

INTER-OBSERVERS LEVEL OF AGREEMENT IN CERVICAL VERTEBRAL MATURATION STAGING

¹AHSAN MAHMOOD SHAH

²FAIZAN UL HASSAN

³UMAR HUSSAIN

⁴FATIMA TU ZAHRA

ABSTRACT

The objective of this study was to determine the inter-observers level of agreement in interpreting cervical vertebral maturation (CVM) stages.

This cross-sectional study was carried out at the Department of Orthodontics, Khyber College of Dentistry. The patient's lateral cephalograms present in the Department were used. Sixty randomly selected cephalograms were digitized by using Nikon camera L-830. The images were cropped to visualize only cervical vertebrae. Subsequently, the images were loaded into PowerPoint to prepare a presentation for rating. A PowerPoint presentation consisted of a detailed description of the CVM method along with the instructions how to rate, separately all stages of skeletal maturity. Two raters assessed the CVM stages according to Baccetti et al. The kappa statistics was used to assess inter-assessor agreement in assigning CVM scores.

Out of 60 sample size twenty-eight (46.7%) were males and 32(53.3) were females. Frequencies of agreement between two raters for CVM1, CVM2, CVM3, CVM4, CVM5, and CVM6 were 100%, 100%, 50%, 100%, 46.1%, and 60% respectively. Frequencies of disagreement for CVM3 were 50%, CVM5 was 53.9% and CVM6 was 40%. The overall level agreement between two examiners was 49.1% with Kappa value of 0.491(moderate agreement) with statistical significance ($P=0.000$). The Spearman's rho correlation co-efficient was 0.886 for two observers.

Within the limit of this study, it is recommended that CVM should be augmented with other biologic maturity indicators while assessing growth status.

Key Words: Level of agreement, cervical vertebral maturation, growth assessment.

INTRODUCTION

Timing of orthodontic therapy may affect the final outcome. Randomized controlled clinical trials¹⁻³ had shown that if treatment of Class II is initiated early, i.e. before pubertal growth spurt, results are mainly in dento-alveolar changes with little alterations of the facial skeleton. This is undesirable as the underlying problem is not corrected and facial profile may not improve. Significantly evidence suggest that deferring treatment with functional appliances until a growth spurt might result in a more favorable skeletal response.^{4,5}

Uptill now, evaluations of secondary sex characteristics, height and weight, hand-wrist maturation, IGF-1 and dental development have been used as alternative to chronologic age.⁶⁻¹¹ Two popular methods which are used in orthodontics; are hand-wrist radiographs (HWR) and evaluation of cervical vertebrae (CVM). In the HWR method, skeletal maturation is based on the stages of ossification of the bones of hand and wrist, whereas changes of the cervical vertebrae morphology are used in the CVM evaluation.^{12,13} Both methods relate maturational stages and facial growth. As the CVM method does not require an additional radiograph for assessment, it has become the most commonly used method by orthodontic practitioners worldwide.

Several studies showed excellent reproducibility of the CVM method^{5,13-18} however, those early findings have been questioned and even refuted in more recent studies.¹⁹⁻²¹ The primary reason for criticism was reliability of the CVM method used in different. A number of studies have shown, however, that the reliability of the method can differ when under ideal conditions and when used in everyday practice.

¹ Ahsan Mahmood Shah, BDS, FCPS (Orthodontics), Assistant Professor Orthodontics, Khyber College of Dentistry, Peshawar University Campus. E-mail: ahsanmshah@gmail.com
Cell: 0333-9117622

²⁻⁴ Faizan ul Hassan, BDS, Umar Hussain, BDS, Fatima Tu Zahra, BDS, Orthodontics Residents, Khyber College of Dentistry

Received for Publication: March 19, 2016
Revised: May 5, 2016
Approved: May 5, 2016

Recently Predko-Engel AM et al²² concluded that the reliability of the CVM method is questionable and if orthodontic treatment should be initiated relative to the maximum growth, the use of additional biologic indicators should be considered. A recent study by Beit et al²³ concluded that assessment of age-dependent changes in the cervical spine offers no advantage over chronologic age, in either assessing skeletal age or predicting the pubertal growth spurt. The objective of this study was to determine inter-observers agreement in interpreting CVM stage for its reliability as no local study was found in literature on this particular subject.

METHODOLOGY

This cross-sectional study was carried at Department of Orthodontics, Khyber College of Dentistry, Peshawar from the January 2016 to February 2016. The patient records at the Department were analyzed to identify healthy subjects who met the following inclusion criteria:

- Pakistani nationals
- Age from 8 to 20 years
- Lateral cephalogram with a good representation of 2nd, 3rd, and 4th cervical vertebrae (C2, C3, C4)
- Absence of visible pathology of cervical vertebrae
- No history of trauma or surgery in the neck region.

Sample size was calculated (based on the previous study²²) using National Council for Social Studies, Powerful and Authentic Social Studies (NCSS PASS 2011; www.ncss.com) for Spearman correlation. A sample size of 11 would achieve a 90% power below the alternative hypothesis correlation of 0.704²² using a two-sided hypothesis test with a significance level of 0.05. However, for normality purpose the sample size of 60 was taken.

Lateral cephalometric radiograph of each individual was taken with a universal counter balancing type of cephalostat at Radiology Department of Khyber College of Dentistry, Peshawar. Kodak' X-ray films (8×10) were exposed to 70 KVP, 45 mA for an average of 1.8 sec, with a tube to film distance of 6 feet.

Sixty randomly selected cephalograms were digitized using Nikon camera L-830. The images were cropped to visualize only cervical vertebrae; thus, the dentition was not visible on any of the images. Subsequently, the images were loaded into PowerPoint to prepare a presentation for rating. A PowerPoint presentation consisted of a detailed description of the CVM method along with the instructions how to rate, examples of all stages of skeletal maturity. Slides of CVM stages were projected through computer power point. Two raters assessed the CVM stages according to Baccetti et al.²⁴

STATISTICAL ANALYSIS

The data were analyzed using SPSS version 20.0. Mean and standard deviation were calculated for nu-

merical variables and cross-tabulation was done for CVM stages. The Spearman's correlation coefficients were calculated to evaluate the correlation between the first and second assessor. The kappa statistics were used to assess inter-assessor agreement in assigning CVM scores.

The interpretation of the kappa values was done according to Altman²⁵ who defined agreement as poor for kappa ≤ 0.20 ; fair for kappa from 0.21 to 0.40; moderate for kappa from 0.41 to 0.60; good for kappa from 0.61 to 0.80; and very good for kappa from 0.81 to 1.00.

RESULTS

A total of 60 patient's cephalograms were used in this study. Twenty-eight (46.7%) were males and 32 (53.3) were females. Age range in this study was from 8 to 25 years with a mean age of 16.15±4.78 years. The age distribution are shown in Table 1.

The frequency and percentages of concordance between two raters for individual CVM staging have been shown in Table 2. Level of agreement between two examiners for CVM1, CVM2, CVM3, CVM4, CVM5, and CVM6 were 4(100%), 4(100%), 4(50%), 13(100%), 12(46.1%), and 3(60%) respectively. Level of disagreement for CVM3 were 50%, CVM5 was 53.9% and CVM6 was 40%. The overall level of agreement between two examiners was 49.1% with Kappa value of 0.491 (moderate agreement) with statistical significance ($P=0.000$). (Table 3). The Spearman's rho correlation co-efficient was 0.886 for two observers. (Table 4)

TABLE 1: AGE DISTRIBUTION OF PATIENTS

Age (years)	Frequency	Percent
8.00	5	8.3
9.00	3	5.0
10.00	3	5.0
11.00	1	1.7
13.00	8	13.3
14.00	2	3.3
15.00	2	3.3
16.00	7	11.7
17.00	4	6.7
18.00	3	5.0
19.00	4	6.7
20.00	5	8.3
21.00	6	10.0
22.00	4	6.7
25.00	3	5.0
Total	60	100.0

TABLE 2: FREQUENCIES OF CONCORDANCE BETWEEN TWO RATERS FOR CVM STAGING

Rater A	Rater B						Total (n=60)
	CVM1	CVM2	CVM3	CVM4	CVM5	CVM6	
CVM1	4(100%)	4(100%)	0	0	0	0	8(13.3%)
CVM2	0	0	4(50%)	0	0	0	4(6.6%)
CVM3	0	0	4(50%)	0	0	0	4(6.6%)
CVM4	0	0	0	13(100%)	9(34.6%)	0	22(36.6%)
CVM5	0	0	0	0	12(46.1%)	2(40%)	14(23.3%)
CVM6	0	0	0	0	5(19.2%)	3(60%)	8(13.3%)
Total	4(100%)	4(100%)	8(100%)	13(100%)	26(100%)	5(100%)	60(100%)

TABLE 3: INTER-RATER RELIABILITY

	Kappa value	Sig.
Measure of Agreement	.491	.000

TABLE 4: CORRELATIONS BETWEEN TWO RATERS FOR CVM STAGING

		Rater A	Rater B
Spearman's rho	Correlation Coefficient	1.000	.886**
	Rater A Sig. (2-tailed)	.	.000
	N	60	60
	Correlation coefficient	.886**	1.000
	Rater B Sig. (2-tailed)	.000	.
	N	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

The objective of this study was to evaluate reliability of the CVM method. Reliability is a measure of the reproducibility, i.e. the extent to which a method gives consistent results. Thus, if the method is reliable, results obtained by the same observer on various occasions or by different observers should be similar.²⁶ As CVM are commonly used to assess skeletal maturity in orthodontic patients. These assessments are important to determine the proper time for growth modification and orthognathic treatment. Therefore, the reliability of this method should be consistent for proper treatment planning/stability in orthodontics patients. Literature ranked CVM with variable reliability.

In this study, the inter-observers reliability was moderate with kappa value of 0.491. Rainey BJ et al²⁸ determine the reliability and reproducibility of Cervical Vertebrae Maturation (CVM) stages assessment amongst orthodontists in training and specialist orthodontists, looking at a sample of consecutive lateral cephalograms taken at Liverpool University Dental

Hospital. The intra- and inter-observer agreements were evaluated, for both image samples, using the weighted kappa statistic. Their results showed the intra-observer and inter-observer agreements were substantial, (weighted kappa 0.6-0.8). The overall intra-observer agreement was 0.70 (SE 0.01) with average agreement 89%. The inter-observer agreement on the first setting was 0.68 (SE 0.03) and 0.66 (SE 0.03) on the second time, with an average inter-observer agreement of 88%. Their results are different from the present study. The difference might be due to sample size and operator experience. In our study, no intra-observers agreement was determined.

Sohrabi A et al²⁸ observed two time 70 lateral cephalograms of Iranian patients, aged 9-15 years, by five experienced orthodontists. In addition to determining the developmental stage, each single parameter involved in this method was assessed in terms of inter- and intra-observer reproducibility. In order to evaluate the reproducibility of clinical decisions based on this method, cervical vertebrae maturation staging (CVMS) I and II were considered as phase 1 and CVMS IV and V were considered as phase . They reported that by considering the clinical approach of the CVMS method, inter-observer reproducibility of this method increased from 0.48 to 0.61 (moderate to substantial) and intra-observer reproducibility enhanced from 0.72 to 0.74. They concluded that difficulty in determining the morphology of C3 and C4 leads to poor reproducibility of the CVMS method. Despite this, it has acceptable reproducibility in determining the timing of functional treatment for Class II patients. In the current study, each class of malocclusion was included. Sohrabi A et al²⁸ results are consistent to the our study.

Predko-Engel A et al²² assessed the reliability of the cervical vertebrae maturation method. In their website based study, 10 orthodontists with a long clinical practice (3 routinely using the method - "Routine user - RU" and 7 with less experience in the CVM method - "Non-Routine user - nonRU") rated twice cervical vertebrae maturation with the CVM method on 50 cropped scans of lateral cephalograms of children in circumpubertal age. Kappa statistics (with lower limits of 95% confidence intervals (CI)) and proportion of complete agreement on staging was used to evaluate

intra- and inter-assessor agreement. They reported that the mean weighted kappa for intra-assessor agreement was 0.44 (range: 0.30-0.64; range of lower limits of 95% CI: 0.12-0.48) and for inter-assessor agreement was 0.28 (range: -0.01-0.58; range of lower limits of 95% CI: -0.14-0.42). They concluded that the reliability of the CVM method is questionable and if orthodontic treatment should be initiated relative to the maximum growth, the use of additional biologic indicators should be considered. These results are also close and support this study.

CONCLUSION

Within the limitation of this study, it is concluded that CVM should be augmented with other biologic maturity indicators while using it for growth status determination.

REFERENCES

- Tulloch JF, Phillips C, Koch G, Proffit WR. The effect of early intervention on skeletal pattern in Class II malocclusion: a randomized clinical trial. *Am J Orthod Dentofacial Orthop* 1997; 111: 62-74.
- O'Brien K. Is early treatment for Class II malocclusion effective? Results from a randomized controlled trial. *Am J Orthod Dentofacial Orthop* 2006; 129 (Suppl 4): 64-65.
- O'Brien K, Wright J, Conboy F, Sanjie Y, Mandall N, Chadwick S, et al. Effectiveness of treatment for Class II malocclusion with the Herbst or twin-block appliances: a randomized, controlled trial. *Am J Orthod Dentofacial Orthop* 2003; 124: 128-37.
- Pancherz H, Hägg U. Dentofacial orthopedics in relation to somatic maturation. An analysis of 70 consecutive cases treated with the Herbst appliance. *Am J Orthod Dentofacial Orthop* 1985; 88: 273-87.
- Baccetti T, Franchi L, Kim LH. Effect of timing on the outcomes of 1-phase nonextraction therapy of Class II malocclusion. *Am J Orthod Dentofacial Orthop* 2009; 136: 501-9.
- Greulich W, Pyle S. Radiologic atlas of skeletal development of the hand and wrist. Stanford, Calif: Stanford University Press; 1959.
- Hunter CJ. The correlation of facial growth with body height and skeletal maturation at adolescence. *Angle Orthod* 1966; 36: 44-54.
- Haavikko K. The formation and the alveolar and clinical eruption of the permanent teeth. An orthopantomographic study. *Suom Hammaslaak Toim* 1970; 66: 103-70.
- Marshall W. Interrelationships of skeletal maturation, sexual development and somatic growth in man. *Ann Hum Biol* 1974; 1: 29-40.
- Tanner JM, Whitehouse RH, Cameron N, Marshall WA, Healey MJR, Goldstein H. Assessment of skeletal maturity and prediction of adult height (TW2 method). London, United Kingdom: Academic Press; 1975.
- Demirjian A, Goldstein H. New systems for dental maturity based on seven and four teeth. *Ann Hum Biol* 1976; 3: 411-21.
- Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. *Angle Orthodont* 1982; 52: 88-112.
- Baccetti T, Franchi L, McNamara JA. The Cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. *Seminars in Orthodontics* 2005; 11: 119-29.
- Franchi L, Baccetti T, McNamara JA. Mandibular growth as related to cervical vertebral maturation and body height. *Am J Orthod Dentofacial Orthop* 2000; 118: 335-40.
- Franchi L, Baccetti T, McNamara JA. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. *Semin Orthod* 2005; 12: 119-29.
- Uysal T, Ramoglu SI, Basciftci, FA, Sari Z. Chronologic age and skeletal maturation of the cervical vertebrae and hand-wrist: is there a relationship? *Am J Orthod Dentofacial Orthop* 2006; 130: 622-28.
- Lai EH, Liu JP, Chang JZ, Tsai SJ, Yao CC, Chen MH, et al. Radiographic assessment of skeletal maturation stages for orthodontic patients: hand-wrist bones or cervical vertebrae? *J Formosa Med Assoc* 2008; 107: 316-25.
- Soegiharto BM, Cunningham SJ, Moles DR. Skeletal maturation in Indonesian and white children assessed with hand-wrist and cervical vertebrae methods. *Am J Orthod Dentofacial Orthop* 2008; 134: 217-26.
- Gabriel DB, Southard KA, Qian F, Marshall SD, Franciscus RD, Southard TE. Cervical vertebrae maturation method: poor reproducibility. *Am J Orthod Dentofacial Orthop* 2009; 136: 478-40.
- Nestman TS, Marshall SD, Qian F, Holton N, Franciscus RG, Southard TE. Cervical vertebrae maturation method morphologic criteria: poor reproducibility. *Am J Orthod Dentofacial Orthop* 2011; 140: 182-88.
- Zhao XG, Lin J, Jiang JH, Wang Q, Ng SH. Validity and reliability of a method for assessment of cervical vertebral maturation. *Angle Orthod* 2012; 82: 229-34.
- Predko-Engel A, Kaminek MK, Kowalski LP, Fudalej PS. Reliability of the cervical vertebrae maturation (CVM) method." *Bratislavské lekárske listy* 2014; 116(4): 222-26.
- Beit P, Peltomäki T, Schätzle M, Signorelli L, Patcas R. Evaluating the agreement of skeletal age assessment based on hand-wrist and cervical vertebrae radiography. *Am J Orthod Dentofacial Orthop* 2013; 144: 838-47.
- Baccetti T, Franchi L, McNamara JA. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. *Angle Orthod* 2002; 72(4): 316-23.
- Altman DG. In: *Practical Statistics for Medical Research*. London: Chapman and Hall, 1991: 404-8.
- Dawson B, Trapp RG. *Basic and clinical biostatistics*. Lange Medical Books/McGraw-Hill. Medical Publishing Division. New York; 2004.
- Rainey B-J, Moore A. The University of Liverpool. Reliability of cervical vertebrae maturation staging method; 2014 Oct 9 <http://repository.liv.ac.uk/18455/>.
- Sohrabi A, Ahari SB, Moslemzadeh H, Rafighi A, Aghazadeh, Z. The reliability of clinical decisions based on the cervical vertebrae maturation staging method. *Eur J Orthod* 2016; 38(1): 8-12.

CONTRIBUTIONS BY AUTHORS

- | | |
|------------------------------|-------------------------------------|
| 1 Ahsan Mahmood Shah: | Paper writing |
| 2 Faizan ul Hassan: | Topic selection, proof reading |
| 3 Umar Hussain: | Data analysis, Rater of CVM staging |
| 4 Fatima Tu Zahra: | Rater of CVM staging |