Detection of skeletal maturity using periapical radiographs (A study on Iraqi growing sample)

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ABSTRACT

Background: Among different treatment modalities of skeletal malocclusion, growth modification is the interceptive procedure undertaken in a growing child. For the growth modification to be successful it is absolutely essential that it should be initiated at the right time. This study aimed to verify the possibility of clinical employment of the developmental stage of middle phalanx of the middle finger and that of mandibular second molar in the determination of maturity in both genders.

Materials and method: The sample consists of 216 Iraqi subjects, 108 males and 108 females, for each subject two periapical radiographical films were used, one for mandibular left second molar and the other for the middle phalanx of the middle finger, to determine their developmental stage according to the method described by Demirjian et al (1973) for ossification of teeth, and Hagg and Taranger (1982) that later modified by adding E ¾ stage given by Leite et al (1987) to describe the relation of epiphysis to metaphysis in the middle phalanx of the middle finger.

Results: A high significant correlations were found among chronological age, in years, calcification stages of mandibular left second molar , and developmental stages of middle finger (P<0.000), with a higher puberty stage in female than in male within the same dental calcification stage.

Conclusion: The maturity stage of growing subject can be detected depending on calcification stage of mandibular 2nd molar using periapical radiograph.

Keywords: skeletal maturity, pubertal growth prediction, orthodontic diagnosis. (J Bagh Coll Dentistry 2011; 23(sp. issue):155-161).

INTRODUCTION

As children grow they also mature. In some parts of the skeleton, measures of growth are commonly interrupted in relation to levels of maturity because future growth, therefore, clinical management may be influenced by these levels. The changes associated with maturation are evident in many parts of the body including the craniofacial skeleton and the dentition[1,2].

Treatment during periods of accelerated or intensive growth can contribute significantly to correction of dento-facial deviations and improvement of facial appearance[3]. Obvious benefits from orthodontic treatment will be gained if the aspects of treatment that depend on growth can be undertaken during the pubertal spurt period[4-6]. Clinical decisions regarding overbite reduction, mode of retention after therapy, use of extra-oral traction and orthopedic forces, functional appliances, extraction versus non-extraction treatment, or orthognathic surgery are greatly based on growth consideration. With many orthodontic patients, therefore, pubertal growth needs to be factored into the diagnostic equation[7,8].

The physiological or anatomical maturity cannot be accurately assessed by chronological age alone because of the great individual variations in timing, duration, and velocity of growth[9,10]. More reliable information is given by the developmental or biological ages which are measures for describing the status of an individual to define progress towards completeness of development or maturity. These ages are estimated from the degree of maturation of different tissue systems. Sexual maturation characteristics, height (stature), skeletal age, dental development, and skeletal development are some of the most common means that have been used to identify stages of growth[11,12].

Developmental stage can be estimated by many ways like estimation the developmental stage of pisiform carbal bone, iliac crest and Hand-Wrist bones. An assessment of the level of development of the bone in the wrist, hand and the fingers can give an accurate picture of child's skeletal development status; to do this, a Hand-Wrist radiograph of the patient is simply compared with standard radiographic images in an Atlas of the development of the Hand and Wrist, to give the skeletal age of individual[13].

The present study tried to verify the most familiar method to orthodontist for pubertal stage estimation, which is very important in orthodontic diagnosis and plan, using only two periapical radiographs, one for middle phalanx of the middle finger and one for the mandibular left second molar, with less radiation exposure comparing to orthopantomograph, cephalometric and hand wrist radiographs, less expensive and almost available in all dental clinics.

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This study aimed to:
1- Detect the skeletal maturity through the relation between the stages of calcification of permanent mandibular left second molar with that of middle phalanx of middle finger.
2- Determine whether significant difference exists between males and females when developmental stages of mandibular left second molar is used as a maturity indicator.

MATERIALS AND METHOD

Sample

The total sample consisted of 216 Iraqi subjects, 108 males and 108 females, with age range of 8-16 years old, and equal number of males and females within each age group, 12 each, collected from oral diagnosis department at the College of Dentistry, University of Baghdad.
Subject selection criteria included:
1. The subject is physically and mentally healthy without history of congenital or developmental disturbances due to syndromes or hormonal disturbance which could affect their growth
2. No previous history of trauma or injury to the face and/or the hand middle finger region.

Materials and equipment

1- Periapical radiographical film (Kodak).
2- X-ray machine for intra-oral periapical radiograghs.

Method

*** Recording mandibular second molar**: Intraoral periapical film was fixed in a film holding device for paralleling technique. Then the film was placed against the lingual surface of mandible with the posterior surface of the film extended till the retromolar area, the electronic timer was set to 0.5 seconds.

*** Recording middle finger developmental stage**: Intraoral periapical films were used to record the middle finger developmental stages. The subjects were instructed to place their left hand with palm downward on a flat table. The middle finger was centered on a periapical film. The cone of the X-ray machine was directed towards the middle phalanx, perpendicular to film.

After processing of the radiographical films, radiographs were analyzed as follows

1. Assessment of developmental stages of mandibular second molar *(Figure1)*

The radiographic appearance of the mandibular left second molar was rated according to the method described by Demirjian et al [14] in which eight stages of calcification, A to H, are described for each tooth. The stages ascribed to teeth in this study ranged from D to H. Each of these stages may be recognized by the following criteria:

Stage D Crown formation has been completed to the level of the amelocemental junction. Root formation has commenced. The pulp chamber has a trapezoidal form.

Stage E The root length remains shorter than the crown height. Formation of the inter-radicular bifurcation has begun.

Stage F Root length is at least as great as the crown length. Roots have funneled shaped endings.

Stage G The walls of the root canal are now parallel, but apices remain open

Stage H Apical ends of the roots are completely closed, and the periodontal membrane has a uniform width around the root.

2- Assessment of the skeletal maturation using middle phalanx of the middle finger as an indicator *(Figure2)*

The middle finger radiographs were evaluated according to the five stages of ossification described by Hagg and Taranger [15] and later modified by adding E¾ stage given by Leite et al [16]. Each subject was given a score from amongst E¾, F, FG, G, H and I corresponding to the relation of epiphysis to metaphysis in the middle phalanx of the middle finger, as follows:

Stage 1 (E ¾) The epiphysis reaches ¾ of the width of the diaphysis.

Stage 2 (F) Epiphysis is as wide as metaphysic. It corresponds to the onset or start of the curve of pubertal growth spurt.

Stage 3 (FG) Epiphysis is as wide as metaphysis and there is a distinct medial and / or lateral border of the epiphysis forming a line of demarcation at right angle to the distal border. It corresponds to the acceleration part of the curve of pubertal growth spurt.

Stage 4 (G) The sides of epiphysis thicken and cap its metaphysic forming a sharp edge distally at one or both the sides. It corresponds to the peak of the curve showing maximum point of pubertal growth spurt.

Stage 5 (H) Fusion of epiphysis and metaphysic begins. It corresponds to deceleration part of the curve of pubertal growth spurt.

Stage 6 (I) Fusion of epiphysis and metaphysic is completed. It corresponds to end of pubertal growth spurt.

The stage of tooth formation of the subjects was then correlated with their corresponding stages of skeletal maturity in the middle phalanx of the middle finger, to find out if there is any association between the two parameters.

Statistical analyses

Data were collected and analyzed using SPSS software version 19 for windows XP Chicago, USA. The following statistics were used:

1- Descriptive statistics include sample distribution within each age group for both genders.
2- Contingency coefficient to show the association among chronological age, calcification stages of mandibular left second molar, and developmental stages of middle phalanx of the left hand middle finger.

In statistical evaluation, the following levels of significance are used:

$P > 0.05$	NS	Non-significant
$P \leq 0.05$	*	Significant
$P \leq 0.01$	**	Highly significant

RESULTS

Table 1 showed the distribution of sample according to the calcification stages of mandibular left second molar within each age group, for both genders. A contingency coefficient value of 0.777, 0.786 and 0.762 in males, females and total sample groups respectively, showing a strong association at high level of significance ($P<0.000$). Also, Table 2 showed a high significant association between the chronological age, in years , and the developmental stage of the hand middle finger with a contingency coefficient of 0.788, 0.775 and 0.739 in males, females and total sample groups respectively, that found to be highly significant ($P<0.000$). Moreover, Table 3 showed a strong association between calcification stages of mandibular left second molar and the developmental stages of hand middle finger with a contingency coefficient of 0.799 in males, 0.736 in females and 0.753 in total sample groups, which found to be highly significant ($P<0.000$).

By dividing the developmental stages of the hand middle finger into pre-peak (E3/4 and F), peak (FG, G and H) and post-peak (I)[17] and relating them with the mandibular left second molar calcification stages, a positive association can be seen between them with a contingency coefficient of 0.661 for males, 0.687 for females and 0.672 for total sample at a high level of significance ($P<0.000$) (Table 4).

DISCUSSION

One of the objectives of orthodontic treatment during adolescence, with skeletal discrepancies, is to take the advantage of the patient's growth change; therefore, prediction of both the time and amount of active growth, especially in the craniofacial complex would be useful to ensure successful outcome of mechanotherapy in the treatment of dentofacial deformities.

The sample subjects of this study were selected with the age range of 8-16 years old, because the pubertal growth spurt occurs within this age range for both genders.

The maturation stages ascribed to the teeth ranged from A – H[14], and since the sample age of this study ranged from 8 to 16 years old, therefore the dental maturation stages earlier than stage D, which have been attained before the age of 8 years, could not be identified; therefore in this study the calcification stages of mandibular left second molar ranged from D – H stages only.

The *mandibular left second molar* was selected for this study due to:

1-Many studies concerning the dental maturation through the pubertal growth stages, using true lateral cephalometric[18] and hand wrist[19,20] radiographs with orthopantomography, showed uniform progression pattern of mandibular canine and second molar, in comparison to the other teeth, with a higher correlation of madibular second molar ($r> 9$) with skeletal maturation stages of hand wrist bones than canine ($r>7$)[20].

2-In normal child, the apex closure of mandibular canine is completed by the age of 13 years old, while mandibular second molar extend up to 16 years[8,21] ,this make this tooth more reliable as a maturity indicator since most children exhibit a period of active growth up to the age of 16-17 years, this is in agreement with the findings of Usman[17] and Al-Bustani[18,22].

The *hand middle finger* was examined in this study because the system of evaluating hand wrist radiographs, which has been found to be generally valid in both clinical and research situations[23], include eleven discrete adolescent skeletal maturational indicators, covering the entire period of adolescent development, are found in hand wrist. And seven, out of these eleven discrete, occur in the third finger; therefore, in this study radiograph restricted to the middle finger to get more benefit with less radiation.

High significant associations were found among chronological age, in years, calcification stages of mandibular left second molar , and developmental stages of middle finger ($P<0.000$) and this in agreement with the findings of Usman[17] and Al-Juboori[20].

After the reduction of the six middle finger developmental stages into pre-peak, peak and post-peak stages, a high significant correlation was found between them and the calcification stages of the mandibular left second molar, with higher puberty stage in female than in male within the same dental calcification stage, which means

that with the advanced calcification stage of mandibular left second molar there will be more chance for males than females to be within pre-peak and peak stages, this is because the maximum growth spurt in female occur at earlier age than male, which in turn affect the skeletal maturation more than the dental development and this is disagree with the findings of Usman[17], in which there is no gender difference in his Indian sample.

CLINICAL CONSIDERATIONS

1- Only two periapical radiographs, one for the middle phalanx of the left hand middle finger and another one for the mandibular left second molar, are almost enough to detect the maturity stage of growing subject with marked reduction in cost and radiation comparing to other studies using middle finger, mandibular second molar and orthopantomographs[17], cephalometric and hand wrist radiographs[18], cephalometric and middle finger radiographs[24].

2- Calcification stages of mandibular left second molar can give a guide for the puberty period, as in stage D all males and females are in pre peak stage, in stages E and F they are within pre-peak and peak stages with more female toward maturity than male, in stage G males in peak stage, whereas about one third of females passed to post peak, in stage H less than 10% of males passed to post peak, while 80% of females are within post peak stage.

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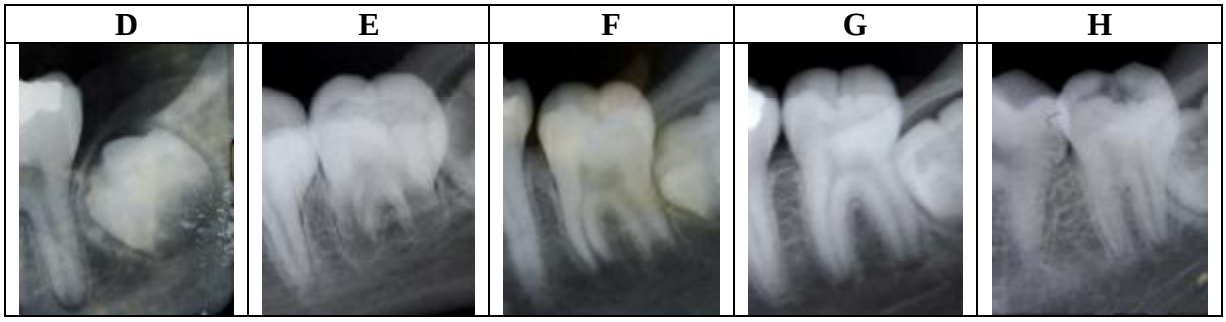

Figure 1: The calcification stages of mandibular left second molar

Table 1: Distribution of the sample according to chronological age and calcification stages of mandibular left second molar for both genders

		Gender	Calcification stages of mandibular left second molar											
			D		E		F		G		H		Total	
			N	%	N	%	N	%	N	%	N	%	N	%
Chronological age (year)	8	M	7	58.3	5	41.7							12	100.0
		F	7	58.3	5	41.7							12	100.0
		T	14	58.3	10	41.7							24	100.0
	9	M	5	41.7	7	58.3							12	100.0
		F	3	25.0	9	75.0							12	100.0
		T	8	33.3	16	66.7							24	100.0
	10	M	5	41.7	7	58.3							12	100.0
		F			5	41.7	7	58.3					12	100.0
		T	5	20.8	12	50.0	7	29.2					24	100.0
	11	M			8	66.7	4	33.3					12	100.0
		F			5	41.7	7	58.3					12	100.0
		T			13	54.2	11	45.8					24	100.0
	12	M			5	41.7	7	58.3					12	100.0
		F			1	8.3	5	41.7	5	41.7	1	8.3	12	100.0
		T			6	25.0	12	50.0	5	20.8	1.0	4.2	24	100.0
	13	M			4	33.3	6	50.0	2	16.7			12	100.0
		F					9	75.0	3	25.0			12	100.0
		T			4	16.7	15	62.5	5	20.8			24	100.0
	14	M			1	8.3			7	58.3	4	33.3	12	100.0
		F					1	8.3	5	41.7	6	50.0	12	100.0
		T			1.0	4.2	1.0	4.2	12.0	50.0	10	41.7	24	100.0
	15	M							8	66.7	4	33.3	12	100.0
		F							4	33.3	8	66.7	12	100.0
		T							12	50.0	12	50.0	24	100.0
	16	M							4	33.3	8	66.7	12	100.0
		F							2	16.7	10	83.3	12	100.0
		T							6.0	25.0	18	75.0	24	100.0
	Total	M	17	15.7	37	34.3	17	15.7	21	19.4	16	14.8	108	100.0
		F	10	9.3	25	23.1	29	26.9	19	17.6	25	23.1	108	100.0
		T	27	12.5	62	28.7	46	21.3	40	18.5	41	19.0	216	100.0

P< 0.000 (HS), Contingency Coefficient: (male =0.777, female= 0.786, total=0.762)

Table 2: Distribution of the sample according to chronological age and developmental stages of left hand middle finger for both genders

		Gender	Developmental stage of left hand middle finger													
			E3/4		F		FG		G		H		I		Total	
			N	%	N	%	N	%	N	%	N	%	N	%	N	%
Chronological age (year)	8	M	10	83.3	2	16.7									12	100.0
		F	6	50.0	6	50.0									12	100.0
		T	16	66.7	8	33.3									24	100.0
	9	M	6	50.0	6	50.0									12	100.0
		F	3	25.0	7	58.3	2	16.7							12	100.0
		T	9	37.5	13	54.2	2	8.3							24	100.0
	10	M	5	41.7	7	58.3									12	100.0
		F	4	33.3	5	41.7	3	25.0							12	100.0
		T	9	37.5	12	50.0	3	12.5							24	100.0
	11	M	4	33.3	5	41.7	3	25.0							12	100.0
		F			4	33.3	4	33.3	4	33.3					12	100.0
		T	4	16.7	9	37.5	7	29.2	4	16.7					24	100.0
	12	M	3	25.0	5	41.7	4	33.3							12	100.0
		F			2	16.7	4	33.3	6	50.0					12	100.0
		T			7	33.3	8	38.1	6	28.6					21	100.0
	13	M			6	50.0	2	16.7	4	33.3					12	100.0
		F			4	33.3	3	25.0	4	33.3	1	8.3			12	100.0
		T			10	41.7	5	20.8	8	33.3	1	4.2			24	100.0
	14	M			1	8.3	1	8.3	7	58.3	3	25.0			12	100.0
		F									4	33.3	8	66.7	12	100.0
		T			1	4.2	1	4.2	7	29.2	7	29.2	8	33.3	24	100.0
	15	M					1	8.3	9	75.0	2	16.7			12	100.0
		F									3	25.0	9	75.0	12	100.0
		T					1	4.2	9	37.5	5	20.8	9	37.5	24	100.0
	16	M									11	91.7	1	8.3	12	100.0
		F									3	25.0	9	75.0	12	100.0
		T									14	58.3	10	41.7	24	100.0
	Total	M	28	25.9	32	29.6	11	10.2	20	18.5	16	14.8	1	0.9	108	100.0
		F	13	12.0	28	25.9	16	14.8	14	13.0	11	10.2	26	24.1	108	100.0
		T	41	19.0	60	27.8	27	12.5	34	15.7	27	12.5	27	12.5	216	100.0

P< 0.000 (HS), Contingency Coefficient: (male= 0.788, female= 0.775, total=0.739)

Table 3: Distribution of the sample according to calcification stages of mandibular left second molar and developmental stages of left hand middle finger for both genders

		Gender	Developmental stage of left hand middle finger													
			E3/4		F		FG		G		H		I		Total	
			N	%	N	%	N	%	N	%	N	%	N	%	N	%
Calcification stages of mandibular left second molar	D	M	15	53.6%	2	6.3 %									17	15.7%
		F	5	38.5%	5	17.9%									10	9.3%
		T	20	48.8%	7	11.7%									27	12.5%
	E	M	13	46.4%	21	65.6%	1	9.1 %	2	10.0%					37	34.3%
		F	6	46.2%	13	46.4%	6	37.5%							25	23.1%
		T	19	46.3%	34	56.7%	7	25.9%	2	5.9%					62	28.7%
	F	M		0.0%	9	28.1%	8	72.7%							17	15.7%
		F	2	15.4%	8	28.6%	9	56.3%	9	64.3%	1	9.1%			29	26.9%
		T	2	4.9%	17	28.3%	17	63.0%	9	26.5%	1	3.7%			46	21.3%
	G	M					2	18.2%	15	75.0%	4	25.0%			21	19.4%
		F			2	7.1 %	1	6.3 %	4	28.6%	6	54.5%	6	23.1%	19	17.6%
		T			2	3.3 %	3	11.1%	19	55.9%	10	37.0%	6	22.2%	40	18.5%
	H	M							3	15.0%	12	75.0%	1	100.0%	16	14.8%
		F							1	7.1%	4	36.4%	20	76.9%	25	23.1%
		T							4.0	11.8%	16	59.3%	21	77.8%	41	19.0%
	Total	M	28	25.9%	32	29.6%	11	10.2%	20	18.5%	16	14.8%	1	0.9%	108	100.0%
		F	13	12.0%	28	25.9%	16	14.8%	14	13.0%	11	10.2%	26	24.1%	108	100.0%
		T	41	19.0%	60	27.8%	27	12.5%	34	15.7%	27	12.5%	27	12.5%	216	100.0%

P<0.000 (HS), Contingency Coefficient: (male=0.799, female=0.736, total=0.753)

Table 4: Distribution of the sample according to calcification stages of mandibular left second molar and developmental peaks of left hand middle finger for both genders

		Males			Females			Total		
		Developmental stages of left hand Middle Finger			Developmental stages of left hand Middle Finger			Developmental stages of left hand Middle Finger		
		Pre	Peak	Post	Pre	Peak	Post	Pre	Peak	Post
Calcification stages of mandibular left second molar	D	100%			100%			100%		
	E	91.9%	8.1%		76%	24%		85.5%	14.5%	
	F	52.9%	47.1%		34.5%	65.5%		41.3%	58.7%	
	G		100%		10.5%	57.9%	31.6%	5%	80%	15%
	H		93.8%	6.2%		20%	80%		48.8%	51.2%
	Total	55.6%	43.5%	0.9%	38%	38%	24%	46.8%	40.7%	12.5%

P<0.000 (HS), Contingency Coefficient: (male=0.661, female=0.687, total=0.672)

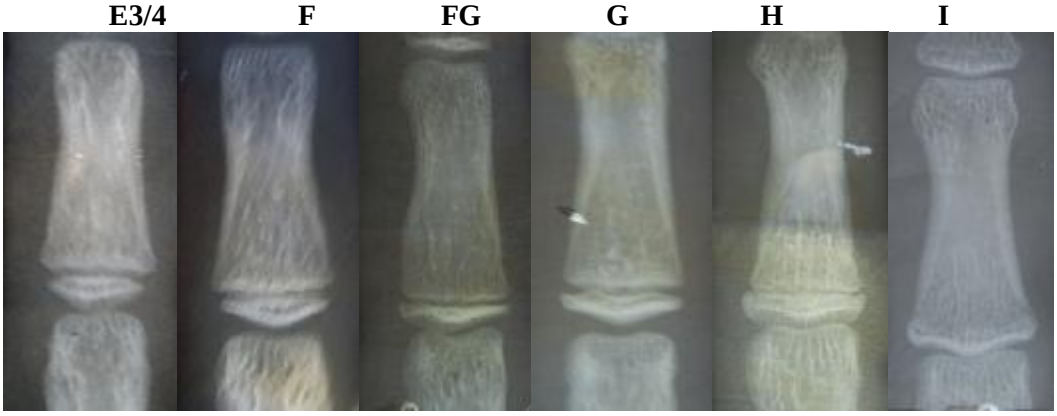

Figure 2: The developmental stages of left hand middle finger