ASSESSMENT OF SKELETAL MATURATION USING THE CERVICAL VERTEBRA MATURATION METHOD AND ITS CORRELATION TO CHRONOLOGICAL AGE AND GENDER. A CROSS SECTIONAL STUDY

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ABSTRACT

Objective: *The aim of the study was to find out the relationship between 'chronological age and skeletal maturation' and 'gender and skeletal maturation.*

Materials and Methods: *The lateral cephalometric radiographs of 103 patients of age ranging from 8-18 years, both genders were taken. Cervical vertebrae maturation (CVM) method was used to determine development stages and its co-relation with the chronological age and gender of the patient. For corelation between the chronological age and developmental age, Spearman rank order correlation coefficient was used. And Fishers exact test was used to determine the correlation between gender and developmental stage.*

Results: *Spearman rank order correlation coefficient was 0.835, between chronological age and cervical vertebral maturation stages. Fishers exact test was found to be significant i.e. p=0.02 between gender and CVM stage. In males the stage 2 of cervical vertebrae stages were the most frequent followed by stage 1. Stage 4 followed by stage 1 in females were the most frequent stages.*

Conclusion: *A statistically significant correlation between chronological age and cervical vertebral maturation stages along with the gender and cervical vertebral maturation stages was concluded. The pubertal growth spurt (i.e. CVM 2 and CVM 3) occupies the age group of 10-14 years.*

Keywords: *Chronological age, Gender, Cervical vertebrae maturation (CVM), Correlation*

INTRODUCTION

Forensic odontology is a new science which is developed as a separate speciality.[1] It utilizes the knowledge of a dentist to serve the judicial system. Estimation of age is an important part of forensic research. The age assessment is useful in planning treatment of orthodontic and pedodontic patients, and in forensic medicine and forensic odontology. It also provides valuable information when the birth date is not available, as in case of illegal immigrants. Also the chronological age of people is important in cases of employment and marriage.[2] Degree of physical maturity can be evaluated either separately or in combination of Skeletal, dental and psychological methods. The chronological age shows variability and therefore cannot accurately determine child's developmental stage, due to which it is not reliable in predicting the amount of residual growth remained.[1,3]

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Human growth shows considerable variation in the chronological ages at which each child reaches similar developmental events. Precise evaluation of the developmental stage is an integral part of both diagnosis and treatment of paediatric patients. Orthopedic growth modification therapy utilities the peak growth potential of an individual and is related with individual's peak of skeletal maturity. Developmental ages shows the stage of development of an individual as a part of chronological age. Children of the same chronological age shows Considerable variation in their development stages due to which the concept of developmental or physiologic age was introduced which was based upon the degree of maturation of different systems and tissues. For this purpose Various biologic ages such as morphologic, sexual, skeletal, and dental have been proposed.[4,5]

Timings of treatment is very important, in the development of a structure and calculation of the final picture of the treatment.[6,7] For orthodontic treatment planning the knowledge about the growth changes of the dentofacial complex is important.[8,9] Chronological age is not a reliable tool for assessment of the development status of an individual because of the variation in the timing of the pubertal growth spurt of an individual.[10] A reliable method to evaluate the skeletal age of the patient is the use of hand-wrist radiography due to the large number of different types of bones available in this area. Skeletal age is generally determined by evaluating the stage of ossification of bones of the hand and wrist.[4,10] By using the morphology of the cervical vertebrae, skeletal maturation and it's possible relationship to facial growth can be assessed.[11]

Lateral cephalograph, a radiograph routinely used in orthodiagnosis and treatment planning is an important diagnostic tool for evaluation of the pubertal growth spurt by using Cervical vertebral maturation method.[12] Growth remaining in an individual can be accurately calculated by the shape and size of the vertebrae. Skeletal age evaluation is more reliable as compared to chronological age, by analyzing lateral cephalometric radiographs.[13,14] The method proposed by Baccetti et al[6] was used in this study as this method has a high reliability and validity. It anticipates the occurrence of mandibular growth peak which happens between stages two and three.

Variations in the timings of skeletal maturation between gender and racial subgroups might be due to other than genetic factors e.g. nutritional factor, environmental factor, socioeconomic factors and hygiene factors. Less favorable environmental or nutritional factors tends to have delayed skeletal maturation. As males and females attain puberty at different times in life but females are ahead of males at all levels of Skeletal maturation which indicates that females tends to develop cervical vertebrae developmental changes earlier.[15,16]

The aim of the study was to find out the correlation between the chronological age and CVM along with gender and CVM.

MATERIALS AND METHODS

A cross sectional study on 103 patients was done using convenience sampling, in the Department of Orthodontics at Khyber College of Dentistry, Peshawar. Inclusion criteria's for this study were Cephalometric radiographs of both male and female patients having age range between 8-18 years were included in the study. Radiographs of the patients with congenital malformations of cervical vertebrae, and with a history of trauma to the vertebrae, were excluded from our study.

Records of the patients who fit our inclusion/exclusion criteria were selected. The age considered was his or her chronological age in complete years without taking months into consideration and gender was noted. Our study was done on lateral cephalometric radiographs that are routinely taken for every orthodontic patient as an aid to treatment planning. The odontoid process and the body of the second cervical vertebrae and the bodies of the third and fourth cervical vertebrae were traced on acetate paper using 4H pencils on an illuminator. The tracings were evaluated by an independent evaluator to eliminate inter-operator error. The anatomical changes observed in the concavity of the lower border and shapes of the vertebral body were studied in the following way:

Concavity of the lower border:

This is present when there is a distance of more than 1 mm between the middle of the lower border of the vertebral body and a line traced from the postero-inferior angle to the anteroinferior angle of the vertebral body. According to the concavity, six

stages are defined:

Stage 1) All vertebrae have a flat lower border.

Stage 2) Concavity is present in the C2 lower border.

Stage 3) Concavity is present in the C3 lower border.

Stage 4) Concavity in C2 and C3 increases and a concavity is present in C4.

Stage 5) Concavity in all vertebrae.

Stage 6) Deep concavities in all vertebrae and the inferior angles are rounded.

Shape of the vertebral body:

This will be calculated at C3 and C4 and the following stages will be defined:

Stage1) Upper border is tapered from the posterior to the anterior and wedge-shaped.

Stage2) Wedge shaped C3 and nearly rectangular shaped C4 with absence of supero-anterior angles.

Stage3) Rectangular shaped bodies.

Stage4) Nearly squared bodies.

Stage5) Squared bodies.

Stage6) Rectangular shaped bodies with height greater than width.

Each stage was correlated with chronological age. Maturation was considered complete or positive when C5 (maturation) stage was achieved i.e. concavities seen in all vertebrae and the vertebrae C3 and C4 are square in shape.

Statistic Analysis

The collected data was analyzed by using SPSS version 20.0. Ratio (M: F) was computed to present gender distribution. Mean and standard deviation were computed to present age distribution. Frequency and percentages were used to present various stages of cervical vertebral maturation. Spearman's correlation coefficient was computed to determine correlation between chronological age and cervical vertebral maturation stages. Fisher exact Test was applied to compute p-value of significance at $p< 0.05$ level of significance, for finding the correlation between gender and CVM.

RESULTS

Of total103 patients, 62(60.2%) females and 41(39.8%) males as shown in Table 1, with a mean age of 13.17 years as shown in Table 2. CVM stage 4 followed by stage 1 and stage 2 were the most frequent cervical vertebrae stage as shown in Table 3. Spearman rank correlation coefficient was 0.835 between chronological age and cervical vertebrae maturation stages for the both genders combined as shown in Table 4. Statistically significant correlation was found between gender and CVM (p-value=0.02) via Fishers test as shown in Table 5. Figure 1 shows the relation between Age and CVM.

DISCUSSION

Our study result shows a high correlation between the chronological age' and CVM stages along with the gender and CVM stages. Of total 103 patients 62 female and 41 males, having age between 8-18 years. Correlation coefficient of spearman rank was 0.835, between CVM stages and chronological age for both genders. Statistically significant correlations (p-value=0.02) were found between gender and CVM stages via Fisher exact test, which showed that deceleration stage 25(40.3%) was more frequent for females followed by initiation stage 14(22.6%) as compared to males, in which acceleration stage 11(26.8%)was more frequent followed by initiation stage 9(22.0 %).

In growing individuals the alteration in size and shape of the cervical vertebrae is an important indicator of skeletal maturity. Skeletal maturity is

Table 1: Frequency and percentage of the gender

Gender	Frequency	Percent
Male	41	39.8
Female	62	60.2
Total	103	100.0

Table 2: Mean and standard deviation of the age range

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	103	8	18	13.17	2.726

Table 3: Frequency and percentage of the cervical vertebrae maturation stages

CVM Stages	Frequency	Percentage
Initiation (Stage 1)	23	22.3
Acceleration (Stage 2)	17	16.5
Transition (Stage 3)	11	10.7
Deceleration (Stage 4)	32	31.1
Maturation (Stage 5)	13	12.6
Completion (Stage 6)	7	6.8
Total	103	100.0

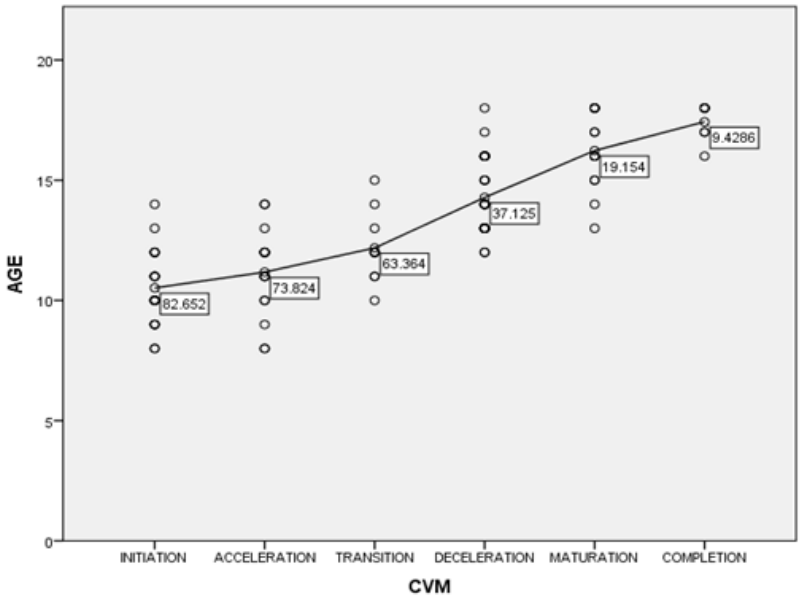

Fig 1: Relationship between age and cervical vertebrae maturation

Table 4: Spearman rank correlation between age and cervical vertebrae maturation

Correlation	CVM
Correlation Coefficient	.835**
P value	.001
N	103

Table 5: Correlation between gender and cervical vertebrae maturation

		CVM						
		INITIATION	ACCELERATION	TRANSITION	DECELERATION	MATURATION	COMPLETION	P VALUE
GENDER	MALE	9(22.0%)	11(26.8%)	5(12.2%)	7(17.1%)	8(19.5%)	1(2.4%)	P(0.02)*
	FEMALE	14(22.6%)	6(9.7%)	6(9.7%)	25(40.3%)	5(8.1%)	6(9.7%)	

*Fisher exact Test

Table 6: Stratification of gender and CVM with age strata

GENDER			Age strata					Total
Male	CVM	INITIATION	1	6	2	0	0	9
		ACCELERATION	3	5	2	1	0	11
		TRANSITION	0	1	3	1	0	5
		DECELERATION	0	0	2	3	2	7
		MATURATION	0	0	0	2	6	8
		COMPLETION	0	0	0	0	1	1
Total			4	12	9	7	9	41
Female	CVM	INITIATION	5	5	3	1	0	14
		ACCELERATION	0	1	4	1	0	6
		TRANSITION	0	2	3	1	0	6
		DECELERATION	0	0	11	7	7	25
		MATURATION	0	0	1	1	3	5
		COMPLETION	0	0	0	0	6	6
Total			5	8	22	11	16	62
Total	CVM	INITIATION	6	11	5	1	0	23
		ACCELERATION	3	6	6	2	0	17
		TRANSITION	0	3	6	2	0	11
		DECELERATION	0	0	13	10	9	32
		MATURATION	0	0	1	3	9	13
		COMPLETION	0	0	0	0	7	7
Total			9	20	31	18	25	103

closely related to bodily and sexual maturity.[7] Individual's maturation level is important to be identified in making a decision on to the type and time of the treatment to be given by the dentist/clinician.[3]

In Orthodontics the information of the residual growth has got an ample clinical significance. The cervical vertebrae maturation method can be used to assess the exact time to start jaw deficiencies treatment. Lamparski first formulated The cervical vertebral method which was later modified by Hassel and Farman. The method proposed by Hassel and Farman is convenient and much easier to use practically as it requires the evaluation of only three vertebrae i.e. C2, C3 and C4. Another benefit of this method is that it excludes the need of an additional radiograph. We can easily estimate the maturational stage of an individual with only lateral cephalometric radiograph.[3,17] There are six stages of CVM arranged in descending pattern and the residual growth is different at each stage. In INITIATION stage residual growth is 80-100%, in ACCELERATION 65-85%, in TRANSITION 25-65%, in DECELERATION 10-25%, in MATURATION 5-10% and almost no growth in COMPLETION stage18. In our study sample the most frequent CVM stage was stage 4 (Deceleration) 32 (31.1%), followed by stage 1 (Initiation) 23(22.3%) and then stage 2 (Acceleration) 17 (16.5%).

In order to find the coincidence of the CVM stages in different age groups we divided 103 patients (41 males and 62 females) into five age groups. In the age range of 13-16 years, CVM S4 was the most frequent for both genders. CVMS3 was found in 13-14 years of age showing peak of the growth, as shown in the Table 6. Similar study done by Majeed O et al[3] in which CVMS4 was the most frequent CVM stage and it lied in the age range of 12-14 years, while CVMS 3 occupied the age range of 10-12 years.

CVM Stage 2 followed by CVM Stage 1 was the most frequent cervical stage in males and the peak of the growth (i.e. CVM 2 and 3) occupied the age range of 11 -14 years as shown in Table 6 showing that mandibular deficiency existing at this stage can be effectively treated. CVM Stage 1 i.e. INITIATION stage was present in the age range of 10-12 years, showing that any maxillary deficiency

should be treated way before this age. In this regard our results were in accordance with the Uysal et al19 study. However, Majeed O et al[3] in their study showed that the peak of the growth in males, lied in the age range of 10 -12 years.

CVM Stage 4 was the most frequent CVM stage in females, lying in the age group of 12-14 years and the peak of the growth i.e. CVMS 3 mostly occupied the age range of 10-14 years as shown in the Table 6. In contrast to Uysal et al[19] and Majeed O et al[3] study in which the peak of the growth occupied the age range of 10-12 years.

There is a significant correlation coefficient between age and CVM as shown in table 4. The Spearman's correlations coefficient between age and CVM is 0.835 for both genders combined. Uysal et al19 and Majeed O et al[3] found that to be 0.72 and 0.90 for both genders respectively. Sukhia and Fida et al[20] found that to be 0.78 for both genders.

Statistically significant correlations (p-value=0.02) were found between gender and CVM stages via Fisher exact test, as shown in table 5. Deceleration stage 25(40.3%) was more frequent for females followed by initiation stage 14(22.6%) as compared to males, in which acceleration stage 11(26.8%)was more frequent followed by initiation stage 9(22.0 %).

A number of studies have been done on finding an associations between cervical vertebral maturation, chronological age and remaining growth in an individual. The reason for selecting such a study was to know about the relationship between gender and CVM, as very little published literature is available in this regard. The limitation of our study is that it had a very small sample size, so the issue of generalizability exist. However further studies are required in this respect.[1]

CONCLUSIONS

A significant correlation was found between chronological age and CVM stages along with gender and CVM stages. Pubertal growth spurt occupied the age group of 10-14 years.

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