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Relationship between root maturity of mandibular first premolars and the developmental stages of cervical vertebrae in orthodontic patients

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ABSTRACT

Introduction: Estimation of the Cervical Vertebral Maturation (CVM) for detection the skeletal maturation is an interesting issue for researchers. The aim of study is evaluation relationship between the developmental stage of lower first premolar roots and CVM

from panoramic X-ray and Cephalogram. *Materials and Methods:* This descriptive and cross sectional study was done in 2014.The material was the panoramic and lateral cephalograms of 47patients in8-13 years old from archive of orthodontic department in dental school of Ahvaz Jundishapur University of Medical Sciences. *Results:* According to the CVM evaluation, the most samples (42.6%) are in the CS3 stage. By using the Spearman's correlation test, the correlation between CVM and maturation of first premolar roots(r=0.04, P_value=0.79), and maturation of upper central incisors roots (r=0.20, P-value=0.17) are not statistically significant. But there is significant correlation between CVM and age (r=0.38, P-value=0.02). *Conclusion:* One of the most important factors in orthodontic treatment planning is detecting growth sport and dental maturation stages of first premolar roots. For better conclusion we suggest further studies with larger sample sizes in different populations.

Keywords: Cervical Vertebral Maturation, dental maturation, lateral cephalogram, panoramic radiography

1. INTRODUCTION

Various treatment modalities are used in orthodontics and that most of them depend on the growth and development mechanisms of the craniofacial skeleton and the dental system. For better diagnosis and treatment planning the clinicians should be evaluate the skeletal and physiologic growth pattern of the patients. As treatment time is in growth spurt period clinicians have more favourable orthodontic and orthopedic results, with less complications and more stability (Lai et al., 2008; Baccetti et al., 2005). The sexual maturity status can significantly affect diagnosis, treatment planning and the final outcomes of treatment. When treatment planning mostly rely on growth factors in facial skeletons like using functional appliances ,distraction forces of extra oral appliances, selection of orthodontic retainers and orthognathic surgery prediction of the time and duration of growth in this areas, especially in the jaws is more important (Mellion et al., 2013; Moore et al., 1990).

We know that the chronological age isn't a reliable parameter for evaluation of maturity and skeletal development age because the significant differences in growth pattern between individuals with the same chronological age (Baccetti et al., 2005; Lund E, Tonje, 2014; Valizadeh et al., 2013). The best estimation can be made from physiological age of some tissues like skeletal and dental ages (Demirjian et al., 1985). Other biologic marker include menstruation time and breast development in girls and voice pitch change in boys (Baccetti et al., 2005; Lund and Tonje, 2014; Uysal et al., 2006; Franchi et al., 2008).

Skeletal maturity contains certain degree of ossification in skeletal tissues. In the growth period, bony tissues undergo a series of different changes and each person has his/her specific biologic clock, but there are some exceptions from repeated process to form a basis for comparisons between different individuals (Hassel and Farman, 1995). One of the known techniques is hand-wrist x-ray, which used for evaluation of skeletal growth stages (i.e. carpal bones). The validity of this technique in assessment of the cranio facial growth stage has been confirmed in many studies (Mito et al., 2003; Caro, 2012; Różyło-Kalinowska et al., 2010). The disadvantage was more exposure of patients. The CVM, who's introduced by Baccetti et al., for evaluation growth pattern of cervical vertebrae has more cost-risk benefit (Alkhal et al., 2008). This technique is based on changes in the concavity of the inferior border, height and shape of the bodies of the 2nd, 3rd and 4thcervical vertebrae, these are based on 6 stages from CS1 to CS6. Most studies have shown that the mandibular growth spurt occurs between the CS3 and CS4 (Alkhal et al., 2008; Proffit, 2007). The ossification of cervical vertebrae begins during the fetal period and continues up to adulthood. By using CVM technique there is no need to extra exposure, because the lateral cephalogram are routinely need for orthodontic diagnosis, can be use for evaluation of this index (Baccetti et al., 2002). A number of studies confirm that validity and reliability of the CVM, with less exposure (Pancherz et al., 2000; Baccetti et al., 2003; Flores-Mir et al. 2006). Evaluation of root growth stages can be a reliable method for determining sexual maturity; however, there is controversy (Demirjian et al., 1985; Kamal and Goyal, 2006). Some studies confirm that calcification pattern of lower premolars is highly related (Coutinho et al., 1993; Krailassiri et al., 2002; Uysal et al., 2004; Emami Meibodi et al., 2012) and in some other not (Różyło-Kalinowska et al., 2010; Chen et al., 2010; Flores-Mir et al., 2005; Nestman et al., 2011). In this study we want to assess correlation between the root development of the lower first premolars and the developmental stage of cervical vertebrae in orthodontic patients.

2. MATERIALS AND METHODS

The study was approved by the Human Subject Research Ethics Committee of The Ahvaz Jundishapur University of Medical Sciences (Ethical code: Ir.ajums.rec.1392.33005776).

This descriptive/cross-sectional study was down in2014using the panoramic and lateral cephalograms of 47 patients between 8–13years old from archive of Orthodontic department, Faculty of Dentistry, Jundishapur University of Medical Science. The

radiographs were assessed for the CVM and root developmental stages of lower first premolars and central incisors (as witness) by Assistant Professor of Orthodontic department. The inclusion criteria's for this study were: No developmental anomalies and systemic disorder, no missing teeth, normal cervical vertebrae and perfect lateral cephalograms and panoramic radiographs.

After radiographs selection and detection chronological age of the subjects, according to the Nolla's schedule the developmental stage of roots of the teeth was determined (Heravi et al., 2006). For detection developmental stage of cervical vertebrae (from CS1to CS6) we used Baccetti technique (Baccetti et al., 2005).

To avoid any mistake in radiographic assessment, all tracing were evaluated by one of assistance professor of Orthodontic department.

The Spearman's correlation coefficient was used for evaluation all variables and the correlation between variables. All the statistical analyses were carried out with SPSS 20.0. Statistical significance was set at $P<0.05$.

3. RESULTS

A total sample of 47 cephalograms from archive of the Orthodontic department of Jundishapur University of Medical Sciences was selected. The mean age was 10.31±1.15 years old with a range of 8–13 years; 40.4% of the subjects were 8–10 and 27.7% were 10–13 years old and undetected age in the 31.9% of the subjects.

The results showed that 42.6% were in the CS3, 36.2%, in the CS2 and 21.3% in the CS1 stages of cervical vertebrae developmental stage. According to the Nollas' schedule the mandibular first premolars, 70.2% (33 cases) were in stage 8, 17% (8 cases) in stage 9 and 12.8% (6 cases) in stage7. In assessment of maxillary central incisors, 72.3% (34 cases) were in stage 10, 25.5% (12 cases) in stage 9 and 2.1% (1 case) in stage 8. These findings revealed that when the CVM was in the CS1 stage, 50% of the cases, were in stage 8 of Nollas' and when the CVM were in the CS 2 stage, 82.4% were in stage 8 of Nollas' and in the CS 3 stage, 70.0% of the roots were in stage 8 of Nollas' schedule (Table1). Spearman's correlation coefficient did not show a significant correlation between these two variables (P=0.79, r=0.04) (Fig. 1).

Table1 Relationship between cervical vertebral maturation and root developmental stage of mandibular first premolar

		Development stage of mandibular first premolar root			
		Stage 7	Stage 8	Stage 9	total
Cervical vertebrae maturation	CS1	2 (20.0)	5 (50.0)	3 (30.0)	10 (100)
	CS2	2 (11.8)	14 (82.4)	1 (5.9)	17 (100)
	CS3	2 (10.0)	14 (70.0)	4 (20.0)	20 (100)
	total	6 (12.8)	33 (70.2)	8 (17.0)	47 (100)

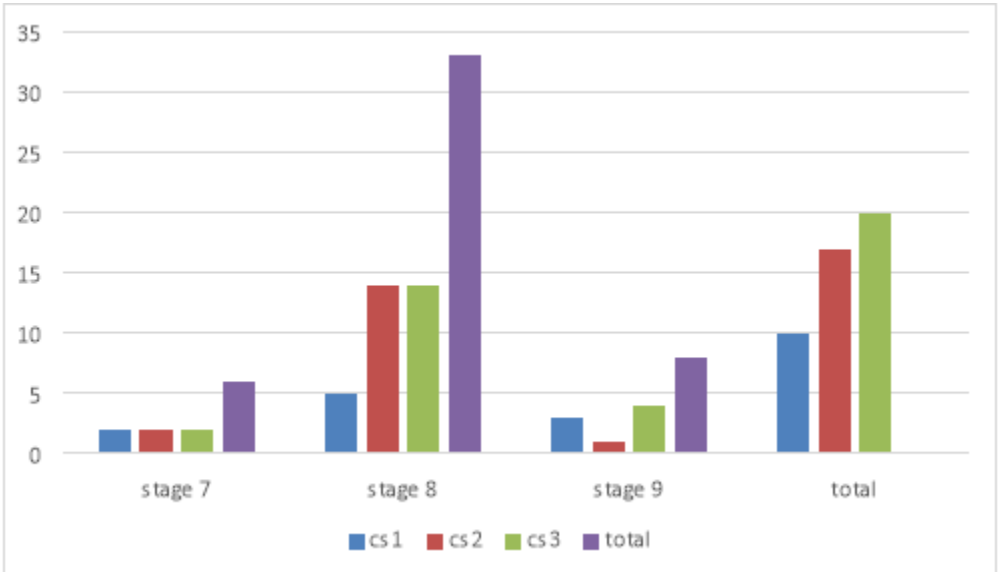

Figure 1 Relation between CVM and mandibular first premolar root development stages

The correlation between the CVM and roots of maxillary central incisors are presented in Table 2. Spearman's correlation coefficient did not reveal any correlation between these two variables (P=0.17, r=0.20). Furthermore, Table 2 and figure 2 presents correlation between the CVM and chronological age. Spearman's correlation coefficient showed a significant correlation between these two variables, i.e. there was an increase in the envelopment stage of cervical vertebrae with aging (P=0.02, r=0.38).

Table 2 Relationship between cervical vertebral maturation and root developmental stage of maxillary central incisor

		Development stage of maxillary central incisor root			
		Stage 8	Stage 9	Stage 10	total
Cervical vertebrae maturation	CS1	1 (10.0)	2 (20.0)	7 (70.0)	10 (100)
	CS2	0 (0)	7 (41.2)	10 (58.8)	17 (100)
	CS3	0 (0)	3 (15.0)	17 (85.0)	20 (100)
	total	1 (2.1)	12 (25.5)	34 (72.3)	47 (100)

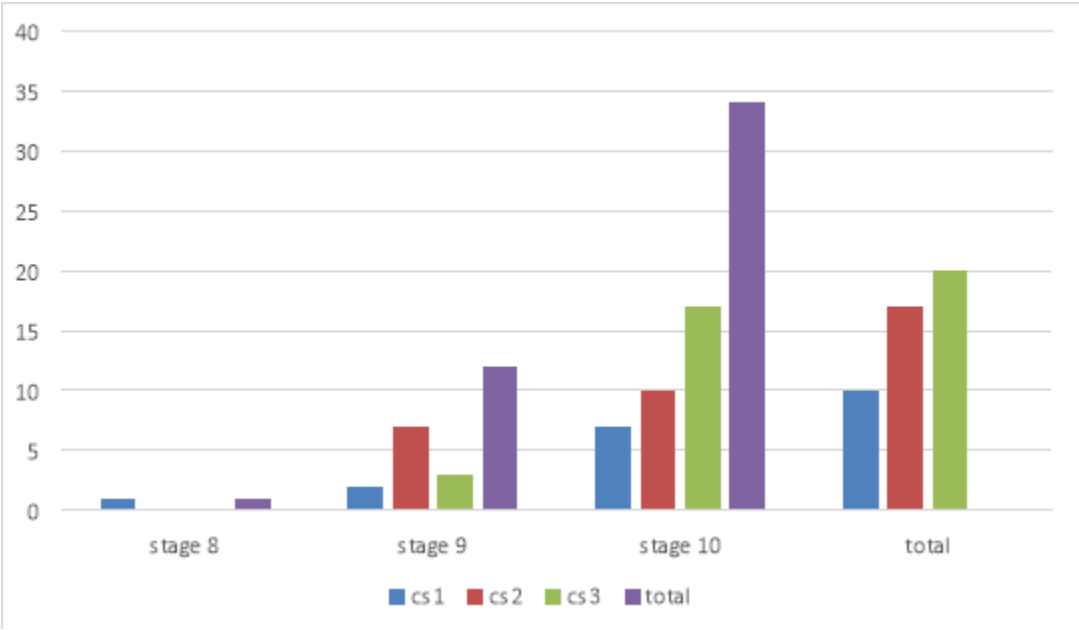

Figure 2 Relation between CVM and maxillary central incisor root development stages

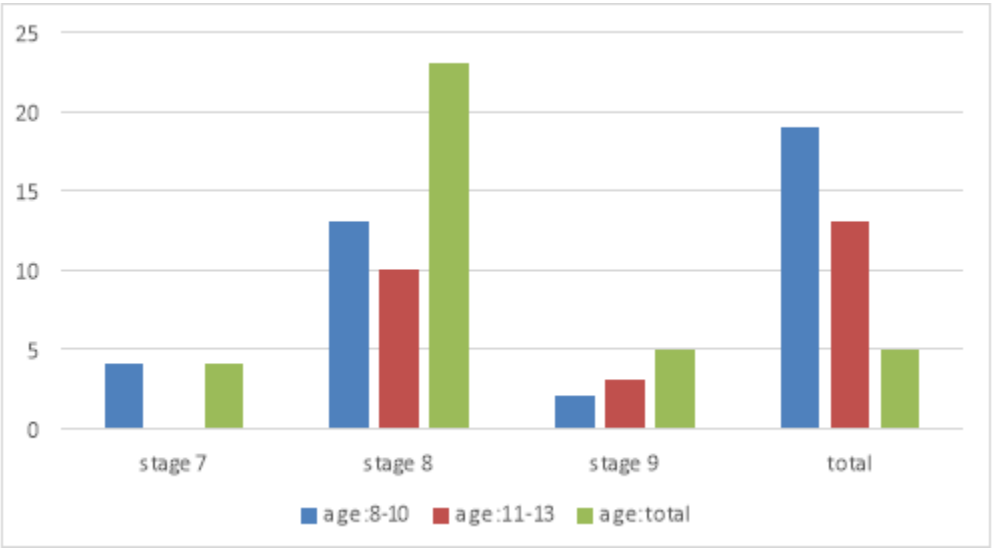

Figure 3 Relation between age and mandibular first premolar root development stages

At the same time, the correlation between the development of the roots of maxillary central incisors and mandibular first premolars and aging was evaluated (Tables 3-4 and figure 3-4). Spearman's correlation coefficient did not show a significant correlation between the development of the root of lower first premolars and age (P=0.08, r=0.31). However, there is a significant correlation between age and the development of the roots of maxillary central incisors (P=0.01, r=0.42).

Table 3 Correlation between root developmental stage of the mandibular first premolar and aging

		Development stage of mandibular first premolar root			
		Stage 7	Stage 8	Stage 9	total
Age group	8-10	4 (21.1)	13 (68.4)	2 (10.5)	19 (100)
	11-13	0 (0)	10 (76.9)	3 (23.1)	13 (100)
	total	4 (12.5)	23 (71.9)	5 (15.6)	32 (100)

Table 4 Correlation between roots developmental stage of the maxillary central incisor and aging

		Development stage of maxillary central incisor root			
		Stage 8	Stage 9	Stage 10	total
Age group	8-10	1 (5.3)	8 (42.1)	10 (52.6)	19 (100)
	11-13	0 (0)	1 (7.7)	12 (92.3)	13 (100)
	total	1 (3.1)	9 (28.1)	22 (68.8)	32 (100)

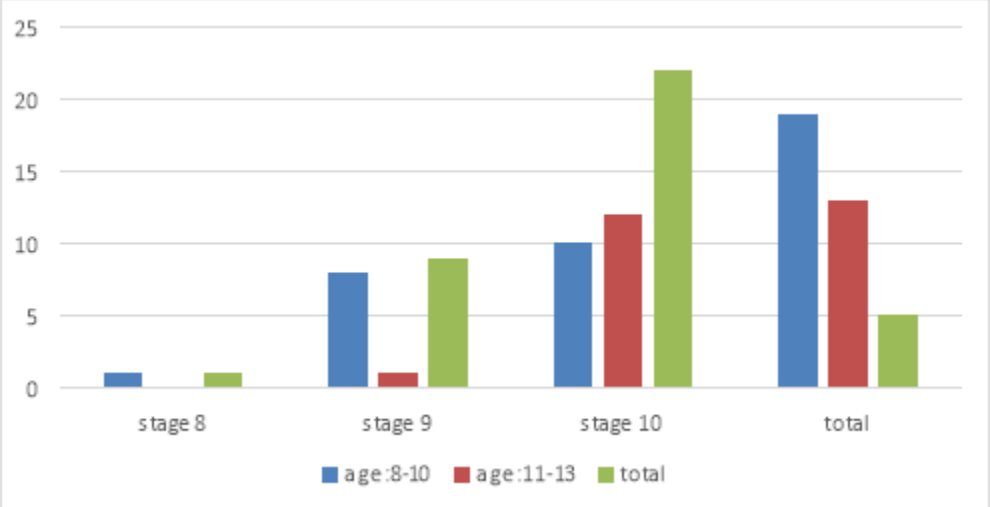

Figure 4 Relation between age and maxillary central incisor root development stages

4. DISCUSSION

Importance of reliable biological indices for determines stages of growth during maturation in order to prepare an appropriate orthodontic treatment planning and determine growth retardation for stability of orthognathic surgeries and treatment outcomes in the long term were evident (Dalili, 2005). Hand-wrist X-ray usually considered as the most reliable biologic markers for evaluation ossification of small bones in the wrist and fingers (Román et al., 2002; Imanimoghadam et al., 2008). However, more exposure and cost-benefit of this technique for patients induced the researchers to carry out studies on the development of cervical vertebrae which are visible on lateral cephalograms that is routine in orthodontic treatment. This technique is more safe and reliable in determination skeletal maturity (Imanimoghadam et al., 2008). In this study, we use 47 cephalograms of patients referred to the Dental Clinic of Ahvaz Faculty of Dentistry, during 2013–2014, in order to determine relationship between the developmental stages of cervical vertebrae and the root formation stage of mandibular first premolar and maxillary central incisor.

As the table 1, 2 showed in the 8–13-years group 21.3% were in CS1 stage (10 subjects) 36.2% in CS2 stage (17 subjects) and 42.6% were in CS3 stage (20 subjects). The result of similar studies and this study at the same ages was different, this might be

attributed to differences in the mean ages of the subjects and frequency of distribution samples in each age group, which can finally, has effect in the frequency of distribution the stages of cervical vertebrae development.

The results this study showed that when the CVM were in CS1 stage of, the majority of the roots of mandibular first premolars, i.e. 50% were in the stage 8 of Nollas' schedule and when the CVM were in CS2, 82.4% and in CS3 developmental stage, 70% were in the stage 8 Nollas' schedule. Spearman's correlation coefficient did not reveal any significant correlation between the CVM and the root development of mandibular first premolars (r=0.04, P=0.79). In evaluation of maxillary central incisors the results showed that in CS1 developmental stage, 70% were in the developmental stage 10 Nollas' schedule, and in CS2 developmental stage, 58.8% were in the stage 10; and in CS3 developmental stage, 85.0% of the roots of maxillary central incisors were in the stage 10. Spearman's correlation coefficient did not reveal a significant correlation between the CVM and the root development of central incisors (r=0.20, P=0.17).

The relationship between the development of the dental system and the skeletal maturity has been evaluated by many researchers. Some of this finding had shown a high correlation between calcification stages of teeth and skeletal maturation (Krailassiri et al., 2002; Uysal et al., 2004). Some others show weak correlation between the development of cervical vertebrae and other physical growth and tooth development (Emami Meibodi et al., 2012; Nestman et al., 2011; Lewis, 1991; Anderson et al., 1975).

There is a high correlation coefficient between the development of cervical vertebrae and the calcification of all the teeth (r=0.70–0.75), however was poor in incisors and permanent first molars teeth (r=0.3, r=0.4) (Valizadeh et al., 2013). Differences in the age, ethnicity, geographical situation, and the development of cervical vertebrae in our groups, are effective in these differences.

There is no or less correlation between dental age and the skeletal maturation (Różyło-Kalinowska et al., 2010; Helm, 1990). According to the relationship between the CVM and age, majority of the subjects in the 8–10-years (36.8%) were in CS2 stage of CVM; and in the 11–13-years (61.5%) was in CS3 stage of CVM. Spearman's correlation coefficient showed a significant correlation between these variables, i.e. the developmental stage of the cervical vertebrae increased with aging (r=0.38, P=0.02), like in other study, the CVM status increased with age (Różyło-Kalinowska et al., 2010; Abesi et al., 2015) and according this study there is high correlation between chronological age and development and maturation of CVM.

Relationship between age and the root development of first mandibular premolars and maxillary central incisors were assessed and the subjects in 8–10 year age group (68.4%), and in the 11–13 years old (76.9%) were in the stage 8 of Nollas' schedule. According to the Spearman's correlation coefficient there is no significant correlation between them (r=0.31, P=0.08). Our finding showed subjects in the 8–10 year old (52.6%), and in the 11–13 year age (92.3%), were in stage 10 Nollas' schedule. Spearman's correlation coefficient revealed a significant correlation between these two variables (r=0.42, P=0.01). The level of significance was set at 0.001.

5. CONCLUSION

In our study the average and standard deviation (SD) of age was 10.31±1.15 years old (range 8–13). There is no significant relation in partial correlation coefficient between age and other measurements (P values >0.15). As importance of determining the root developmental stage of teeth (especially 1st premolars) in orthodontic treatment planning and the correlation between the development of cervical vertebrae and teeth development, we recommend further studies with larger sample sizes in different populations.

Source of funding

The study was self-funded by the authors. Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval All procedures

Ethical approval all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards did not differ significantly.

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