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To Evaluate and Compare Hand Wrist Radiographs with Cervical Vertebrae for Skeletal Maturation in 10-12 Years Old Children In Rajnandgaon Population

Piyush Khandelwal[1*] G Hanmanth Reddy[2] Johar Rajvinder Singh[3] Achint Chachada[4] Megha Jain[5] Nehal Saraf[6]

[1]Reader, Department of Orthodontics and Dentofacial Orthopaedics, Chhattisgarh Dental College and Research Institute, Rajnandgaon, India.
[2]Ex Professor and Head, Department of Orthodontics and Dentofacial Orthopaedics, Chhattisgarh Dental College and Research Institute, Rajnandgaon, India.
[3]Professor, Department of Orthodontics and Dentofacial Orthopaedics, Kannur Dental College, Anjarakandy, Kerala, India.
[4]Professor, Department of Orthodontics and Dentofacial Orthopaedics, Chhattisgarh Dental College and Research Institute, Rajnandgaon, India.
[5]Associate Professor, Department of Orthodontics and Dentofacial Orthopaedics, Chhattisgarh Dental College and Research Institute, Rajnandgaon, India.
[6]PG Student, Department of Orthodontics and Dentofacial Orthopaedics, Chhattisgarh Dental College and Research Institute, Rajnandgaon, India.

ABSTRACT

Background: To evaluate and compare Hand Wrist Radiographs with Cervical Vertebrae for Skeletal Maturation in 10-12 Years Old Children in Rajnandgaon Population.

Materials and Method: The sample consisted of 50 subjects (divided into 2 groups of 25 subjects with equal males and females in each group) aged between 10-12 years with either normal occlusion, malocclusion or those undergoing orthodontic treatment with no congenital disorders and falling into the norms of Indian society. Lateral cephalogram and the left-hand wrist radiographs were taken under standardized conditions. CVMI and Hand wrist radiographs were compared. Data obtained was analyzed with karl pearson correlation coefficient

Results: The study shows that there is no significant difference between the cervical vertebrae and hand-wrist radiographs the techniques for a total number of samples. The 'r' value turns out to be 0.94 with a 'P' value of 0.000, which is statistical significance.

Conclusion: The cervical vertebrae can be used with the same confidence as hand wrist radiographs to evaluate skeletal maturity, thus avoiding the need for an additional radiograph. Cervical vertebrae developmental changes are the same for males and females; however, females develop the changes earlier.

Keywords: Hand wrist radiograph, skeletal growth, orthodontics.

INTRODUCTION

Growth biologically and histologically is a composite of morphogenetic and histogenetic changes occurring continuously over a period of time in response to genetic coding and environmental influences. Human growth is characterized by considerable variation in the rate of progress of different persons towards physiologic maturity. It is one of the most myriad variations in nature and plays an important role in the aetiology of malocclusion and also in the evaluation of diagnosis, treatment planning, retention and stability of any case.

The developmental status of a child is usually assessed in relation to events that take place during

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*Correspondence Dr. Piyush Khandelwal.
Department of Orthodontics and Dentofacial Orthopaedics, Chhattisgarh Dental College and Research Institute, Rajnandgaon, India.
Email: drpiyush.cdcri@gmail.com

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the progress of growth. Thus chronological age, dental development, height and weight measurements, sexual maturation characteristics and skeletal age are some biological indicators that have been used to identify stages of growth. The chronologic age is governed by various factors like genetic, epigenetic, environmental, nutritional, hormonal etc. Dental age is not an accurate method because of wide variations in time of eruption of teeth due to the influence of local and environmental factors. Children vary in the age at which they attain stages of physical development. Height and weight measurements are one of the powerful tools in growth assessment but become impractical as it requires longitudinal data and needs time and repeated observations. Growth prediction using appearances of secondary sexual characteristics require frequent examination, and therefore, it is important in clinical orthodontic practice.

History of onset of menarche in females is a reliable indicator that the maximum pubertal status of skeletal growth has been attained. The stages of sexual development in boys are more difficult to define than in girls as there is no single reliable indicator such as menarche. Many researchers have agreed that skeletal maturity is also closely related to the craniofacial growth, and bones of hand wrist and cervical vertebrae are very reliable parameters in assessing it. The complete hand wrist radiograph involves 30 bones, and assessment of these stages is one elaborate task which needs time and experience and also involves increased radiation exposure, therefore, putting a question mark on ALARA (As Low As Reasonably Achievable) principle, since this is very important mainly for children and young adults who have proliferating cells in crucial organs e.g. thyroid gland, bone marrow and salivary gland.[1]

Tanner et al. [2] described ossification events in various bones of hand and wrist, including MP3 (classified from A to I). Hagg and Taranger suggested 5 distinct stages of MP3 (middle phalanx of 3 rd finger) in which 4 stages; MP3 F to I were adopted from the classification of Tanner. S.M. Chapman[3] was the first to use intra oral periapical x-ray films (IOPA) to relate ossification of ulnar sesamoid bone as skeletal maturity marker, and Abdel-Kader used his idea successfully to record MP3 stages using Intraoral periapical radiograph (IOPA). Fishman[4] developed a system of skeletal maturity indicators using four stages of bone maturation found at six anatomical sites on hand and wrist radiographs.

The cervical vertebrae, seen in normal routine lateral cephalograms were as statistically and clinically reliable in assessing skeletal age as hand wrist technique was confirmed by A.G Farman and B. Hassel[5], Gracia Fernandz. [6] The ability to accurately appraise skeletal maturity from the cervical vertebrae without the need for an additional radiograph has the potential to simplify and improve orthodontic diagnosis and therapeutic decisions in addition of being cost-effective and decreasing the amount of exposure to the patient. A comparative radiographic evaluation of developmental stages of cervical vertebrae and hand wrist bones are seen clearly in lateral cephalogram, and hand-wrist radiographs respectively are undertaken among Rajnandgaon population in this study.

MATERIALS AND METHOD

Screening of 275 subjects aged between 10-12 years visiting the Department of Oral Medicine, Diagnosis and Radiology, Department of Orthodontics and Department of Pediatric Dentistry, Chhattisgarh Dental College and Research Institute Rajnandgaon and from schools of the local suburban area of Rajnandgaon city was done. 150 subjects fulfilling the inclusion criteria were selected. Out of which 50 subjects were selected randomly through a computer-generated sequence were divided into 2 groups of 25 subjects with equal males and females in each group. The radiographs taken included the lateral cephalogram and the left-hand wrist radiograph.

METHOD

Protocol

Selected subjects were clinically examined and the following points were recorded:

1. Age and date of birth: The age considered was his or her chronological age in completed years, without taking the months into consideration.

2. Sex: As males and females attain puberty at different times in life.

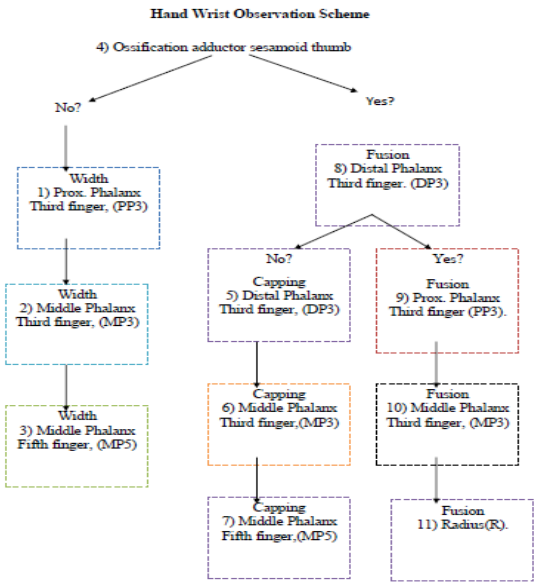
Radiographs:

Lateral cephalogram and Hand wrist radiographs of the left hand were taken on Sirona orthophos XGS digital x-ray machine at 90 Kvp, 12mA, with an exposure time of 0.94s using Kodak Diagnostic film. Radiographs were exposed and developed using the digital printer (Konica Minolta, dry pro model 832).

Methodology:

The system developed by Fishman[5] was used to determine skeletal maturation by hand wrist evaluation on each subject.

Cervical vertebrae development of the sample was evaluated by Hassel and Farman, modification of Lamparski's criteria, which assess maturational changes of the second, third and fourth cervical vertebrae. 6 Six distinct stages of growth can be related to the skeletal maturity indicator developed by Fishman.[5]



Comparison and Correlation:-

Each CVMI is designated equivalent to two skeletal maturation indicators (SMI) was taken to evaluate the growth status in males and females.

Table 1: Comparison and Correlation of CVMI Vs SMI

CVMI	SMI	Percentage of growth completed according to SMI	
		Male	Female
1	1,2	0 15.02	0 12.15
2	3,4	21.60 28.92	22.54 32.73
3	5,6	34 52.62	39.75 51.70
4	7,8	74.29 87.32	73.58 86.58
5	9,10	91.98 95.34	91.87 96.14
6	11	100	100

The SMI and CVMI were compared with each other, and their correlation was established statistically using Karl Pearsons test.

RESULTS

The skeletal maturity indicator (SMI) scores and cervical vertebrae maturity indicator (CVMI) scores were obtained and analyzed with reference to chronological age and sex (Table 1). The following results were drawn from the statistical analysis.

Descriptive statistics are described in table 2, which shows the mean values of the variables. The minimum value of chronological age is 10 years, and the maximum is 12 years, with a mean of 10.96 ± 0.83 years. The minimum value for CVMI score is 1, and the maximum is 4, with a mean of 1.90 ± 0.90. The minimum value of SMI score is 1, and the maximum is 8, with a mean of 3.10 ± 1.96. The minimum value of percentage of growth completed according to SMI is 0%, and the maximum value is 86.58% with a mean of 27.85% ± 22.26.

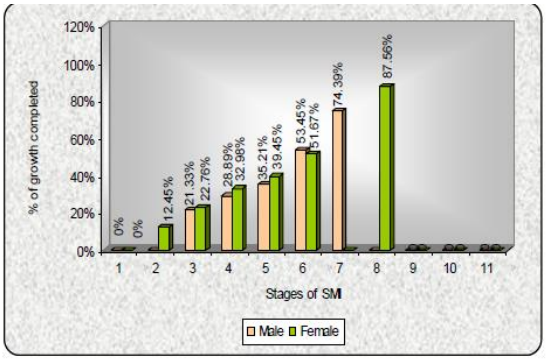
Table 2: Mean and Standard Deviation (n=50)

	Minimum	Maximum	Mean	Standard Deviation
Age in years	10 years	12 years	10.96	0.83
CVMI Score	1	4	1.90	0.90
SMI Score	1	8	3.10	1.96
Growth	0%	86.58%	27.85	22.26

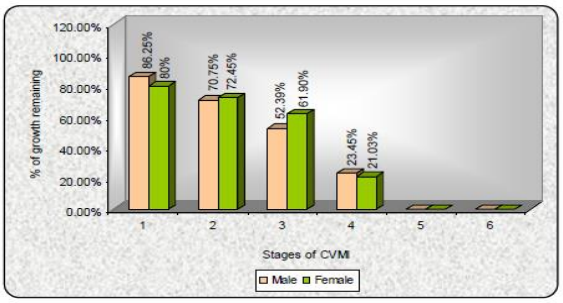
Table 3: The Percentage of Adolescent Growth Completed and Remaining according to SMI and CVMI

SMI	Male	Percentage of growth completed	Female	Percentage of growth completed	CVMI	Male	Percentage of growth remaining	Female	Percentage of growth remaining
1	15	0.00	2	0.00	1	15	86.25	5	80.00
2	-		2	12.45	2	7	70.75	11	72.45
3	5	21.33	7	22.76	3	2	52.39	7	61.90
4	2	28.89	5	32.98	4	1	23.45	2	21.03
5	1	35.21	6	39.45	5	-	-	-	-
6	1	51.67	1	53.45	6	-	-	-	-
7	1	74.39	-	-					
8	-	-	2	87.56					
9	-	-	-	-					
10	-	-	-	-					
11	-	-	-	-					

Table 3 and Graph 1 show the percentage of growth completed of males and females according to SMI score. 15 males and 2 females are in SMI stage 1, which suggests 0% of growth completed, whereas 2 females lie in stage 2, suggesting 12.45 % of growth completed. In SMI stage 3, 5 males and 7 females lie, which suggests 21.33% in males and 22.76% of growth in females is completed. In SMI stage 4, 2 males and 5 females lie suggesting 28.89% in males and 32.98% of growth is completed in females. In SMI stage 5 lies 1 male and 6 females showing 35.21% of growth is completed in male and 39.45 % in females. In SMI stage 6 lies 1 male and 1 female showing 51.67% and 53.45% of growth completed respectively. In stage 7 lies 1 male showing 74.39% of growth completed whereas in stage 8, single female showing 87.56 % of growth completed show percentage of growth remaining of males and females according to CVMI score. 15 males and 5 females are in CVMI stage 1 which suggests 86.25% and 80% of growth remaining, whereas 7 males and 11 females lie in CVMI stage 2 suggesting 70.75% and 72.45% of growth remaining. In CVMI stage 3, 2 males and 7 female lies which suggests 52.39% in males and 61.90 % of growth in females is remaining. In CVMI stage 4, 1 male and 2 female lies suggesting 23.45% in males and 21.03% of growth is remaining in females (Graph 2).



Graph 1: SMI Gives the Percentage of Adolescent Growth Completed.

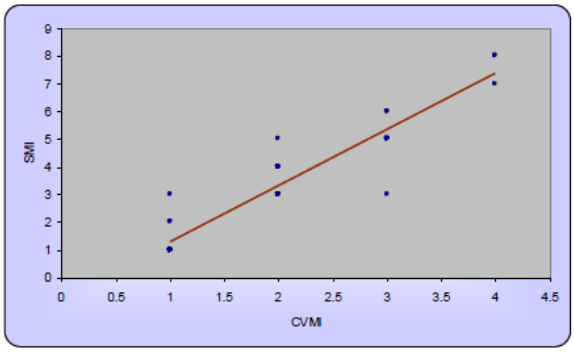


Graph 2: CVMI gives the percentage of adolescent growth

Results scoring for SMI and CVMI for all sample was correlated according to karl pearsons correlation coefficient test (Table 4, Graph 3). The test shows that there is no significant difference between the techniques for a total number of samples. The 'r' value turns out to be 0.94 with a 'P' value of 0.000, which is statistical significance at 'P'< 0.001 level.

Table 4: Karl Pearsons Correlation Coefficient Test for total patients.

No of patients MALE	Degrees of Freedom	Correlation 'r'	p-value
25	23	0.98	0.000
FEMALE			
25	23	0.89	0.00
TOTAL			
50	48	0.94	0.00



Graph 3: Karl Pearsons Correlation Coefficient for Total Patients

DISCUSSION

Knowledge of maturation status of a child plays an important role in the diagnosis, treatment planning and eventual outcome of the treatment. Skeletal maturity among all is the most commonly used index in routine clinical work and is closely related to the sexual and somatic maturity. The present scenario in clinical orthodontics requires an accurate method with well-defined and easily identifiable stages which could be interpreted in a cross-sectional study without requiring long observation periods. The method should also be non-invasive, safe and economical with no elaborate armamentarium required and should be such as to be easily used in day to day orthodontic practice.

The common practice of comparing an individual cephalometric measurement to chronologically based *'Normal'* standards provides no biologically sound basis for growth evaluation, prediction or treatment timing. However, an appropriate maturational age can provide an accurate indication of development and may be used as a means of making comparisons between children. [7-9]

The chronological age was included in our study and it formed an important part of case history even though it is a poor indicator of maturity as been clearly demonstrated by number of investigators like Bjork and Helm (1967)[10] , Tofani (1972)[9], Fishman (1979, 1982)[7, 11] Hagg and Taranger (1982)[12]. But when it is compared with a reliable skeletal maturation indicator, it may help the clinician to categorize the individual as early, average or late mature.

An age group of 10-12 years was chosen because males and females have their maximum cicumpubertal growth spurt during this period.[13] Hand wrist radiographs, although the most standardized method to evaluate skeletal maturation are being criticized because of Additional radiation exposure and expense to the patient. The interpretation from the hand wrist radiographs gives a general idea about the amount of growth and not about the direction of growth.[14]

To overcome this researchers diverted their mind to determine skeletal maturation from those clinical records that are routinely used for orthodontic diagnosis and treatment planning i.e lateral cephalogram. The first seven cervical vertebrae in the spinal column constitute the cervical spine. The first two, namely, atlas and axis are quite unique; and the third through seventh have a great similarity.[15] Maturational changes can be observed in these vertebrae from birth to full maturity.

The present study combines the observations of changes in the bones of hand wrist and in the cervical vertebrae during skeletal maturation. The shapes of cervical vertebrae were seen to differ at each of the skeletal developments. This provided a means to determine skeletal maturity of an individual and thereby determine whether the possibility of potential growth existed.

The percentage of similar and dissimilar assessments at different age groups for males and females were determined. There is 100% correlation at ages 10, 11 and 12 years in males and in females 90% of correlation in 10 years of age, 87.5% of correlation in 11 years of age and 100% of correlation in 12years of age. Overall, 95% of correlation in 10 years of age 93.5% correlation in 11 years of age and 100% of correlation in 12 years of age. It suggests that skeletal maturity indicators are less reliable for females as compared to males, which has been reported by

Bambha and Natta[13]. Hence, the present study shows that chronological age was not a reliable indicator of maturation and did not correlate with skeletal maturation indicators (SMI and CVMI). These results are in confirmation with studies conducted by Bjork and Helm (1967)[10], Fishman (1979, 1982) [7, 11] and Hagg and Taranger (1982)[12].

According to the present study, chronological age was not a reliable indicator of maturation and did not correlate with skeletal maturation indicators (SMI and CVMI). These results are in confirmation with studies conducted by Bjork A and Helm[10], Fishman (1979, 1982) [7, 11] and Hagg and Taranger (1982) [12]. Between SMI scores, a significant difference existed in their chronological age. A general trend observed from the above table is that as the SMI scores increased, the corresponding chronological age also increased linearly. A striking feature is that in the male subjects skeletal maturity is much slower as compared to female subjects of same age group.

A significant association was observed between SMI stages and CVMI stages. The correlation coefficient of 0.94 is found to be highly significant (P<0.0001). Further, it is evident that the lesser the SMI stages, the lesser the CVMI stages and also, as SMI stages increased, CVMI stages also increased almost linearly. As in the case of previous instances, a significant association was observed between SMI stages and CVMI stages when the data were subjected to correlation coefficient analysis for females and males alone. The correlation coefficient of 0.98 and 0.89, respectively, is found to be highly significant (P<0.0001). So, for clinicians wishing to start orthopaedic treatment, continuous monitoring of the skeletal maturity using hand-wrist films may not be necessary. Instead, they can monitor the changes in the shape and inferior border curvature of the cervical vertebrae as seen on the routinely taken lateral cephalogram, which could be more easily interpreted and readily available and acceptable. Orthopaedic treatment can be accomplished when the patient is in the stages of initiation and acceleration as there is a good amount of adolescent growth potential still left. The same is difficult to accomplish during the stage of transition, wherein probably fixed functional orthopaedic treatment can be accomplished. Once the stage of transition is completed, not much of growth is expected. Once the patient attains the stage of deceleration, orthopaedic appliances can bring about only minimal skeletal changes and more of dental changes. The same becomes unrealistic in the stage of maturation where in the bone is completely matured and hence cannot undergo any orthopaedic change. Carrying out dentofacial orthopaedic treatment in the stage of completion is futile as growth phase is completed and orthopaedic remodelling cannot be attained. Studies conducted by Rodrigo Ce'sar et al [16] & Roberto et al [17] hold coincidences with the present study in their results, registering a moderate to high statistically significant correlation, between hand- Wrist & CVMI methods. Benny M. Soegiharto et al[18] found both the CVM index and the SMI are valid methods to discriminate between patients who have not yet attained peak pubertal growth and those who have reached or passed it. The differences in

discriminatory ability between the SMI and the CVMI index in detecting peak pubertal growth were small. These results question the necessity of taking hand-wrist radiographs and exposing a child to additional radiation when the discriminatory ability is similar to the CVMI index, which is readily derived from most lateral cephalograms.

Limitations and Scope of the study:

There is a need for a longitudinal study with a larger sample as it can show much higher correlation.

CONCLUSION

1. Females are ahead of males at all levels of skeletal maturity; tend to achieve higher percentage of their growth than males, especially during the age of 11-12years.

2. Cervical vertebrae developmental changes are same for males and females but females develop the changes earlier

3. Skeletal maturity indicators are less reliable for females as compared to males.

4. There is no significant difference between the two techniques of evaluation. This shows that the cervical vertebrae can be used with the same confidence as hand wrist radiographs to evaluate skeletal maturity, thus avoiding the need for additional radiograph.

CONFLICTS OF INTEREST

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

REFERENCES

1. Kader H.M.A. The reliability of the dental X-ray film in assessment of the MP3 stages of the pubertal growth spurt. AJODO 1998; 114: 427-429.

2. Hagg U. Taranger J. Maturation indicators and the pubertal growth spurt. Am. J. Orthodontics 1982; 82: 299-309.

3. Chapman S.M. Ossification of the adductor sesamoid and the adolescent growth spurt. Angle Orthod. 1972; 42: 236-244.

4. Fishman L.S. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. Angle Orthod. 1982; 52: 88-112.

5. Hassel B., Farman A.G. Skeletal maturation evaluation using cervical vertebrae. Am. J. Orthod Dentofac. Orthop. 1995; 107: 58- 66.

6. Garcia Fernandez P., Torre H., Flores L.I. Rea. The cervical vertebrae as maturational indicators. J.C.O. 1998; 32: 221-225.

7. Fishman L.S. Chronological versus skeletal Age, an evaluation of Craniofacial Growth. Angle Orthod. 1979; 49:181-189.

8. Rajagopal R., Kansal S. A comparison of modified MP3 stages and the cervical vertebrae as growth indicators. JCO; 2002: 36, 395- 406.

9. Tofani M.I. Mandibular growth at puberty, Am. J. Orthod 1972; 62, 176-195.

10. Bjork A., Helm S. Prediction of age of maximum puberty growth in body height. Angle Orthod. 1967; 37: 134-143.

11. Fishman L.S. Maturation patterns and prediction during adolescent.Angle Orthod. 1987; 57:178 -193.

12. Hagg U. Taranger J. Maturation indicators and the pubertal growth spurt. Am. J. Orthodontics 1982; 82: 299-309.

13. Bambha J.K., Natta P.V. A longitudinal study of occlusion and tooth eruption in relation to skeletal maturation. Am. J.Orthodontics 1959; 45: 847-85.

14. Letite H.R., O'Reilly M.T. Skeletal age assessment using the first, second and third finger of the hand. Am. J. Orthodontics Dentofac. Orthop 1987:92:492:498.

15. Franchi L., Baccetti T., McNamara Jr. J.A. Mandibular growth as related to cervical vertebral maturation and body height. Am. J. Orthod. Dentofac. Orthop 2000; 118: 335-340.

16. Rodrigo Ce´sar Santiago et al: Cervical vertebrae maturation as a biologic indicator of skeletal maturity.

17. Roberto S. Baptista et al: A semi-automated method for bone age assessment using cervical vertebral maturation.

18. Benny M. Soegiharto et al. Discriminatory ability of the skeletal maturation index and the cervical vertebrae maturation index in detecting peak pubertal growth in Indonesian and white subjects with receiver operating characteristics analysis Am J Orthod Dentofacial Orthop 2008;134:227-37.