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Cervical Vertebrae and Dental Age: Is there a Correlation?

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Keywords: Dental age; Cervical vertebrae; Maturation index; Demirijian method; Panoramic; Lateral radiographs.

Abstract

Introduction: The determination of skeletal growth is very important in orthodontic practice. Different radiological tools are used such as Hand and wrist X ray and maturation of cervical vertebrae from lateral cephalograms.

Aim: The main objective of this study was to find a method to evaluate the growth potential through the stages of dental maturation from the panoramic radiograph.

Materials and methods: This is a cross-sectional retrospective study of 123 panoramic and lateral radiographs .It was conducted at the Department of orthodontics of Farhat Hached hospital in Sousse. The chronological age, cervical vertebral maturation, and the stages of Demirijian's dental maturation, for the seven permanent left mandibular teeth for each subject, were studied. Statistical analysis was performed using the SPSS version 22 and the significance rate was set at 5%.

Results: A strong relationship between dental and skeletal maturation is proven. The coefficient of correlation ranged between 0.536 and 0.738 for male and between 0.562 and 0.812 for female.

Discussion: The growth peak overlapped with stage f and g of Demirijian of the second permanent left mandibular molar for Tunisian female and the stage g of second left mandibular premolar and second permanent left mandibular molar for Tunisian male. This coincidence can be considered as an announcement of the acceleration of pubertal growth.

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Introduction

The estimation of skeletal growth in orthodontic is paramount for diagnosis, planning and post-treatment stability although the use if chronological age .Several authors recognized chronological as an underestimated tool of growth evaluation and confirmed that physiological age would be more reliable for assessing the state of maturation. Physiological age is estimated by several indicators such as the appearance of sexual characteristics, bone maturation and dental development. The most widely used method for estimating bone maturation has been the reading of the X-ray of the hand and wrist. The wealth of this part of the body, made up of small bones that calcify at different rhythms, gives this method a strong clinical reliability. Thus a precise determination of bone age can be made with tables of the atlas of Greulich and Pyle on a radiograph of the left hand. Björk and Skiller placed patients on a growth curve and compared their bony age to the peak growth (stage MP3cap). However, this methods had limits: the sexual variability of the ossification sequence of hand and wrist bones and the need for additional irradiation [1,2]. That's why the determination of bone maturation was established from the maturation of cervical vertebrae (CVM) by Lamparski (1972), who defined 6 stages of skeletal maturation, by assessing the concavity of the lower edge of the five cervical vertebrae (C2à C6). Then Hassel and Farman (1995) improved this method by analyzing a limited number of cervical vertebrae (C2, C3, C4), with a more detailed description of the 6 stages. Finally, the working group of Bacetti, Franchi and McNamara has twice modified the original version of Lamparski. The second version developed in 2005 is the most used. Modifications to the original version of Lamparski include: analysis of a limited number of cervical vertebrae (C2, C3 and C4), the definition of the different stages of skeletal maturation by combining the observation of the concavity of the lower edges of the vertebral bodies and their morphology (trapezoid, square or rectangular); changes in vertebral size and morphology that characterize the 6 stages; the status of the different stages relative to the pubertal peak of mandibular growth [3,4]. Concerning the estimation of maturation from the development of teeth , radiological methods, namely, those of Nolla, Haavikko, Demirjian and modified from Demirjian by Willems et al. are perfect tools. The most widely used method is that of Demirjian (1973); where the development teeth is divided into eight stages according to an alphabetical scale from A to H.

Materials and methods

Type of study

This is a cross-sectional retrospective study of 123 files (dental panoramic and lateral radiography) of a Tunisian population treated within the orthodontics unit of Farhat Hached hospital, Sousse and who consulted from January 2015 to January 2019. **Inclusion Criteria:** Tunisian origin and nationality.

Age of patients between 8 and 17 years for boys and 8 to 15 years for girls.

The panoramic and the lateral radiography are taken on the same day and at the same radiologist and having a good quality.

Exclusion Criteria: Bilateral dental abnormalities (agenesis, inclusion, transposition, ankylosis) or bilateral absence of one or more permanent mandibular teeth.

Presence of systemic disease affecting skeletal development or dental calcification such as hypophosphatemia, hypophosphatesia, Ehlers Danlos syndrome.

History of orthopedic or orthodontic treatment, trauma or surgery at neck or dentofacial level.

Methods

All radiographs are analyzed on a conventional viewport by a single examiner.

Definition of variables

The chronological age:

The chronological age of each patient is calculated by subtracting the date of birth from the date of the taking of the radiographs (It is calculated in months; if 15 days it is rounded at least if not it is rounded to the maximum).

Stages of dental maturation:

The method described by Demirijian et al, 1973 and 1976a was used to estimate dental maturation Figure 1.

Vertebral Maturation Index (CMV):

The second version of Bacetti, Franchi and McNamara developed in 2005 Figure 2 (Fig .2)

Statistical analysis of data:

All collected data were analyzed by SPSS 22 software. The normal distribution of the sample was studied with the tests of Shapiro-Wilk and kolmogorov-Smirnov.The threshold of statistical significance was set at 5%.

Results

Descriptive results

The studied population contains 61 girls and 62 boys Figure 3 with an average age of 11 years and 6 months for females and 11 years and 5 months for males.

Based on the vertebral maturation stages, the average age ranges from 9 years and 2 months

for girls in stage CS1 to 14 years and 4 months for girls in stage cs6 and 9 years and 4 months for boys in stage CS1 to 15 years and 7 months for boys in stage CS6 Table 1.

The distribution of the dental maturation stages varies according to the vertebral maturation stages: For stage CS1, stage g of the 36 has the highest percentage for girls and boys with a percentage of 100% for girls and 73.7% for boys Table 2,3.

For stage CS2, stage h for the 32 and for the 31 present for boys the highest percentage (72.2%).

Stage g of 36 has the highest percentage for girls (80%) Table 4,5. For stage CS3; Stage h of 31 and 32 presents for both genera the highest percentage (100%) Table 6,7.

Stages CS4 and CS5 have the same results. Stage h of 36, 32 and 31 for boys has the highest percentage (100%). Stage h of 32 and 31 shows the highest percentage (100%) for girls Table 8, 9,10,11. For stage CS6 all teeth, for boys are in stage h, except the 37 which are in stage g Table 12,13.

Analytical results

Comparison of Average Ages of Both Gender by DAC

The t-test for two independent samples was used to compare the mean ages of the two gender for each vertebral maturation stage. There is no significant difference between the chronological ages of the two gender for all stages of vertebral maturation (p>0.05) Table 14.

Correlation between dental and vertebral maturation

The Spearman correlation test is used to study the correlation of different stages of vertebral maturation and each tooth. All correlations between teeth and vertebral maturation stages are significant (p0.05). Correlation coefficients vary from 0.536 to 0.738 for male and from 0.562 to 0.812 for female Table 15.

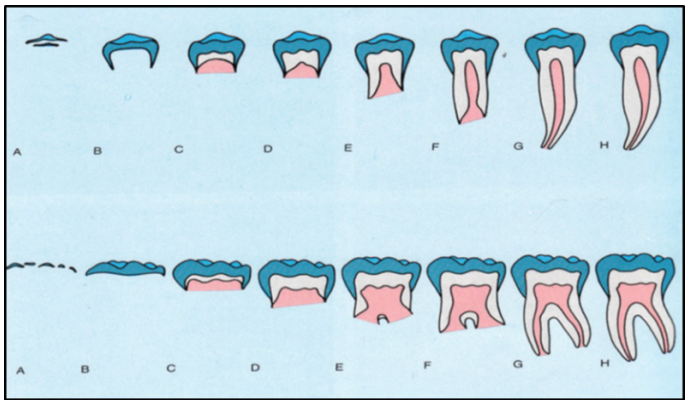

Figure 1: Demirjian's Stages of Dental Development [21].

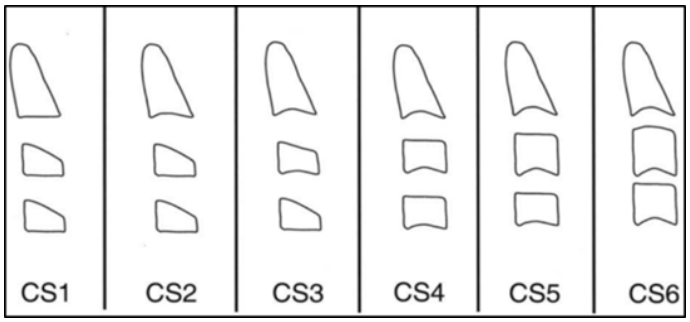

Figure 2: Schematic representation of vertebral maturation stages [3].

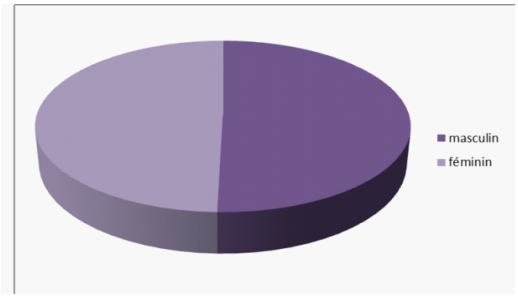

Figure 3: Population Distribution by gender.

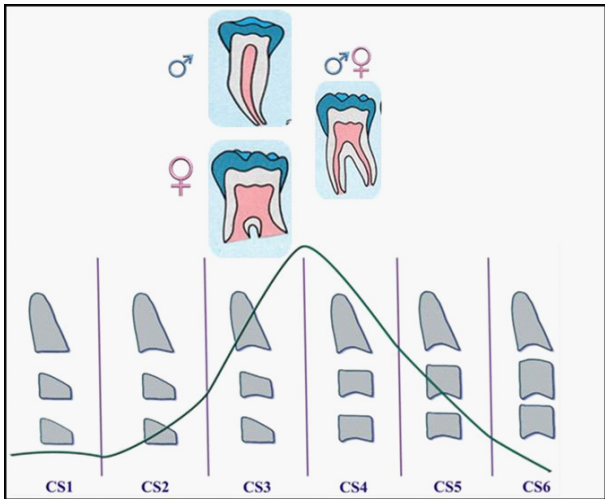

Figure 4

Table 1: Mean age of the sample by vertebral stage.

	Vertabral stage	Mean of age(in month)	Standard deviation
Femin	Cs1 Cs2 Cs3 Cs4 Cs5 Cs6	110,8 124,4 150 161 160 173,5	15,4 12,8 18,5 7,3 8 9,1
Male	Cs1 Cs2 Cs3 Cs4 Cs5 Cs6	113,7 131,3 150 162,8 172,6 188,3	14,1 22 6,9 10,6 11,7 9

Table 2: Distribution of Posterior Teeth Maturation Stages for Vertebral Maturation Stage 1.

CS1								
tooth	37		36		35		34	
gender stage	F	H	F	H	F	H	F	H
c	27,8	26,3	-		11,1	10,5	5,6	-
d	27,8	10,5	-		11,1	26,3	11,1	10,5
e	38,9	42,1	-		44,4	47,4	50	47,4
f	5,6	21,1	-	10,8	22,2	10,5	22,2	21,1
g	-		100	73,7	5,6	5,3	11,1	15,8
h	-		-	15,8	5,6	-	-	5,3

Table 3: Distribution of Maturation Stages of Anterior Teeth for Vertebral Maturation Stage 1.

CS1						
Dent	La 33		La 32		La 31	
genre stade	F	H	F	H	F	H
c	5,6	-	-		-	
d	11,1	10,5	-		-	
e	27,8	42,1	5,6	-	-	
f	33,3	26,3	11,1	5,3	11,1	5,3
g	22,2	15,8	66,7	57,9	61,1	52,6
h	-	5,3	16,7	36,8	27,8	42,1

Table 4: Distribution of Posterior Teeth Maturation Stages for the Vertebral Maturation Stage 2.

CS2								
tooth	37		36		35		34	
Gender Stage	F	H	F	H	F	H	F	H
c	1	5,6	-		-		-	
d	-	16,7	-		-	22,2	-	16,7
e	30	27,8	-		40	27,8	20	22,2
f	40	22,2	-		30	-	40	11,1
g	20	27,8	80	61,1	30	38,9	30	33,3
h	-		20	38,9	-	11,1	10	16,7

Table 5: Distribution of Maturation Stages of Anterior Teeth for the Vertebral Maturation Stage 2.

CS2						
Tooth	33		32		31	
gender stage	F	H	F	H	F	H
e	40	27,8	-		-	
f	20	33,3	-	5,6	-	
g	30	38,9	60	22,2	60	27,8
h	10		40	72,2	40	72,2

Table 6: Distribution of Posterior Teeth Maturation Stages for the Vertebral Maturation Stage 3.

CS3								
Tooth	37		36		35		34	
gender stage	F	H	F	H	F	H	F	H
e	16,7	-	-		16,7	-	-	
f	66,7	27,3	-		16,7	18,2	16,7	-
g	16,7	72,7	33,3	9,1	33,3	45,5	50	63,6
h	-		66,7	90,9	33,3	36,4	33,3	36,4

Table 7: Distribution of Maturation Stages of Anterior Teeth for the Vertebral Maturation Stage 3.

CS4								
Tooth	37		36		35		La 34	
gender stage	F	H	F	H	F	H	F	H
e	8,3	-	-		-		-	
f	16,3	-	-		25	20	8,3	-
g	75	100	16,8	-	33,3	40	50	20
h	-		83,3	100	43,7	40	41,7	80

Table 8: Distribution of Posterior Tooth Maturation Stages for the vertebral maturation stage 4.

CS4						
Tooth	33		32		31	
Gender stage	F	H	F	H	F	H
f	33,3	20	-		-	
g	8,3	60	-		-	
h	58,3	20	100		100	

Table 9: Distribution of Maturation Stages of Anterior Teeth for the Vertebral Maturation Stage 4.

CS5								
Tooth	37		36		35		34	
Gender stage	F	H	F	H	F	H	F	H
f	33,3		-		22,2	16,7	-	
g	55,6	50	44,4	-	44,4	33,3	44,4	50
h	11,1	16,7	55,6	100	33,3	50	55,6	50

Table 10: Distribution of Posterior Teeth Maturation Stages for the Vertebral Maturation Stage 5.

CS5						
Tooth	33		32		31	
Gender stage	F	H	F	H	F	H
f	66,7	33,3	-		-	
g	-	16,7	-		-	
h	33,3	50	100		100	

Table 11: Distribution of Posterior Teeth Maturation Stages for the Vertebral Maturation Stage 5.

CS6								
Tooth	37		36		35		34	
Gender stage	F	H	F	H	F	H	F	H
g	83,3	100	16,7	-	33,3	-	33,3	-
h	16,7	-	83,3	100	66,7	100	66,7	100

Table 12: Distribution of Posterior Teeth Maturation Stages for the Vertebral Maturation Stage 6.

CS6						
Tooth	33		32		31	
gender stage	F	M	F	M	F	M
G	50	-	-		-	
H	50	100	100		100	

Table 13: Distribution of Maturation Stages of Anterior Teeth for the Vertebral Maturation Stage 6.

	Male		Female		P value
Age Vertebral stage	Mean of age	Standard deviation	Mean of age	Standard deviation	p
CS1	113,7	14,1	110,8	15,4	0,547
CS2	131,3	22	124,4	12,8	0,299
CS3	150	6,9	150	18,5	0,991
CS4	162,8	10,6	161	7,3	0,705
CS5	172,6	11,7	160	8	0,27
CS6	188,3	9	173,5	9,1	0,06

Table 14: Comparison of chronological age averages of the two gender by vertebral stage.

	Garçons		Female	
Tooth	P value	Correlation r value	P value	Correlation r value
37	0.00	0.738**	0.00	0.812**
36	0.00	0.689**	0.00	0.615**
35	0.00	0.722**	0.00	0.681**
34	0.00	0.664**	0.00	0.764**
33	0.00	0.517**	0.00	0.624**
32	0.00	0.736**	0.00	0.562**
31	0.00	0.536**	0.00	0.668**

Discussion

Chronological age by vertebral stage and gender

In our study, the mean ages of both gender for each vertebral stage do not show significant differences (Table 2). For the same vertebral stage girls are younger than boys, except for stage 3 where both gender are of equal age. Our results are consistent with literature where girls are generally younger than boys for the same vertebral stage with some variations [5-11]. These results can be explained by physiological bone growth, which is more accelerated in girls than boys [12,13].

Distribution of dental maturation stages for each vertebral stage

The distribution of dental maturation stages for each vertebral stage is variable. Depending on the age of the studied patients (>8 years) the stages a and b of Demirijian are no longer present. The variability of the stages of dental maturation becomes more and more limited by advancing in the stages of vertebral maturation. With the continuation of root-building, it is the g and h stages that dominate the stages from CS3 to CS6, and because the incisors and the first permanent molars make their eruptions the first they end up first the apical closure.

In the literature; this restriction of the variability of the dental maturation stages is approved with some variations. This inter-population difference in the composition of the dental maturation stages for each vertebral stage is due to the variability in the duration of mineralization that is attributed in the literature to genetic determinism [14-18] environmental factors [5,19-22] and even strong adaptation of dental maturation to nutrition [23].

Correlation between dental maturation and skeletal maturation

Our findings on the correlation between dental and skeletal maturation are consistent with the literature which proposed the use of dental maturation stages as an indicator of skeletal growth. The tooth with the highest correlation coefficient is the second permanent mandibular molar for both gender. This result is also found by B.Rai [24], Goyal Sandeep [25], SushilKumara [26], and George Litsas [27]. On the other hand, for other authors it is the mandibular canine that shows the most important correlation for the two gender as Chertkow [28]; Sandra Coutinho [3]; and for boys only as for Jianwei Chen [29]. On the other hand, the 2nd mandibular premolar showed an important correlation in some populations such as the Thai population [30], Croatian [31-34] and also for Iranian girls [28]. The diversity of the results can be explained by the wide variety in morphology as well as the time and duration of mineralization of the teeth. Since the second permanent mandibular molar has the highest correlation coefficient between dental and skeletal maturity, the mineralization pattern of this tooth could be considered as a guideline to follow the growth curve and especially to detect the peak growth. According to the used method for the determination of the vertebral maturation stage, the growth peak appears between CVS 3 and CVS 4, We will therefore use the stages of mineralization of the 37 which have the highest percentage for these two vertebral stages to detect the peak of bone growth by referring only to panoramic radiography.

For female, the f and g stages of the 37 have the highest percentage in CS3 and CS4 respectively. Because of , all the second permanent mandibular molars are in stage g for CS4, we will use another tooth to represent the stage CS3.According to the correlation coefficients, the tooth following 37 is 32 (r=0.736). However, the lateral incisors result in an apical closure earlier than the other teeth since they are among the first teeth that appear in the mouth. They're all in stage h from CS3. The second premolar, with the highest correlation coefficient after 37 and 32 (r=0.722), can be used to determine the CS3 stage for male. Stage G of the 35 has the highest percentage in CS3.Our results are summarized in the diagram below where we added the stages of dental maturation to the Bjork curve and the stages of maturation of the cervical vertebrae Figure 4.

Conclusion

The success of the mainly orthopedic treatment depends essentially on the reasoned determination of the optimal moment of the beginning of the treatment; for this the results of our study can be used as a means to detect the peak of growth in the Tunisian population. Referring to panoramic radiography,

dental mineralization stages could be used clinically as an indicator of growth period. Indeed, the peak growth is located between the f and g stages of the 37 for Tunisian girls, and between the g stages of the 35 and 37 for Tunisian boys.

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