correlation was tested.⁵

RESULTS

The study material of patients of 140 male and 225 female patients. The distribution of the study patients in age from 8 to 20 years. according to skeletal and chronological ages for each skeletal maturity stage is written in (Table 1).

Table 1: Chronological Ages and Skeletal Ages for Study Subjects Grouped by Skeletal Maturity Indicators

Skeletal Maturity Stage	Sex	No. of Subjects	Chronological Age, Mean \pm Sd, Y	Skeletal Age, Mean \pm Sd, Y
MP ₃	Male	38	11.3 \pm 1.6	11.7 \pm 0.7
	Female	20	9.8 \pm 1.0	9.2 \pm 0.5
S	Male	25	11.7 \pm 1.4	12.7 \pm 0.6
	Female	36	10.2 \pm 1.3	10.2 \pm 0.7
MP _{3cap}	Male	54	13.3 \pm 1.2	13.9 \pm 0.8
	Female	77	11.5 \pm 1.4	12.2 \pm 0.9
DP _{3u}	Male	8	14.4 \pm 0.9	15.9 \pm 0.2
	Female	32	12.7 \pm 1.5	13.8 \pm 0.4
MP _{3u}	Male	15	15.4 \pm 1.7	17.6 \pm 0.7
	Female	61	14.1 \pm 1.6	15.8 \pm 0.8

The mean age for each stage of skeletal maturity was younger in female patients. The mean chronological age of the female group was approximately 1.6 years (range 1.4 years, through 1.9 years) younger than that of male group.

The correlation coefficients between the development stages of hand and wrist bones and development stages of the 5 individual teeth are shown in table 2 the association ranged from 0.44 to 0.65.

Table 2: Correlation Coefficient between Skeletal and Dental Development Stages in Male and Female Subjects

Tooth	Correlation Coefficients	
	Female Subjects	Male Subjects
Canine	0.64*	0.57
First Premolar	0.65*	0.63*
Second premolar	0.68*	0.67*
Second molar	0.69*	0.64*
Third molar	0.32*	0.45*

+ Values are r values.

* Correlation is significant at the.01 level.

For male subjects and from 0.32 to 0.69 for female patients. The sequence of teeth in order of the highest to the lowest correlation for male subjects was the second molar, the canine and third molar the corresponding sequence in female subjects was the second premolar, the second molar, the first premolar as well as the canine and the third molar. The second premolar was the tooth showing the highest correlation as indicated by ' r ' value of 0.67 to 0.69, ($p < 0.01$) for male and female subjects respectively the third molar showed the lowest correlation for both sexes.($r = 0.45$ in male subjects, $r = 0.32$ in female subjects, $p < 0.01$ for each)⁶

The coefficient of first & second premolars as well as second molar were similar in male patients the distribution for stages of calcification of individual teeth and stages of skeletal maturity of hand wrist X- Ray relationship in percentage wise are shown in table 3 to table 7. In female patients, when all the teeth studied except for the third molar, showed virtually the same correlation.

Exclusion of third molar from study due to its poor association with skeletal maturity.

At the MP₃ stage (table 3), the canine stage 'F' and the second premolar stage E in female subjects showed the highest percent distribution (64.3 %) whereas all the remaining teeth had a scattered distribution (55.1 %) among all the teeth studied.

Table 3: Percent Distribution of Calcification Stages of Individuals Teeth at the 'Mp3' Stage

Stage	Canine		First Premolar		Second Premolar		Second Molar	
	Female	Male	Female	Male	Female	Male	Female	Male
D							26.4	16.3
E	15.9	5.5	47.5	16.3	63.3	28	52.7	32.5
F	63.3	54.2	36.9	46	26.4	48.7	10.6	24.4
G	15.9	19	0	21.7	10.6	16.3	10.6	28
H	5.4	19	5.4	16.3	0	8.2	0	4
MISSING	0	2.8	10.6	0	0	0	0	0
TOTAL	100.1	100	99.9	100	100	99.9	99.9	99.9

At the 's' stage(table 4), in female patients the second premolar stage F & second molar stage E demonstrated marked distinction of the percent distribution (54.5% and 52.5 %) respectively, whereas in male subjects so tooth calcification stages in any teeth studied had distribution greater than 52 %.

Table 4: Percent Distribution of Calcification Stages of Individuals Teeth at the ‘S’ Stage

Stage	Canine		First Premolar		Second Premolar		Second Molar	
	Female	Male	Female	Male	Female	Male	Female	Male
D			3	0	5.8	0	11.5	0
E	5.7	4.1	28.7	8.1	23	8.1	51.5	20.1
F	45.8	32.1	40.1	16.1	54.4	36.1	23	28.1
G	31.5	28.1	20.1	48.1	11.5	44.1	14.4	40.1
H	17.2	28.1	8.7	24.1	5.8	12.1	0	12.1
MISSING	0	8.1	0	4.1	0	0	0	0
TOTAL	99.9	100	100.1	100	100	100	100	100

* Because of rounding values may not total 100?

At the ‘MP_{3cap}’ stage (table 5) wide distribution of tooth calcification stages was clearly seen in all of the teeth for female subjects, with less than 50 % in each stage. For male patient root formation of the canine as well as the first premolar was completed (stage H) in the many of patients (78.5% & 82.5%) respectively. The second molar development was highly concentrated in stage ‘G’ (67.1%). There were no predominant calcification stages for second premolar (< 45% in each stage

Table 5: Percent Distribution of Calcification Stages of Individuals Teeth at the ‘Mp_{3cap}’ Stage

Stage	Canine		First Premolar		Second Premolar		Second Molar	
	Female	Male	Female	Male	Female	Male	Female	Male
E	1.4	1	11.9	1	18.5	1	30.4	2
F	27.7	5.7	26.4	9.4	34.3	13.1	21.2	11.2
G	22.5	14.9	30.4	9.4	29	44.5	40	67
H	48.7	78.51	31.6	82.51	18.5	43	9.3	20.5
MISSING	0	1.9	0	0	0	0	0	0
TOTAL	100	100.1	100	100.1	99.9	100	100.1	100.1

At the ‘DP_{3u}’ (table 6) stage of maturity, in female patients most of the canine & first premolars were in stage ‘H’ (70% & 65% respectively). In male patients the root information of most of the teeth with the exception of second molar has attained stage ‘H’.

Table 6: Percent Distribution of Calcification Stages of Individuals Teeth at the ‘Dp_{3u}’ Stage

Stage	Canine		First Premolar		Second Premolar		Second Molar	
	Female	Male	Female	Male	Female	Male	Female	Male
E							6.6	1
F	6.6	1	9.8	1	22.7	1	22.7	1
G	13	12.6	25.9	1	45.3	12.6	54.9	37.6
H	71	87.6	66	100.0	33	88	13	62.6
MISSING	9.8	0	0	0	0	0	3.2	0
TOTAL	100.1	100	100	100	100.1	100	100	100

At the ‘MP_{3u}’ stage (table 7), in both sexes most of tooth formation of all of the teeth, with the exception of the second molar, showed stage ‘H’ calcification. The second molar development was approximately equally distributed between stages G & H.

Table 7: Percent Distribution of Calcification Stages of Individuals Teeth at the 'Mp_{3u}' Stage

Stage	Canine		First Premolar		Second Premolar		Second Molar	
	Female	Male	Female	Male	Female	Male	Female	Male
E					1.7	1	1.7	1
F			1.7	1	1.7	1	1	1
G	5	6.8	5	6.8	16.5	20.1	52.6	40.1
H	93.5	93.4	93.5	93.4	80.4	74	46	53.4
MISSING	1.7	1	1	1	1	6.8	1	6.8
TOTAL	99.9	99.9	99.9	100	99.9	100	100	100

ASSESSMENT REPRODUCIBILITY

All the assessments have high coefficient values. The reliability of coefficient was 0.99 for skeletal age & dental calcification stage assessments & 1.00 for skeletal maturity assessments.

DISCUSSIONS

Assessment of Dental Maturity

In routine practice intraoral peripheral radiographs are available and panoramic X-Ray also used to assess the dental maturity in orthodontic clinics whereas all the jaw bones are able to diagnose properly.

Different methods of skeletal maturity indices are there. To evaluate assess the bones Demerjian was chosen in the present study as teeth calcification stage assessment. All the shape of tooth, size, and length root its formation and maturity is considered in this stage.

Skeletal Age Assessment

Different types of methods are there to determine the skeletal age hand wrist X Ray. But we have taken into consideration 'GREULICH' and 'PYLE' method which is quick and relatively easy to diagnose the skeletal maturity age assessment.

Table 8: Comparisons of Mean Chronological Ages in Years

Stage	Grave And Brown ³³ Present Study					
	Female	Male	Female	Male	Femal	Male
MP ₃	9.8	11.3	10.7	11.8	9.8	11.3
S	11.4	13.6	11.3	12.4	10.3	11.7
MP _{3cap}	12.5	14.1	12.2	13.4	11.5	13.3
DP _{3u}	13.2	15.5	13.2	15.2	12.7	14.4
MP _{3u}	14.4	16.1	14.9	16.5	14.2	15.5

There are many small bones in the hand wrist region. They follow a pattern in ossification and union of epiphysis and diathesis. Hand wrist region has 8 carpals, 5 Meta carpals, 14 phalanges which makes total 27 bones.

Skeletal age differs according to the population. The male & female age is different for skeletal maturity determination criteria. The given skeletal age value as standard age plates should be recalibrated for each population. All the aspects of carpal, metacarpal, phalanges should be considered anatomically to determine perfect age of the male of female patient. Fishman's skeletal maturity was used. This system uses only the sites located on the phalanges and they

mature together at the onset of puberty in carpals first and metacarpals then and phalangeal epiphyses.⁷

To make simple the maturity determination only 5 stages considered out of 11 skeletal maturity indicators.

The MP₃ stage assess during the onset of accelerating growth velocity.

'S' and 'MP_{3cap}' stage become visible during a period of every rapid growth velocity.

The 'DP_{3u}' & 'MP_{3u}' stage coincide with the time interval of decelerating growth rate.

The chronological age for each skeletal maturity level presented in table 1 which shows female getting equally mature than male.

The average ages for 5 skeletal maturity stages were within the range of derived from the other population groups as listed in tables.

Difference between skeletal age & chronological age for each of skeletal maturity stages were studied for male & female patients. (Table 1). The first three stages 'MP_{3u}', 's' & 'MP_{3cap}' demonstrated smaller deviations between skeletal & chronological ages than did the 'DP_{3u}' & 'MP_{3u}' stages. There is little verification in selected development & chronological age.⁸

Verification occurs due to 3 main reasons.

- Natural verification between individuals in their rate of skeletal maturation.
- Systematic error in the method used to assess skeletal age and variation.
- Different observer's variation.

In this study, skeletal age assessment was performed by only 1 observer & reproducibility test was also shown a very strong coefficient of reliability.

(r=0.99) between double assessments.

CONCLUSIONS

The relationship between the stages of calcification of various teeth & skeletal maturity stages. Everything is determined by panoramic **X-Ray** & hand wrist **X-Ray** of 140 male & 225 female patients age of 8 years to 20 years.⁹

The correlation coefficient and percent distribution of stages, there was a relationship between dental & skeletal development.

The canine stage 'F' for both sexes coincided with MP₃ stage & indicated the onset of a period of accelerating growth. The second molar stage E for female subjects & stage 'G' for male subjects were related to the 'S' stage & MP_{3cap} stage, respectively which shows the period of rapid growth velocity.

This study shows the tooth calcification stage might be clinically used as a maturity indicator of pubertal growth period.¹⁰

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