A CORRELATIVE STUDY OF DENTAL AGE AND CERVICAL VERTEBRAE MATURATION

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The operational goal of orthodontics in a growing child is to maximize the growth potential and guide towards a pattern of optimal development. Growth standards are generally based on chronological age that alone provides little insight for indentifying the stage of development progression. The study was aimed to explore if canine calcification and cervical vertebrae maturation could be used for assessment of skeletal maturity. The study comprised of 45 males (10-13 years) and 45 females (9-12 years). Hand wrist radiograph was employed as skeletal maturity indicator, Lateral cephalogram to show cervical vertebrae maturation and intra-oral periapical X-ray of right maxillary and mandibular canine for dental maturation. Statistically strong correlations were drawn between the three variables. Statistically strong correlation were found between skeletal and cervical vertebrae maturation in both males and females (r =0.849, 0.932), skeletal maturity indicator and canine calcification for both male and female (r = 0.635, 0.891), Indicating thereby that cervical vertebrae maturation and canine calcification can be useful for assessing skeletal maturity.

INTRODUCTION

Human growth shows considerable variation in the chronologic ages at which individual children reach similar development events. Chronologic age alone is not sufficient for assessing the stage of development of a growing child. Accurate information of the stage of development is provided by skeletal maturation, secondary sex characters, maturation of different tissue systems etc. appearance and union of different skeletal centers of ossification follows a fairly definite pattern and time schedule. A roentgenographic study of these skeletal maturational processes provides a valuable criterion of the child's level of developmental maturation. One of the important diagnostic tools currently used in determining the timing of pubertal growth spurt is the hand-wrist radiograph. However, *Lamparski (1972)*[1], found the changing concavities on lower border of cervical vertebrae to be a reliable method for growth prediction apart from hand-wrist radiographs for skeletal maturational assessment. Since the cervical vertebrae are recorded in lateral cephalogram which is a routine orthodontic diagnostic aid, the need for an additional radiograph is eliminated.

Tooth development is also reported to be a measure of individual maturity [6,8,9]. It represents a series of recognizable changes that occur in a sequence from an initial event to a constant end point in a way similar to hand-wrist and/ or cervical vertebrae development.

The present study was aimed to evaluate skeletal maturity using hand-wrist radiograph & cervical vertebrae maturation using lateral cephalogram and dental maturity using intraoral periapical X-ray for maxillary and mandibular right canine. To compare and correlate cervical vertebrae maturity with skeletal maturity at different age subgroups and finally canine calcification with skeletal maturity will be compared and correlated.

MATERIAL AND MATHOD

The study was based on lateral cephalometric radiographs, hand- wrist radiograph, IOPA radiograph of maxillary and mandibular right canine of

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90 subjects, 45 males (age range 10-13 years) and 45 females (age range 9-12 years). Sample for the present study was collected from out outpatients Department of Orthodontics, Faculty of Dental Sciences, King George's Medical College, Lucknow.

All subjects were divided into two main groups, Groups 1 consists of male subject and Group II consists of female subjects. Each group was further divided on the basis of chronological age into 3 subgroups comprising of 15 subjects each. They are a1 (10-11- years), b1 (11-12 years) and c1 (12-13 years) for males and a2 (9-10 years), b2 (10-11 years) and c2 (11-12 years) for females.

All the subjects selected were moderately built and were of growing age as given above, with no history of bony or muscular deformities, tumour or surgery of head and neck region or any systemic illness in the past.

Lateral cephalometric radiograph of each individual was taken with, a universal counter balancing type of cephalostat at the Faculty of Dental Sciences, King George's Medical College, Lucknow 'Kodak' X-ray films (8"X1O") were exposed to 70 KVp, 45mA for an average of 1.8 sec. With a tube to film distance of 5 feet for cervical vertebra to assess C.V.M.I. (Fig3). It was evaluated as per the system developed by Lamparski, 1972.

Hand- Wrist radiograph was taken by placing the left and right hands and wrists on the cassette with fingers slightly separated. The film was exposed to 20mA current for an average of 0.5 seconds at tube film distance of 90cm. The hand-wrist film was compared to the index given by Fishman, 1981[2] (Fig 1&2). Intraoral periapical radiograph of maxillary and mandibular canine region was taken by using Bisecting angle technique. The Kodek film (13 x 41mm) was exposed to 60 kilovolt power for 1.4

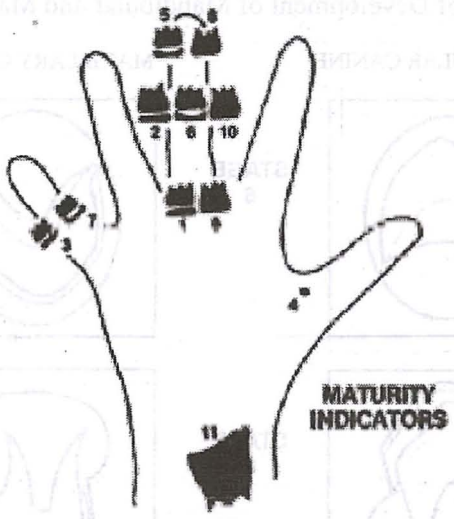
Table 1: Mean and S.D. of different development stage of male subjects

	a1 (10-11 years)	b1 (11-12 years)	c1 (12-13 years)
SMI	11.35± 0.40**	11.97 ± 0.20**	12.29 ± 0.30
CVMI	11.69 ±0.25**	12.21 ±0.25**	12.48 ±0.37
Maxillary canine calcification stage	10.2 ±0.68	11.8 ± 0.41	12.40 ±0.74
Mandibular canine calcification stage	11.2 ± 0.68	11.60 ±0.51	12.13 ±0.74
Chronological age	10.47 ±0.29	11.56 ±0.20	12.45 ± 0.26

Table 2: Mean and S.D. of different development stage of female subjects

	a2 (9-10 years)	b2 (10-11 years)	c 1 (11-12 years)
SMI	10.57 ± 0.25**	11.0 ± 0.15*	11.97 ± 0.31
CVMI	10.40 + 0.11**	10.77 ±0.28*	11.86 ± 0.47
Maxillary canine calcification stage	9.2 ±0.56	10.27± 0.46	11.60 ±0.74
Mandibular canine calcification stage	9.2 ±0.56	10.27 ± 0.46	11.60 ± 0.57
Chronological age	9.41 ± 0.72	10.46 ±0.28	11.52 ± 0.30

**p<0.05 (significant); * p<0.01 (highly significant)*



HAND-WRIST OBSERVATION SCHEME

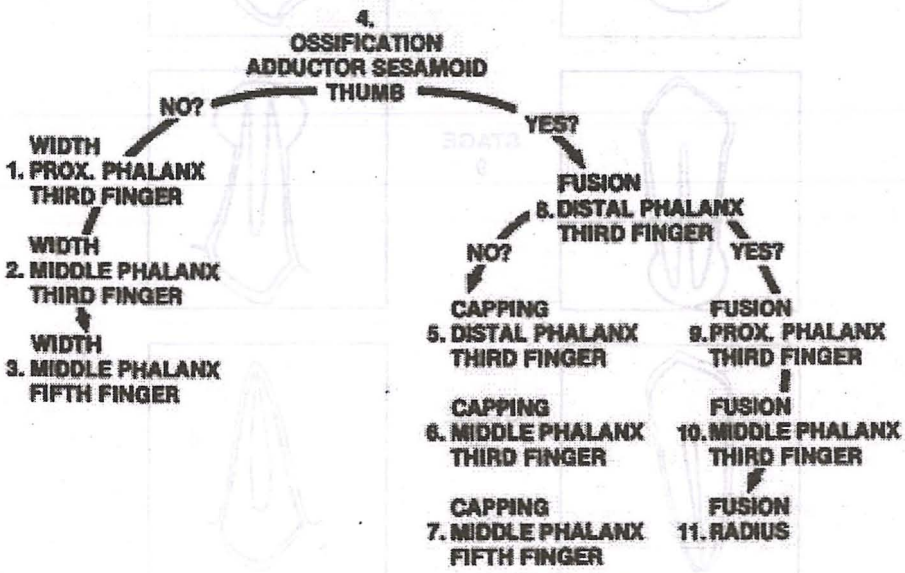
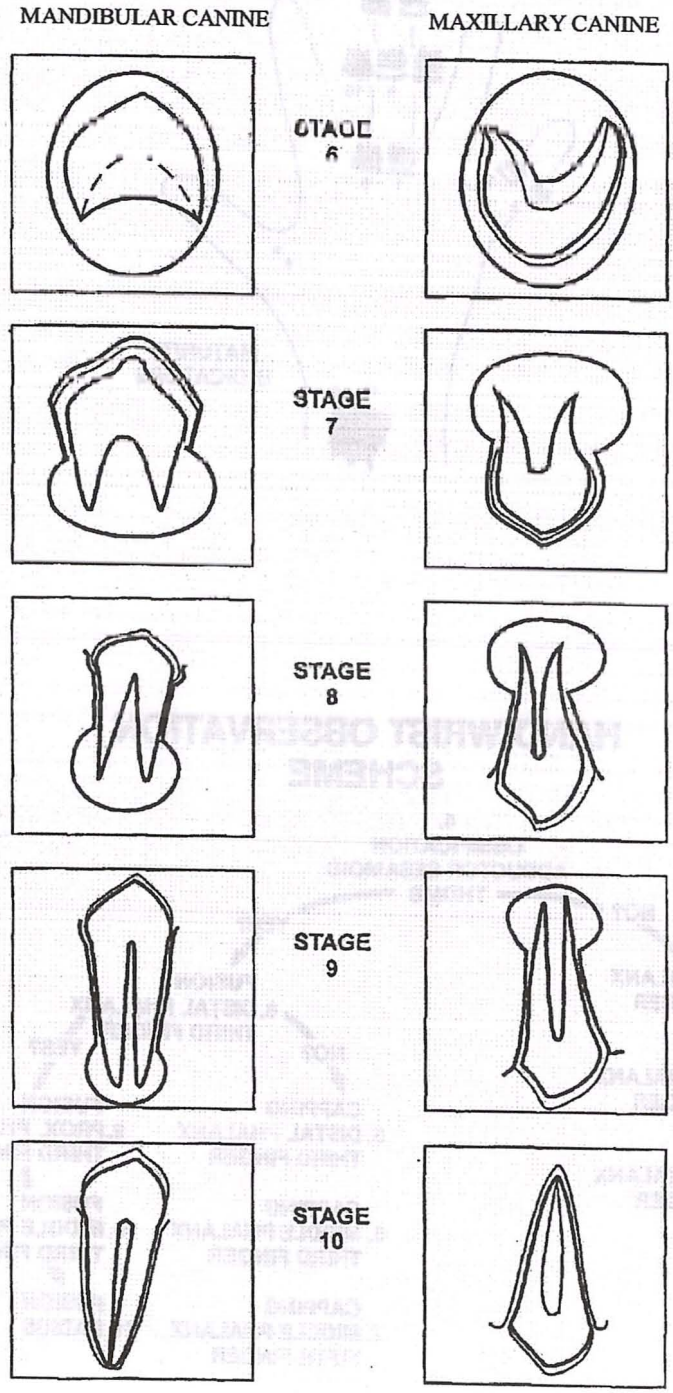


Fig. 4: Stages of Development of Mandibular and Maxillary Canine



seconds. The canine calcification-was studied according to the stage of tooth development given Nolla[3], 1960 (Fig 4).

The data obtained was subjected to statistical analysis Mean, standard deviation and standard error were calculated for both groups. Correlation coefficients were computed for the samples collected. The 'Newman Keul's test' was employed to evaluate the difference between the mean value of chronological age, skeletal maturation and canine calcification stages.

To evaluate the magnitude of error in the measurements double determination was carried out on 10 individuals at an interval of 15 days. These tracings were analyzed separately and two sets of readings were obtained from each case. The reliability of the measurements taken was tested by students 'f' test. Since the difference between the mean of all the variables was found to be insignificant, this means that the observations recorded in whole study are reliable.

RESULTS

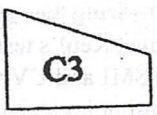
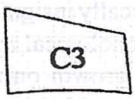
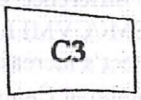
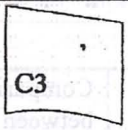
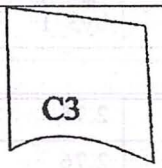
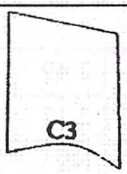
The age assessed by SMI, CVMI maxillary and mandibular canine and chronological age has been shown in Table 1 and 2. On comparing the mean age by ANOVA followed by Newman Keul's test it was found that the age assessed by SMI and CVMI was significantly higher than the chronological age and dental age of the subjects for males up to 12 and female up to 11 years of age. However, the age of the third subgroup of subjects (Male 13-14 years, Female 12-13 years) assessed by SMI, CVMI and canine calcification were statistically insignificantly different ($p>0.05$) from the chronological age. This shows the strong influence of growth on skeletal age. Insignificant difference is seen between Dental and Chronological age indicating correlation between these two parameters. Looking closely at Table 1 and 2 reveals that the difference between chronological age and age by SMI/CVMI has been decreasing as the age of the subject's increases. Age assessed from maxillary & mandibular Canines was insignificantly different from the chronological age

Table 3: Showing comparison of chronologic age with age by SMI, age by CVMI, age by 3 and age by 3_1

Subgroup	No. of subjects	Comparison between chronological age and age by SMI	Comparison between chronological age and age by CVMI	Comparison between chronological age and age by 3_1	Comparison between chronological age and age by3_1
Group I: Male					
A1	15	6.89**	9.56**	2.15	2.15
B1	15	4.67**	7.53**	0.46	2.76
C1	15	NS	NS	NS	NS
Group II: Female					
A2	15	11.10**	10.03**	2.09	2.49
B_2	15	6.02**	3.49**	2.17	2.17
c_2	15	NS	NS	NS	NS

*$p<0.05$ (significant); **$p<0.01$ (highly significant)*

Fig: 3. Cervical vertebrae maturation indicators

 CVMI- 1	**1. Initiation** ■ Very significant amount of adolescent growth expected. ■ C2, C3 and C4 inferior vertebral body borders are flat ■ Superior vertebral borders are tapered posterior to anterior.	SMI 1&2 
 CVMI-2	**2. Acceleration** ■ Significant amount of adolescent growth expected. ■ Concavities developing in lower borders of C2 and C3. ■ Lower border of C4 vertebral body is flat ■ C3 and C4 are more rectangular in shape.	SMI 3&4 
 CVMI - 3	**3. Transition** ■ Moderate amount of adolescent growth expected. ■ Distinct concavities in lower borders of C2 andC3. ■ C4 developing concavity in lower border of body. ■ C3 and C4 are rectangular in shape.	SMI-5&6 
 CVMI – 4	**4. Deceleration** ■ Small amount of adolescent growth expected. ■ Distinct concavities in lower borders of C2, C3 and C4. ■ C3 and C4 are nearly square in shape.	SMI-7&8 
 CVMI-5	**5. Maturation** ■ Insignificant amount of adolescent growth expected. ■ Accentuated concavities of inferior vertebral body borders of $C2_3$ C3 and C4. ■ C3 and C4 are square in shape.	SMI-9&10 
 CVMI - 6	**6. Completion** ■ Adolescent growth is completed ■ Deep concavities are present for inferior vertebral body borders of C2, C3 and C4. ■ C3 and C4 heights are greater than widths.	SMI- 11 

of all use subjects of all 3 sub groups in small & tense.

The correlation between different radiographic methods of determining maturity is represented in table 3. It shows a positive correlation between the different measure of maturity determination in both males and females. The very high correlation between CVMI and SMI indicates that any one of them can be used.

Table 4 shows the correlation coefficient of male and female subjects when all subgroup have been considered together irrespective of age. The con-elation coefficient (r) between by SMI, age by CVMI and age by mandibular and maxillary canine calcification was observed to be highly significant

DISCUSSION

Every bone undergoes a series of changes during growth that can be seen radiographically. The sequence of changes is relatively consistent for a given bone and its timing varies for every individual. As each bone has different developmental pattern, it is important to study the common denominators in skeletal maturation of different bones. Such basic information is considered essential to a more biological and clinically defensible approach to craniofacial growth evaluation, growth prediction and treatment planning. The present study was conducted to correlate and compare the skeletal maturity of hand-wrist with maturation of cervical vertebrae and with calcification of maxillary & mandibular canine.

A significant difference was found between chronological age and age assessed by SMI, and age assessed by CVMI from table 1 we can say that skeletal maturation is more advanced than chronological age. This study is supported by Hunter[4] (1969), Fishman (1981)[2], Schour and Masseler (1941)[3]. They also reported a significant between the mean chronological age and skeletal age. It means that attempts made at the correction of skeletal problems may not succeed if chronological age is used as the parameter to assess the individual maturity.

There is insignificant difference between chronological age with age assessed by maxillary Rt canine and mandibular Rt canine. This indicates that dental development takes place more in accordance with chronological age than the skeletal maturation with the later. Similar findings were earlier reported by Lemons & Gray (1958)[6]. In a way it shows that applying chronological age for the correction of dental problems will be more accurate than if the same was applied to correct skeletal problems. Interpreting it in reverse order means that

Table 4: Showing correlation of age by SMI with age by CVMI, age by max Rt canine and age by mandibular Rt canine

Group	Correlation between age by SMI and age by CVMI	Correlation between age by SMI and age by maxillary Rt. Canine	Correlation between age by SMI and age by mandibular Rt canine
Group I: Male			
For total sample	0.849**	0.635**	0.697**
Group II: Females			
For total sample	0.932**	0.891**	0.869**

**p<0.05 (significant); **p<0.01 (highly significant)*

dental maturation of individual can be used to assess the chronological age.

Strong correlation was found between age shown by skeletal maturity indicators of hand wrist and age by CVMI (in both male and females - r = 0.849** and r =0.932**). This suggests that as SMI is used for assessing skeletal age, CVMI can also be used for the same. This study is supported by Lamparski (1972)[1] and Hassel & Farman (1995)[7]. This finding not only eliminates the need of an additional radiographic exposure of the patients but also saves some precious time of the clinicians.

Correlation of age assessed by SMI with age by max Rt canine and age by mandibular Rt canine are also highly significant. It indicates that there is strong correlation between dental and skeletal development. Lauterstein (1961)[8], Lewis and Garn (1960)[9], Coutinho and Buschang (1983)[10], Demirjian and Buschang (1985)[11], Gireen (1961)[12] have also reported similar findings.

These results reveal that chronological age cannot be used reliably for assessing skeletal maturity. Timing variability can be reduced by using development age rather than chronological age as an expression of individual growth status. Strong correlation observed between SMI and CVMI, SMI and maxillary & mandibular canine calcification. It shows that the pattern is expressed at different times chronological but not physiologically. It also confirms the reliability and validity of cervical vertebrae and canine to be used as skeletal maturity indicator. This also eliminates the use of additional radiographic exposure (Hand-wrist radiograph) of patients in orthodontic practice because cervical vertebrae are will visualized in lateral cephalogram and canine are very easily seen periapical radiograph.

CONCLUSION

Skeletal age is advanced as compared to respective chronologic age of the patients. Strong correlation was found between age assessed by SMI & CVMI. Canine calcification stages and SMI Stage also are strongly correlated. This suggests that CVMI and canine calcification both can also be used as skeletal maturity indicator.

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