Relationship between Cervical Vertebral Maturation and Chronological Age: A mixed longitudinal study

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Introduction

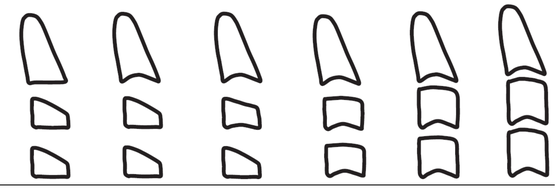
Predicting growth potential in orthodontic patients is a valuable tool for treatment planning and achieving successful outcomes. For decades, hand-wrist radiographs were used in orthodontics for determining a patient's skeletal development and growth potential. The cervical vertebral maturation (CVM) method, originally developed Lamparski,[1] which utilizes lateral cephalograms has been proposed as an alternative method to skeletal maturation determination. This study aimed to evaluate the relationship between chronological age and the individual skeletal maturity as assessed by means of the cervical vertebral maturation (CVM) method.

Material and Methods

Mixed longitudinal data were used. Sample was collected from the Burlington Growth Studies (data obtained between early 1950s and middle 1970s) available on the American Association of Orthodontists Foundation (AAOF) Craniofacial Growth Legacy Collection (www.aaoflegacycollection.org). Subjects with more than four cephalometric radiographs available between age 7 and 18 years and if cervical vertebrae 2, 3, and 4 were visible in all films were included in this study. The sample consisted of 100 subjects (51 males and 49 females) of Northern European white ancestry.

The CVM was evaluated using the method developed by Baccetti and coworkers. [2,3] This method depend on the anatomical changes of the three cervical vertebrae (C2, C3, and C4), which were evaluated visually concerning two sets of variables: (1) the presence or absence of a concavity at the inferior border of the C2 (odontoid process), C3, and C4; and (2) the differences in the shape of the body of cervical vertebrae with the progressive ages, where four shapes were considered, namely trapezoid, rectangular horizontal, square, and rectangular vertical. These variables were subdivided into six consecutive stages in cervical maturation (CS1 to CS6) (Table 1 and Figure 1).

Table 1: Schematic illustration of developmental stages of cervical vertebrae.

Schematic representation	CS 1	CS 2	CS 3	CS 4	CS 5	CS 6
						
Inferior borders of C2, C3, and C4*	F, F, F	C, F, F	C, C, F	C, C, C	C, C, C	C, C, C
C3 morphology*	T	T	T	RH	S/RH	RV/RH
C4 morphology*	T	T	T/RH	RH	S/RH	RV/RH
Clinical implication	Prepubertal stage	Prepubertal ("get-ready") stage	Circumpubertal stage	Circumpubertal stage	Postpubertal stage	Postpubertal stage

* F= Flat; C= Concavity; T= Trapezoid; RH=Rectangular Horizontal; S=Square; RV=Rectangular Vertical

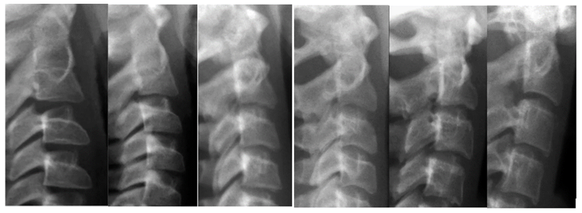


Figure 1: Examples of CVM Stages 1-6

After multiple calibration sessions, four judges (S.L, G.S, V.N, A.G) evaluated independently cervical vertebral maturation stages for total of 806 lateral cephalometric radiographs.

The average of the four judges' CVM scores were used as the individual CVM scores. Precise chronological age of the patients (years and months) was extracted from the AAOF legacy growth collection website.

Results

The inter-judge agreement on assessment of the CVM was reported as 0.9. The individual CVM stages from 7 to 18 years is summarized in Table 2 and Figure 2.

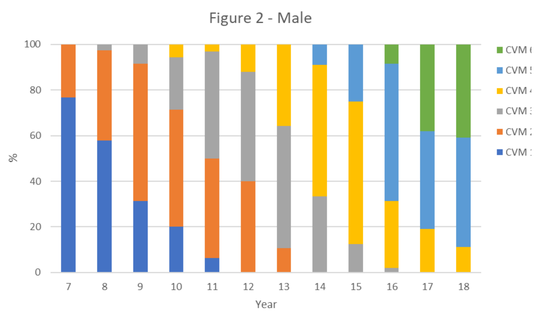
Table 2: Distribution of number of CVM stages in males and females

A. Males

Age	CVM1	CVM2	CVM3	CVM4	CVM5	CVM6	Total
7y	23	7					30
8y	22	15	1				38
9y	15	29	4				48
10y	7	18	8	2			35
11y	2	14	15	1			32
12y		20	24	6			50
13y		3	15	10			28
14y			15	26	4		45
15y			1	5	2		8
16y			1	14	29	4	48
17y				4	9	8	21
18y				3	13	11	27

B. Females

Age	CVM1	CVM2	CVM3	CVM4	CVM5	CVM6	Total
7y	20	13					33
8y	18	21	3				42
9y	8	25	12				45
10y	4	14	20	2			40
11y	2	5	13	9	2		31
12y		4	15	26	3		48
13y		1	5	14	11		31
14y			2	13	22	6	43
16y				3	24	19	46
17y					6	7	13
18y					11	13	24



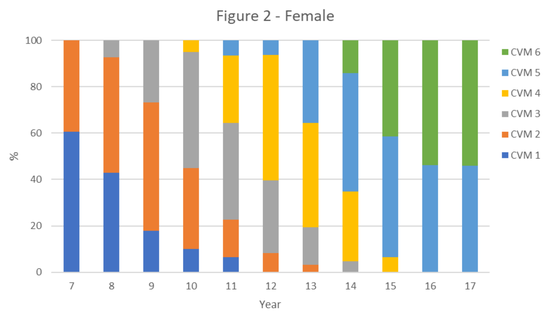


Figure 2: Distribution frequency of cervical vertebral maturation stages in each age group in males and females .

Table 3 shows the mean chronological ages for CVM stages in male and female. Mean chronological ages for CVM3 and CVM4 (peak pubertal growth) were about 12.1±1.6 year and 14.5±1.9 for males and 10.7±1.4 and 12.6±1.3 years for females. A positive correlation between mean CVM and chronological age from CS1 through CS6 (r=0.9).

Table 3: Mean chronological age of the samples according to the cervical maturational stage

CVM Stages	Male		Female	
	Mean	SD	Mean	SD
CVM1	8.02	1.27	7.79	1.28
CVM2	9.46	1.95	8.65	1.63
CVM3	12.09	1.58	10.73	1.44
CVM4	14.54	1.87	12.61	1.29
CVM5	16.52	1.10	15.17	1.88
CVM6	17.37	0.82	16.53	1.32

Conclusions

The result presented large variability and chronological age has a moderate correlation with skeletal age (CVM method) during circumpubertal phase. Maximum variation in maturation of cervical vertebrae occurs during the growth spurt period. The cervical vertebral measurements might be useful for evaluating the stages of skeletal maturation.

References

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Acknowlegements

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