Original Article

Comparison of Cervical Vertebral Maturation with Fishman's Skeletal Maturity Index Method in Assessment of Growth Status

Faizan ul Hassan[1], Ali Ayub[2], Nadeem Hussain[3], Sarfaraz Hussain[4], Madiha Khalid Memon[5], Ausaf Ali Rizvi[6], Saba Ayman Bokhari[7], Ahsan Mehmood Shah[8] and Salman Shams[9*]

[1] Department of Orthodontics, Rehman Dental College, Peshawar, Pakistan
[2] Department of Orthodontics, HBS Medical and Dental College, Islamabad, Pakistan
[3] Department of Health, Government of Sindh, Pakistan
[4] Department of Orthodontics, Dow University of Health Sciences, Karachi, Pakistan
[5] Department of Oral Biology, Muhammad Dental College, Mirpurkhas, Pakistan
[6] Smile Engineers Clinic Islamabad, Islamabad, Pakistan
[7] General Dental Practitioner, United Kingdom
[8] Department of Orthodontics, Khyber College of Dentistry, Peshawar, Pakistan
[9] Department of Oral Medicine, Liaquat University of Medical and Health Sciences, Jamshoro, Pakistan

ARTICLE INFO

ABSTRACT

Assessment of skeletal maturity is paramount for orthodontists since optimal use and effectiveness of orthodontic and orthopedic appliances depends on it. **Objective:** To compare the cervical vertebral maturation (CVM) with Fishman's hand wrist radiograph (HWR) method in assessment of growth status. **Methods:** This comparative cross sectional study was conducted at the Orthodontics department at the Khyber College of dentistry, Peshawar on 100 participants. The patients with 9 to 15 years of age, relatively well aligned arches, both genders, mild to moderate skeletal discrepancy, minimal dental compensations, vertical normal angle, and without temporomandibular joint disorders were included. Along with age and gender, stages of HWR and CVM were recorded. HWRs were acquired by standardized method and lateral cephalograms were taken in natural head position. The staging of HWR was done by using Fishman method while CVM staging. Comparison of CVM stages and Fishmann's HWR stages were done using chi-square test. **Results:** The mean age was 11.79 ± 1.62 years. The females were 53(53%) and males were 47(47%). Most common stage of CVM was III (n=33, 33%) followed by IV (n=27, 27%). Similarly, common stage of hand wrist radiograph was III (n=32, 32%) followed by IV (n=28, 28%).There was no statistically significant different between two methods for assessing skeletal growth status (p=0.697). **Conclusions:** Cervical vertebral maturation can have used as an alternative to hand wrist radiograph for growth assessment without an extra radiation.

INTRODUCTION

The objective of orthodontic treatment is to improve esthetic, phonetic and masticatory function of patients. The main outcome of orthodontic care is achievement of ideal dentofacial appearance.[1] Due to awareness among the people of modern era because of easy access to social and other media there is increased presentation for orthodontic treatment at younger ages [2]. Orthopedic and functional appliances are usually used for correcting skeletal malrelations in growing patients [3]. Skeletal class II malocclusion is more amenable to growth modification therapy than class III. Treatment at growing age is to modify skeletal growth to favorable direction [4]. Growth is

Hassan FU *et al.,*

continuous process spanning over many years [5]. For successful growth modification treatment the short possible time is of utmost importance to improve patients compliance, reduce financial burden, and minimize iatrogenic effect of orthodontic treatment [6]. Growth spurt is the period during maximum growth occurs in individuals. If the functional appliances are given to the patients during growth spurt with skeletal discrepancies optimal corrections can be expected [7]. Many indicators are available for assessing skeletal maturity for growing patients. Some of the biological indicators for growth determination are chronological age, dental age, tooth eruption, cervical vertebral maturation(CVM), hand wrist radiographs and peak height velocity [–8]. The gold standard for recording growth status of an individual is peak height velocity but it involves longitudinal assessment of the subjects which not feasible from clinical stand point of view [9]. The reliability of hand wrist radiograph is next to peak height velocity but it is associated with extra radiation to the patients [10]. The CVM is very commonly used method for growth status assessment but there is a lot of controversies about its efficacy [11, 12]. Some studies showed it is very effective and other show it is least affective [13]. The variation in results can be due to level of experience in assessing CVM staging, ethnic and genetic factors. There is lack of local literature on this topic. This study helped the clinicians in assessing the growth status with reliable method. This study was conducted to compare CVM against Fishman's hand wrist radiographic method in assessing skeletal growth status.

METHOD

This comparative cross sectional study was conducted on 100 cases conducted at the department of Orthodontics at the Khyber College of Dentistry, Peshawar, which is a tertiary care center. A verbal informed consent was obtained from all participants after complete explanation of the study. Hospital ethical approval was obtained. The inclusion criteria were patients 9 to 15 years of age, relatively well aligned arches, both genders, mild to moderate skeletal discrepancy, minimal dental compensations, vertical normal angle, and no temporomandibular joint disorders. The cases with long face syndrome, severe skeletal dysplasia and non-Pakistani nationals were excluded. Along with age and gender, stages of hand wrist radiograph (HWR) and CVM were recorded. HWRs were acquired by standardized method and lateral cephalograms were taken in natural head position. The staging of HWR was done by using Fishman method while CVM staging by Bacetti *et al.,* [14].
The results of hand wrist radiograph evaluation were as

follows:
- Growth Stage I = CVM stage I = Fishman's skeletal maturity indicator(SMI)1–3
- Growth Stage II = CVM stage II = Fishman's SMI 4–5
- Growth Stage III = CVM stage III = Fishman's SMI 6–8
- Growth Stage IV = CVM stage IV = Fishman's SMI 9–10
- Growth Stage V = CVM stage V = Fishman's SMI 11

The CVM staging were done from cervical stage 1 (CS1) to CS6 based on presence of concavity on inferior surface of cervical vertebra 2 to 4 and shape of these vertebrae according to Bacetti *et al.,* [14]. Statistical analysis was done in R version 4.1.2. Continuous data like age were computed as mean and SD while qualitative variables like gender, CVM stages and HWR stages as frequencies and percentages. Comparison of CVM stages and HWR stages were done using chi-square test. P ≤0.05 was significant level.

RESULTS

The mean age was 11.79 ± 1.62 years with range from 9 to 15 years. The females were 53(53%) and males were 47(47%). Most common stage of CVM was III (n= 33, 33%) followed by IV (n = 27, 27%). Similarly, common stage of hand wrist radiograph was III (n=32, 32%) followed by IV (n=28, 28%) (Table 1).

Variable	Characteristic	n(%)
Gender	Female	53 (53)
	Male	47 (47)
CVM stage	I	11 (11)
	II	22 (22)
	III	33 (33)
	IV	27 (27)
	V	7 (7.0)
HWR stage	I	11 (11)
	II	22 (22)
	III	32 (32)
	IV	28 (28)
	V	7 (7.0)

Table 1: Frequency of gender, CVM and hand wrist stages
*CVM, cervical vertebral maturation; HWR, Hand wrist radiograph

The relation between age and CVM were similar in both males and females as shown (Table 2).

Gender	CVM	Mean ± SD
Male	I	9.29 ± 0.49
	II	10.7 ± 1.06
	III	12.19 ± 1.11
	IV	13.09 ± 0.83
	V	13.67 ± 1.15
	I	9.5 ± 0.58

Gender		Mean ± SD
Female	II	10 ± 0.74
	III	12.18 ± 1.19
	IV	12.94 ± 0.85
	V	13.75 ± 0.96

Table 2: Mean age in various stages of CVM in both genders

Similarly, the relation between age and hand wrist radiograph were similar in both males and females (Table 3).

Gender	HWR	Mean ± SD
Male	I	9.29 ± 0.49
	II	10.64 ± 1.03
	III	12.36 ± 1.01
	IV	13 ± 0.85
	V	13.67 ± 1.15
Female	I	9.5 ± 0.58
	II	10 ± 0.77
	III	12.28 ± 1.23
	IV	12.88 ± 1.2
	V	13 ± 0.82

Table 3: Mean age in various stages of HWR in both genders

Comparison of cervical vertebral maturation and hand wrist radiograph show that there was no statistically significant different between two methods for assessing skeletal growth status (p=0.697). All stage 1 of CVM was correlating with stage 1 of HWR. There was 95.45% correlation between stage II of both methods. Rest of results is shown (Table 4).

HWR growth stages	CVM stages n(%)					p-value
	I	II	III	IV	V	
I	11(100.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	
II	0(0.00)	21(95.45)	1(3.03)	0(0.00)	0(0.00)	
III	0(0.00)	1(4.55)	30(90.91)	1(3.70)	0(0.00)	0.697
IV	0(0.00)	0(0.00)	2(6.06)	25(92.59)	1(14.29)	
V	0(0.00)	0(0.00)	0(0.00)	1(3.70)	6(85.71)	

Table 4: Comparison of cervical vertebral maturation and hand wrist radiograph
*Fisher exact test

DISCUSSION

This study was conducted to compare two methods for assessing skeletal maturation. Our results showed that there is no significant difference between hand wrist method of Fishman and CVM of Bacetti *et al.,*[14]. Our findings showed that the mean age was 11.79 ± 1.62 years with range from 9 to 15 years. We include only growing participants which commonly belong to this age range. Due to secular trend and modern life style now individuals grow early and achieve maturity a bit earlier than before [15]. Our finding showed that all stage 1 of CVM was correlating with stage 1 of HWR. There was 95.45% correlation between stage II of both methods. Our results revealed that CVM can be used as an alternative to Fishman HWR method. The most common drawback of HWR was extra radiation

exposure for the orthodontic cases[16]. Most of the orthodontic cases were in growing age and many factors are associated with this age which predisposes these patients more to the malignant changes than adult population. Some of the factors are: during growth cell multiplication was more so, more chances of malignancy, second these cases have more life expectancy and third their body structure was small as compared adults so more concentration of radiation [17]. We used Chi-square test to see association between the two methods. As both HWR method and CVM method were categorical variables and from statistical standpoint correlation between categorical variable was impossible by Pearson correlation test which is gold stand test for linear relationship. The correlation between such variables was computed Spearman correlation test which assign rank to data and transform the original. Liu *et al.,* study results were just like contingency table of chi-square test [18]. A study was conducted on Chinese population by Alkhal *et al.,* on 400 subjects in which female were in age range of 10-15 years and males were in age range of 12-17 year [19]. All the subjects were in circumpubertal growth spurt (stage 3 and 4 of CVM). Their results showed a very high correlation between CVM and HWR by Fishman method (for males r = 0.93, for female r = 0.94). These results are similar to our study. Gandini *et al.,* study was conducted on comparison of CVM and HWR on 30 cases in age range of 7 to 18 years. They used Cohen Kappa test for relation between CVM and HWR and reported concordance of 83.3% between two methods[20].

CONCLUSIONS

Within limitations of this study it can concluded that cervical vertebral maturation can be reliable alternative to hand wrist radiograph for skeletal maturation assessment.

Conflicts of Interest

The authors declare no conflict of interest

Source of Funding

REFERENCES

[1] Nugroho MJ, Ismah N, Purbiati M. Orthodontic treatment need assessed by malocclusion severity using the Dental Health Component of IOTN. Journal of International Dental and Medical Research. 2019 Sep; 12(3): 1042-6.

[2] Batista KB, Thiruvenkatachari B, Harrison JE, O'Brien KD. Orthodontic treatment for prominent upper front teeth (Class II malocclusion) in children and adolescents. Cochrane Database of Systematic

Reviews. 2018 Mar; 2018(3): 1–90. doi: 10.1002/146 51858.cd003452.pub4

[3] Morris KM, Fields Jr HW, Beck FM, Kim DG. Diagnostic testing of cervical vertebral maturation staging: an independent assessment. American Journal of Orthodontics and Dentofacial Orthopedics. 2019 Nov; 156(5): 626-32. doi: 10.1016/j.ajodo.2018.11.016

[4] Bozorgnia Y, Moradi M, Molkizade N. The Prevalence of Malocclusion Requiring Early Orthodontic Treatment in 7-11 Years Old Children in Bojnurd, 2018. Journal of North Khorasan University of Medical Sciences. 2021 Feb; 12(4): 66-71.

[5] Zymperdikas VF, Koretsi V, Papageorgiou SN, Papadopoulos MA. Treatment effects of fixed functional appliances in patients with Class II malocclusion: a systematic review and meta-analysis. European Journal of Orthodontics. 2016 Apr; 38(2): 113-26. doi: 10.1093/ejo/cjv034

[6] El-Huni A, Salazar FB, Sharma PK, Fleming PS. Understanding factors influencing compliance with removable functional appliances: a qualitative study. American Journal of Orthodontics and Dentofacial Orthopedics. 2019 Feb; 155(2): 173-81. doi: 10.1016/j.ajodo.2018.06.011

[7] Perinetti G, Contardo L, Castaldo A, McNamara Jr JA, Franchi L. Diagnostic reliability of the cervical vertebral maturation method and standing height in the identification of the mandibular growth spurt. The Angle Orthodontist. 2016 Jul; 86(4): 599-609. doi: 10.2319/072415-499.1

[8] Günen Yılmaz S, Harorlı A, Kılıç M, Bayrakdar İŞ. Evaluation of the relationship between the Demirjian and Nolla methods and the pubertal growth spurt stage predicted by skeletal maturation indicators in Turkish children aged 10–15: investigation study. Acta Odontologica Scandinavica. 2019 Feb; 77(2): 107-13. doi: 10.1080/00016357.2018.1510137

[9] Hägg U and Taranger J. Maturation indicators and the pubertal growth spurt. American Journal of Orthodontics. 1982 Oct; 82(4): 299-309. doi: 10.1016/ 0002-9416(82)90464-X

[10] Mahajan S. Evaluation of skeletal maturation by comparing the hand wrist radiograph and cervical vertebrae as seen in lateral cephalogram. Indian Journal of Dental Research. 2011 Mar; 22(2): 309. doi: 10.4103/0970-9290.84310

[11] McNamara Jr JA and Franchi L. The cervical vertebral maturation method: A user's guide. The Angle Orthodontist. 2018 Mar; 88(2): 133-43. doi: 10.2319/ 111517-787.1

[12] Santiago RC, de Miranda Costa LF, Vitral RW, Fraga MR, Bolognese AM, Maia LC. Cervical vertebral maturation as a biologic indicator of skeletal maturity: a systematic review. The Angle Orthodontist. 2012 Nov; 82(6): 1123-31. doi: 10.2319/103111-673.1

[13] Başaran G, Özer T, Hamamcı N. Cervical vertebral and dental maturity in Turkish subjects. American Journal of Orthodontics and Dentofacial Orthopedics. 2007 Apr; 131(4): 447-e13. doi: 10.1016/j.ajodo.2006.08.016

[14] Baccetti T, Franchi L, McNamara JA Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthodontic. 2002 Aug; 72(4): 316-23. doi: 10.1043/0003-3219(2002)072<0316:AIVOTC> 2.0.CO;2.

[15] Profit WR, Fields HW, Larson BE, Sarver DM. Contemporary orthodontics 6th ed. St Louis: Mosby Elsevier. 2018.

[16] Kamal M and Goyal S. Comparative evaluation of hand wrist radiographs with cervical vertebrae for skeletal maturation in 10-12 years old children. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2006 Jul; 24(3): 127-35. doi: 10.4103/0970-4388.27901

[17] Chalasani S, Kumar J, Prasad M, Shetty BS, Kumar TA. An evaluation of skeletal maturation by hand-wrist bone analysis and cervical vertebral analysis: A comparitive study. Journal of Indian Orthodontic Society. 2013 Oct; 47(4_suppl4): 433-7. doi: 10.5005/jp-journals-10021-1201

[18] Liu Q, Li C, Wanga V, Shepherd BE. Covariate-adjusted Spearman's rank correlation with probability-scale residuals. Biometrics. 2018 Jun; 74(2): 595-605. doi: 10.1111/biom.12812

[19] Alkhal HA, Wong RW, Rabie AB. Correlation between chronological age, cervical vertebral maturation and Fishman's skeletal maturity indicators in southern Chinese. The Angle Orthodontist. 2008 Jul; 78(4): 591-6. doi: 10.2319/0003-3219(2008)078[0591:CB CACV]2.0.CO;2

[20] Gandini P, Mancini M, Andreani F. A comparison of hand-wrist bone and cervical vertebral analyses in measuring skeletal maturation. The Angle Orthodontist. 2006 Nov; 76(6): 984-9. doi: 10.2319/070605-217

121