

# A comparison between analysis of handwrist bone and cervical vertebrae radiographs in measuring skeletal maturation

## Abstract

**Aim:** The goal of this research was examination of agreement between analysis of Hand wrist bones and cervical vertebrae to determine the skeletal age and patient's growth value in 8-18 years of Iranian children referred to the department of orthodontics, faculty of Dentistry, Tehran University of Medical Sciences.

**Materials and Methods:** A group of 123 subjects, in accordance with specific treatment design for these patients, performed right hand wrist and lateral cephalograms. Bones evolutionary stages of hand wrist examined based on Grave & Browns and Bjork methods in 9 phase and in 7 regions of hand and wrist. Evolutionary stages of cervical vertebrae determined based on Baccetti method by using from sight or aspect trunk of 2,3,4 vertebrae in 5 phase. These analyses repeated 6 month later. . Kappa Correlation index used for comparison of two used method in order to determine stage of skeletal maturity in general sample.

**Results:** and **Conclusion:** correlation value in these two methods was weak to determine the skeletal age by analysis of Hand wrist radiography and cervical vertebrae. These cannot be considered as the alternate to determine skeletal age and growth peak with each other.

**Keywords:** Hand wrist - Cervical vertebrae - Growth spurt - Chronologic age.

(Received Dec 2011; revised and accepted May 2012)

**A**ssessment and forecasting jaw and face growth is an essential aspect, although not for all, but for many patients in clinical orthodontics. However, in recent years the numbers of adult patients increased, but yet majority of treatments introduce to the patient in before and within maturity time.<sup>1</sup>

<sup>a</sup>Assistant professor, Department of Orthodontics, Tehran University of Medical Sciences.

<sup>b</sup>Assistant professor, Department of Radiology, Tehran University of Medical Sciences.

<sup>c</sup>Orthodontist

<sup>d</sup>Dentist

**Corresponding author:**  
Dr Javad Chalipa  
E-mail: jchalipa@yahoo.com

Many of orthodontic treatments will have better results in short time, if actually correspond with facial growth patterns. Appliances Dependent on the growth, including functional, appliances external mouth appliances, e.g. headgear and face mask, Herbst appliance must apply in the clear growth period. By contrast, orthognathic surgeries can be done only when maturity growth peak is passed; because significant growth after it can result in relapse.

There are significant differences in different parts of craniofacial complex within

growth.<sup>2</sup> For orthodontists, mandible growth especially due to its determinant role in the formation of relationship anterior- posterior of two jaws, is significant and considered as a goal for dentofacial orthopedic treatments.<sup>3</sup>

Significant growth of mandible occurs within maturity growth spurt. Many conducted studies showed that chronologic age isn't suitable for assessment of mandibular growth stage and the degree of skeletal maturity, which is most important for measuring mandibular growth. As chronologic age can vary about 1-3 year in the relation of this critical periods<sup>3,4</sup>, in orthodontics, skeletal age of patient applies to determine and measure the remainder growth value.<sup>5,6</sup>

Many procedures including examination of body height<sup>5</sup>, hand wrist growth<sup>6</sup>, sexual maturity<sup>7</sup> or bone age of cervical vertebrae innovated and applied in order to determine degree of skeletal maturity.<sup>7,8,9</sup> Nowadays, radiography of hand wrist is one of diagnostic device to determine the beginning of, occur or finishing of growth spurt.<sup>3</sup> Nevertheless, the problem with this procedure is that some researchers believe on this has limited value because of complexity in differentiation of landmarks, that can lead to unacceptable estimation in future of growth. Furthermore; child or patient exposure on rays once more.<sup>10</sup>

Other procedure for assessment of skeletal maturity is assessment of cervical vertebrae maturity.<sup>8,10,11,14-18</sup> Advantages of this procedure is it's simplicity and replication and, most important of all, respect of health rays and prevent from patient further radiation (in comparison of hand wrist radiography) by using the available lateral cephalograms even with protective necklace of thyroid<sup>16</sup>. Studies published for examination of corresponding between analysis of hand wrist bones and cervical vertebrae to determine Of skeletal age and

patient's growth value in different races e.g. Chinese, Arabian, European and American. The goal of current study is examination of same corresponding in 8-18 years of Iranian children referred to orthodontics department faculty of Dentistry, Tehran University of Medical sciences.

### Materials and Methods

Population examined in this study was included 8-18 years old referred to orthodontic ward of dentistry faculty of Tehran university of medical sciences in 1387-1388 approved in order to treatments associated with growth. Individuals with any history of suffering to the serious systemic disease, long term use of drugs and metabolic, hormone disorders and inheritance problems as well with history of trauma in the region of face, neck and jaw arrived and examined in this study.

Individual with these conditions (n=123) were examined as successive and available samples in this study.

After selection of patients and informing their parents about receiving rays value and its possible risks and their approve, in accordance with specific treatment design for these patients, performed right hand wrist radiography. Right hand wrist radiographs obtained with panoramic-cephalometry set CC Proline (Planmeca, Finland) by using of Kodak radiographic film under conditions including 4 mA (current), 60 KV p(voltage), radiation time 0.2 s and hand in manner closed palm or cuff contact with film and collimator 5 (intermediate symmetric) and lateral cephalogram under condition 12 mA ,68 KVp with radiation time 0.6-0.8 s by using of collimator 4 (asymmetric vertical). Chronologic age calculated and recorded regarding to identity and asked from their parents. Radiologists analyzed radiologic

film on view box in the dark cell. Bones evolutionary stages of hand wrist examined based on Grave & Browns and Bjork methods in 9 phases and in 7 regions of hand and wrist. Evolutionary stages of cervical vertebrae determined based on Baccetti method by using from sight or aspect trunk of 2,3,4 vertebrae in 5 phase. These analyses repeated 6 month later in order to confirm accuracy of results with the same raters. Agreement coefficient calculated in order to determine relationship between determined growth stages by CVMS method of Bjork criterion in the different age groups. Kappa Correlation index used for comparison of two used method in order to determine stage of skeletal maturity in general sample. Growth stages summerised in 5 intervals in order to relate and comparison of 9 stage of Bjork analysis with 5 analysis stages of CVMS by using of Kappa index in following:

Interval A. Growth stages before accelerate growth maturity peak equivalent with stages 1-3 Bjork.

Interval B. Accelerate growth stages to reaching the peak equivalent with stage 4 Bjork.

Interval C. Peak of growth stage equivalent with stage 5 Bjork.

Interval D. The phase of continuous reduction of growth equivalent with stages 6,7 Bjork.

Interval E. Phase of compeleting growth indicator of adult beginning equivalent with stages 8, 9 Bjork.

There is necessity attention, that reduction of 9 stages to 5 stages does not result in loss of significant lots of data, because this study aim isn't to determine closely relation between stages of two methods used, but is comparison these for determine intervals involved important and effectiveness events. Data obtained analyzed regarding to research assumptions or theories by using of SPSS (Ver. 16) software and calculating of Cohen's Kappa.

### Results

Of 67 boys(%50.37) and 66 girls(%48.62)with age range of 8-18 years examined, greater frequency related to age group of 9-10 years(n=18). Least number account for each group was10.

Radiographs analyzed and grouping in order to determine evolutionary stages of hand wrist bones based on Bjork method and according with interval time examined in this study. In all age groups observed that girls showed greater advance evolution.

The six month later analysis confirmed these results.

All age groups of girls showed greater advanced evolution for determination maturity stage of cervical vertebrae in comparison with boys.

**Table 1. Correlation value (degree) between evolutionary stages of hand wrist bones and growth stages of cervical vertebrae in the examined samples**

general sample	Girls	boys	
133	66	67	Number of individuals
0/312	0/258	0/332	correlation value (Kappa)
46/7	42/5	50/8	agreement value (percent)



in boys. In other ages, correlation value between the results of these two methods is not suitable.

**Table 4. Agreement value in different age groups (in boys) between growth stages of hand wrist bones and cervical vertebrae**

18	17	16	15	14	13	12	11	10	9	8	Age group
5	5	5	5	5	8	5	6	8	10	5	number
2	1	3	2	2	2	1	2	6	8	5	number correlation
0/4	0/2	0/6	0/4	0/4	0/25	0/2	0/33	0/75	0/8	1	agreement coefficient

**Table 5. Agreement value in different age groups (in girls) between growth stages of hand wrist bones and cervical vertebrae**

18	17	16	15	14	13	12	11	10	9	8	Age group
5	5	5	5	6	5	6	8	8	8	5	number
3	3	3	1	0	2	1	3	2	6	4	number
0/6	0/6	0/6	0/2	0	0/4	0/17	0/37	0/25	0/75	0/8	agreement coefficient

Agreement value obtained in examined sample with sexual separation is represented in Tables 4 and 5.

In overall, correlation value and agreement coefficient strongly reduce with approaching to growth mutation (11-15 years) and increased with distance of it. Correlation values of these two methods are acceptable only for 8-9 age in two sexual and for 10 age

### Discussion

The skeletal maturity period of each patient and assessment biologic aspects of mandible growth are important in jaw and face orthodontics and orthopedics<sup>22</sup>. Skeletal age can determine with large individual differences by hand wrist radiography and by using from Greulich & Pyle Atlas (1950).<sup>4</sup> Smith (1980) in his own study announced that although application of hand wrist

radiography is useful in boys for expect of growth, but exposure with radiation ray does not recommend for girls patients without any growth problem. He concluded that skeletal age does not obtain information about expected maturation growth spurt more than chronological age specially in girls, although in both sexuality has better relation with maturation growth spurt (in comparison of chronologic age) but radiographic films of hand wrist are not entirely suitable for this goal. According to Smith and other studies after him, today's general agreement is that data obtained from determination of skeletal age are not valuable for usual issues in orthodontic diagnoses especially in girls. This difference in sexuality is due to very excessive difference in hormonal balance that affects skeletal ossification and general growth and secondary sexual properties.<sup>12,15</sup> In the method of examination of ossification events (that used in our study) can determine bones evolutionary stages and bone age with single radiography, but these information cannot be used for growth peak expected, because these events exist for significant time, thus their relation with certain event e.g. peak of growth acceleration (PHV) is weaker in the rate of bones events, decreasing their value. In regarding to these cases, Houston et al.<sup>22</sup> concluded that bones events have limited valuable for prophecy of growth acceleration peak. According their study, acceleration growth peak less impressed by using of time regression coefficient in comparison of ossification events. In the recent years, relation between different evolutionary stages of cervical vertebrae and growth acceleration peak due to increased safety against radiation and regarding to radiographic limitations in hand wrist, has increasingly attended. CVM method demonstrated that is effective and valid procedure for clinical assessment of mandible skeletal maturity in growing

children. Fengshon et al. used cervical vertebrae to assess the expected mandibular length by a regression equation and its comparison with two methods (percent of growth and growth potential) of available methods; The method of cervical vertebrae had higher precision and ability in forecast, that its reasons explained as following:

1. Growth potential and percent of growth are methods based on analysis of bone age according to hand wrist radiographic films that there is 9 stages for illustration of bones evolutionary degree by using a ruptured criterion. These methods are not careful for expect mandible continue growth. The regression equation method (that developed by themselves) obtains continue criterion by using measurement of cervical vertebrae that can more careful for expect continued events such as mandible growth.

2. Formation time of mandible due to its proximity to cervical vertebrae, is nearer to formation time of them in comparison by formation time of hand wrist bones, thus, probably mandible length has nearer relationship with cervical vertebrae.

In our study, comparison between two analysis methods for hand wrist radiographs and cervical vertebrae in order to expect of maturity growth stages in the 133 patients (girl and boy) in different age groups wasn't shown high agreement. As well, Cohen's Kappa index wasn't indicated acceptable correlation in general sample, thus, these two methods cannot alternate with each other ( $K=0.29$ ). Highest agreement observed in 8,9,10 years boys and 8, 9 years girls, that reduced with approaching to maturity age very high and reached to %20 in 12 years boys and 14 years girls. In overall, age groups of boys showed higher correlation between the two methods in comparison with girls age groups. The results obtained in our study are similar results obtained in Caltabino et al. study (1990) with 72 Italian's patients.<sup>20</sup> In overall, recent studies

about relationship between maturity index of cervical vertebrae and hand wrist bones showed that correlation index between skeletal maturity determined in hand wrist radiographs and cervical vertebrae is very different (42-97%). Differences between these studies can attribute to factors such as sample size, sexuality and used methods as well probably different skeletal level of sample individuals. Flores-Mir et.al<sup>23</sup> with considered 79 Canadian patients skeletal level in their study, announced intermediate correlation between these two methods. They declared that skeletal level effects on correlation value between skeletal maturity determined with different methods, thus, in studies related to skeletal maturity must consider it as one of factors. Results obtained in current study are similar for higher correlation in boys groups in comparison with girls group with results obtained in many studies including Garcia-Fernandez et.al., Silveria et.al., Lamparski and etc. Among these, probably San Roman et.al.<sup>13</sup> study is only study in years after 1980, that in it, in contrast with findings these researches, higher correlation reported in women groups in comparison with men groups. Results obtained in current study is similar for reduction correlation between results obtained in assessment method with approaching to maturity growth spurt, with results obtained by Fernandes *etal.*<sup>17</sup>

### Conclusion

Based on results of this study, correlation value in these two methods was weak for determine skeletal age by analysis of hand wrist radiography and cervical vertebrae, and these cannot alternate for determine skeletal age and growth peak with each other.<sup>20</sup>

### References

- 1-Samir E. Bishara. Facial and Dental Changes in Adolescents and Their Clinical Implications. *Angle Orthod* 2000; 70(6): 471-83.
- 2-Sidlauskas A, Zilinskaite L, Svalkauskiene V. Mandibular pubertal growth spurt prediction. Part one: Method based on the hand-wrist radiographs. *Baltic Dental and Maxillofacial J* 2005; 7: 16-20.
- 3-Hunter CJ. The correlation of facial growth with body height and skeletal maturation at adolescent. *Angle Orthod* 1966; 36: 44-54.
- 4-Hosseinzade Nik T. Assigning the skeletal age by means of hand and hand-wrist X-ray. *The Journal of Islamic Dental Association of Iran* 1995; 21: 27-42.
- 5-Kucukkeles N, Acar A, Biren S, Arun T. Comparisons between cervical vertebrae and hand-wrist maturation for the assessment of skeletal maturity. *J Clin Pediatr Dent* 1999; 24:47-52.
- 6-Al-Hadlagh AM, Hashim HA, Al-Dosari MA, Al-Hamed A. Interrelationship between dental development, skeletal maturity and chronological age in Saudi male children. *Egyptian Dental J* 2008; 54: 55-65.
- 7-San Roman P, Palma JC, Oteo D, Nevado E. Skeletal maturation determined by cervical vertebrae development. *Eur J Orthod.* 2002; 24:303-11.
- 8-Rakosi T, Jonas I, Graber TM. *Orthodontic diagnosis*. 1st ed. New York: Thieme medical publishers, 1993.
- 9-Baccetti T, Franchi L, McNamara Jr. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. *Angle Orthod* 2002; 72:316-23.
- 10-Smith RJ. Misuse of hand-wrist radiographies. *Am J Orthod.* 1980; 77:75-8.
- 11-Lamparski DG. Skeletal age assessment utilizing cervical vertebrae [Master of Science dissertation]. Pittsburg, Pa: The University of Pittsburg; 1972. In: Chance CA. Dependence of craniofacial growth on

stage of cervical vertebral maturation and stage of mandibular canine mineralization. [Master of Dental Science]. The University of Tennessee; 2006.

12-Hassel B, Farman AG. Skeletal maturation evaluation using cervical vertebrae. *Am J Orthod Dentofac Orthop* 1995; 107:58–66.

13-Houston WJB. Relationships between skeletal maturity estimated from hand-wrist radiographs and the timing of the adolescent growth spurt. *Eur J Orthod* 1980; 2:81–93.

14-Kimura K. Skeletal maturity of the hand and wrist in Japanese children by the TW2 method. *Ann Hum Biol* 1977; 44:353–6.

15-Mitani H. Comparison of mandibular growth with other variables during puberty. *Angle Orthod* 1992; 62(3): 217–22.

16-Proffit WR, Fields HW, Sarver DM. *Contemporary orthodontics*. 4th ed. St. Louis: Mosby Elsevier, 2007.

17-Todd T, Pyle SI. . A quantitative study of the vertebral column by direct and roentgenoscopic methods. *Am J Phys Anthropol* 1928; 12: 321-38.

18-Lanier R. Presacral vertebrae of white and Negro males. *Am J Phys Anthropol* 1939; 25:341–417.

19-Moore RN, Moyer BA, Dubois LM. Skeletal maturation and craniofacial growth. *Am J Orthofacial orthop* 1990; 98:37-40.

20-O'Reilly M, Yanniello GJ. Mandibular growth changes and maturation of cervical vertebral longitudinal cephalometric study. *Angle Orthod* 1988; 58:179- 84.

21-Franchi L, Bacceti T, Mcnamara JA. Mandibular growth as related to cervical vertebral maturation and body height. *AM J Orthod Dentofacial Orthop* 2000; 118: 335-40.

22-Houston WJB, Miller JC, Tanner JM. Prediction of the timing of the adolescent growth spurt from ossification events in hand- wrist films. *British Journal of orthodontics* 1979; 6: 145- 52.

23-Moore RN, Moyer BA, Dubios LM. Skeletal maturation and craniofacial growth. *Am J Orthod Dentofacial Orthop* 1990; 98: 37-40.